Contract CR2005
Provision of Services to Conduct Environmental Impact Study

Environmental Impact Study (Turf City and Holland Plain)

Study Stage: Final

Volume 3 of 5

Submitted by:
AECOM Singapore Pte Ltd

Submitted to:
Land Transport Authority

07 October 2022

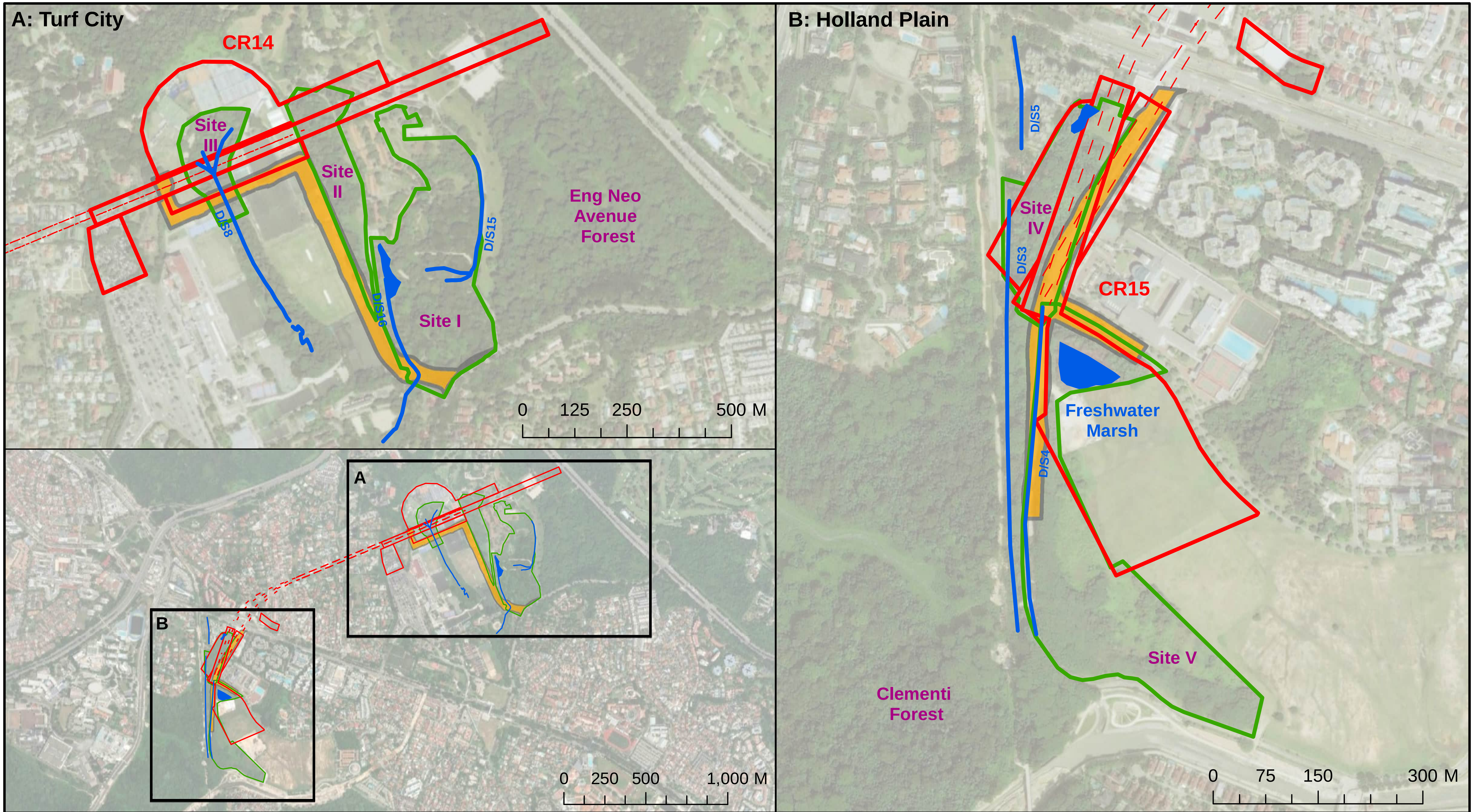
8. Hydrology and Surface Water Quality

8.1 Introduction

This section includes the assessment of hydrology and surface water quality within the Study Areas, as well as the prediction and evaluation of the impacts from the Project's construction and operational phases on the hydrology of the Study Area and the water quality of the impacted watercourses (refer to Figure 8-1). Results from the site surveys were analysed and used to establish the baseline conditions to assess the subsequent changes due to construction and operational activities associated with the Project. Sensitive receptors were identified and classified according to the sensitivity categorisation defined in Section 6.2.2. 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 to allow for impact prediction. Thereafter, an impact evaluation was carried out to assign significance to predicted impacts and where necessary, mitigation measures were proposed. An EMMP was also developed to specify methods and measures to be included during construction, commissioning and operation of the Project which are necessary to reduce the environmental impacts to minimal levels (see Section 13).

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

- Reviewing of data provided by the Client to understand the topographic characteristics of the Study Area;
- Conducting 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);
- Identifying sampling locations for in-situ and ex-situ water quality analysis of existing watercourses located within the Study Area;
- Carrying out hydrological and surface water quality impact analysis to assess the potential impacts of the Project during construction and operational phases; and
- Proposing EMMP to mitigate potential impacts of the Project during construction, commissioning and operational phases.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Road Works
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

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Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title : STUDY AREA FOR THE HYDROLOGY AND SURFACE WATER QUALITY IMPACT ASSESSMENT

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Note: Source of basemap - Google Earth Map

8.2 Methodology and Assumption

8.2.1 Baseline Hydrology and Surface Water Quality Study

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

- To assess the accessibility of the watercourses within the Study Area;
- To verify the information collected from the available topographic survey data and satellite images;
- To identify and map out the location of existing watercourses within the Study Area;
- To determine the flow conditions and bank characteristics of watercourses; and
- To assess current surface water quality conditions in existing watercourses within the Study Area.

8.2.1.1 Desktop Assessment

Desktop research aided in determining the location of existing watercourses within the Study Area. The topographic survey data provided by LTA and topographic survey data from concurrent study carried out by AECOM in the vicinity as well as the catchment map (i.e. defines the areas which contributes water flow to existing reservoirs) from PUB website [W-19] were used to support the findings of the hydrological survey. The information used for this desktop assessment consisted of publicly available data from government and technical agencies, existing publicly available data (e.g. online satellite images), as well as published books, relevant articles, and other online sources.

8.2.1.2 Hydrological Baseline Assessment

The hydrological survey was conducted by casual exploration methods to identify and outline existing major watercourses within the study area. The conditions of these watercourses, such as stream bank characteristics (e.g., natural bank or artificial bank) and flow characteristics, was identified based on visual observations and professional experience. The Project alignment and worksites were also overlaid with the topographic data using ArcGIS to support the hydrological survey. Catchment analysis was carried out to identify the water sources and to determine how the runoff flows within the Study Area using topographic data and catchment map from PUB website [W-19].

A Global Positioning System (GPS) device was used to track the hydrology survey route. The GPS data was then synchronised with the photos taken onsite to identify the location of the identified watercourse.

8.2.1.3 Water Quality Baseline Assessment

As mentioned in the section above, major watercourses present in the Study Area were identified during site surveys. Suitable locations were selected within the identified watercourses for collection of water samples in order to assess the baseline in-situ and ex-situ water quality of existing watercourses within the Study Area. The baseline conditions of the surface water quality at the Study Area were then established.

Water samples were collected at eight (8) water quality stations along major streams or roadside drains from Site I, II, III, IV and V as detailed in Figure 8-2 and Table 8-1.

Based on hydrology findings in Site I and Site II, stations WQ21 and WQ22 were selected to capture the water quality of the roadside concrete drain at upstream of D/S15 and naturalised stream D/S16, where the latter is located near planned road works. Station WQ8 and WQ9 are located in Site III, which were selected to capture the water quality along the upstream and downstream of the man-made earth drain D/S8, which will be partially encroached by the CR14 worksite footprint and may receive surface runoff from the worksite. In Site IV, water quality sampling stations WQ3 and WQ5 were selected to capture water quality from earth drains D/S3 and concrete drain D/S5, respectively, which receive runoff from and/or are encroached on by the CR15 worksite in Holland Plain. Station WQ4 and WQ36 in Site V was selected to capture the water quality of concrete drain D/S4 and Freshwater Marsh which are encroached on by the CR15 worksite footprint.

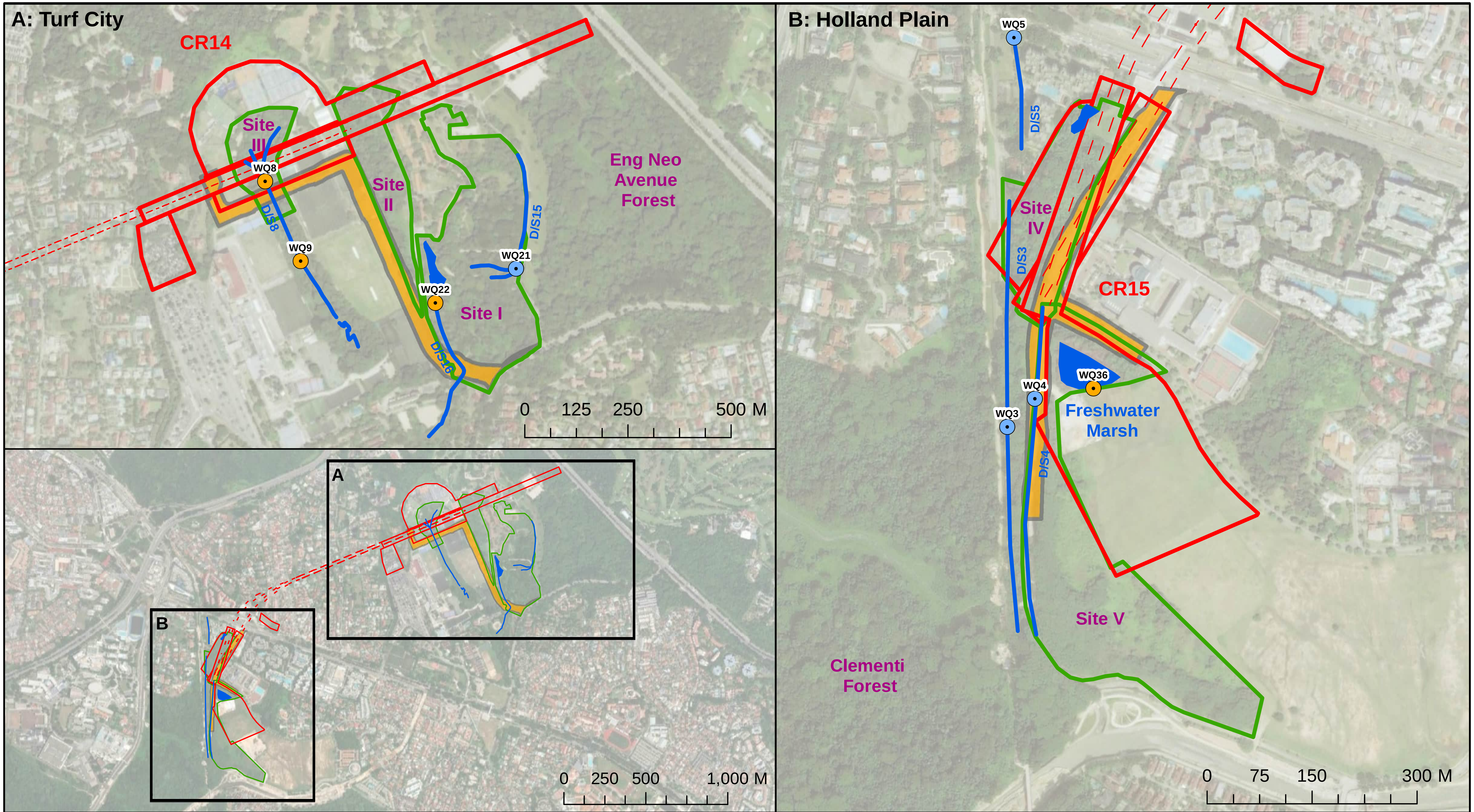
Dry-weather conditions are defined as after a continuous 48-hour period of no-rain, while wet-weather conditions are defined as a rainfall event having more than 10mm of rainfall, with samples to be collected within three (3) hours after the rain stops. Generally, two (2) dry weather (normal conditions) and one (1) wet weather (after a storm event) samples were collected from each water quality station. However, some of the watercourses (i.e. D/S3, D/S4, D/S5, D/S15) in the Study Area were sampled during storm event as they were mostly dry or had no flow during dry weather conditions. Hence, only wet weather samples were collected at WQ3, WQ4, WQ5 and WQ21, while both dry and wet weather samples were collected at WQ8, WQ9, WQ22 and WQ36.

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

- Temperature;
- pH;
- Conductivity;
- Total Dissolved Solids (TDS), and
- Dissolved Oxygen (DO).

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

- Turbidity;
- Total Suspended Solids (TSS);
- Biochemical Oxygen Demand (BOD_5);
- Chemical Oxygen Demand (COD);
- Total Nitrogen (TN);
- Nitrate (NO_3-N);
- Total Phosphorus (TP); and
- Orthophosphate (PO_4-P).



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Water Quality Sampling Locations

- Dry and Wet
- Wet
- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Road Works
- Biodiversity Study Area

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Project Title :

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :

WATER QUALITY SAMPLING LOCATIONS WITHIN THE STUDY AREA

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	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

Table 8-1 Rationale for the Selection of Water Quality Sampling Locations

S/N	Monitoring Location[7]	Nearest Construction Worksite Area/Project Footprint	Justification (refer to Figure 8-2)
Turf City			
WQ8	At upstream of earth drain D/S8, which is located in the forested area of Site III	CR14, Planned road works (construction worksite area) CR14, Future road under study (operation stage)	To capture the baseline water quality within earth drain D/S8 receiving water from the proposed construction and operational footprints. It has relatively low ecological significance, with low numbers of conservation significant biodiversity (refer to Section 7.4.1). Samples were collected during dry and wet weather to understand existing water quality condition of runoff from surrounding forested areas.
WQ9	At downstream of earth drain D/S8 which is located in the forested area in the vicinity of Site III	CR14, Planned road works (construction worksite area) CR14, Future road under study (operation stage)	To capture the baseline water quality within earth drain D/S8 receiving water from the proposed construction and operational footprints. It has relatively low ecological significance, with low numbers of conservation significant biodiversity (refer to Section 7.4.1). Samples were collected during dry and wet weather to understand existing water quality condition of runoff from the surrounding forested areas.
WQ21	At roadside concrete drain at the upstream of D/S15 which located near the edge of the forested area of Site I	CR14, Planned road works (construction worksite area) Future road under study (operation stage)	To capture the water quality of runoff from forested areas of Site I and nearby urban areas (i.e. road) before it discharges back into forested area of Site I. It is not supporting an ecosystem of biodiversity conservation significance but has relatively high ecological value as its downstream is located within the native-dominated secondary forest (refer to Section 7.5.1).
WQ22	At naturalised stream D/S16 located in forested area of Site I	Planned road works (construction worksite area) Future road under study (operation stage)	To capture the water quality of naturalised stream D/S16 flowing south, through Site I, which will receive water from the proposed construction and operational footprints. It is supporting an ecosystem of biodiversity conservation significance (refer to Section 7.5.1).
CR15			
WQ3	At midstream of earth drain D/S3	CR15 (construction worksite area)	To capture the baseline water quality within the earth drain D/S3, whose upstream is located partially within Site IV and the CR15 worksite. The stream is dry, with no permanent flow observed during dry weather. Samples were collected during wet weather to understand existing water quality condition of runoff from the surrounding forested areas.

[7] The monitoring locations are shown in Figure 8-2.

S/N	Monitoring Location[7]	Nearest Construction Worksite Area/Project Footprint	Justification (refer to Figure 8-2)
WQ4	At concrete drain D/S3	CR15 (construction worksite area) Permanent road (operation stage)	To capture the baseline water quality within concrete drain D/S4 running along Blackmore Drive and receiving water from the proposed worksite footprint during construction and operational phase. The drain is dry, with no permanent flow observed during dry weather. Samples were collected during wet weather to understand existing water quality condition of runoff from surrounding forested areas.
WQ5	At concrete drain D/S5	CR15 (construction worksite area)	To capture the baseline water quality within roadside concrete drain D/S5, in the vicinity of CR15 worksite. The drain is dry, with no permanent flow observed during dry weather. Samples were collected during wet weather to understand existing water quality condition of runoff from surrounding forested areas.
WQ36	At Freshwater Marsh in the forested area of Site V	CR15 (construction worksite area)	To capture the baseline water quality of Freshwater Marsh in the Site V. This waterbody is an important habitat for marsh-specific odonates and birds, including those of conservation significance.

8.2.2 Water Quality Baseline Assessment Criteria

During construction phase, the locations of the construction worksites can potentially impact the hydrology and water quality of existing watercourses. During operational phase, increased urbanised area and human activities may lead to increased surface runoff and waste management practices (such as littering). Hence, any watercourses that are directly impacted by the proposed development were included in the impact assessment.

The baseline water quality of the watercourses located within the Study Area was analysed against the NEA Trade Effluent Discharge limits for controlled watercourses [R-27]. 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 has already exceeded 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 water quality along the identified streams is suitable for aquatic life, certain parameters were compared to the water quality criteria for aquatic life from other countries including United Nations Economic Commission for Europe [R-20], World Health Organization [R-22], United States Environmental Protection Agency [R-21], Australian & New Zealand [R-28], Canada [R-29], Philippines [R-18], and Malaysia [R-30], which provides guidelines for the protection of aquatic life. The relevant limits and guidelines for water quality parameters were summarised in Table 8-2; however, where no guidelines exist, the monitored results would be considered as the minimum criteria.

Table 8-2 Water Quality Guidelines and Criteria

Parameter	NEA Trade Effluent Discharge Limits[a]	Water Quality Criteria for Aquatic Life from other countries[b]
pH	6 - 9	6.5 - 9
Temperature (°C)	45	-
Conductivity (µS/cm)	-	-
Total Dissolved Solids, TDS (mg/L)	1,000	1,000
Dissolved Oxygen, DO (mg/L)	-	> 4.0
Turbidity (NTU)	-	50

Parameter	NEA Trade Effluent Discharge Limits[a]	Water Quality Criteria for Aquatic Life from other countries[b]
Total Suspended Solids, TSS (mg/L)	30 SDA: 50[d]	50
Biological Oxygen Demand, BOD_5 (mg/L)[c]	20	3
Chemical Oxygen Demand, COD (mg/L)	60	25
Total Phosphorous, TP (mg/L)	-	Eutrophic limit: 0.075 mg/L
Orthophosphate, PO_4-P (mg/L)	0.65 (equivalent to 2 as PO_4)	0.033 (equivalent to 0.1 as PO_4)
Total Nitrogen, TN (mg/L)	-	Eutrophic limit: 1.5 mg/L
Nitrate, NO_3-N (mg/L)	4.52 (equivalent to 20 as NO_3)	10 (equivalent to 44 as NO_3)

Note:

a. NEA Trade Effluent Discharge Limits for discharge into a controlled watercourse.

b. The sources of international water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-20], World Health Organization [R-22], United States Environmental Protection Agency [R-21], Australian & New Zealand [R-28], Canada [R-29], Philippines [R-18], and Malaysia [R-30]

c. BOD_5 is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material per litre of sample during 5 days of incubation at 20 °C.

d. The limit value is for TSS discharge into storm water drainage system (i.e. ECM discharge) which referred from Sewerage and Drainage (Surface Water Drainage) Regulations.

8.2.3 Prediction and Evaluation of Impact Assessment

Qualitative and analytical methods were applied to assess hydrological and water quality impacts of the development construction and operational phases.

The hydrological impact study will provide an understanding of the impact of construction/operational activities on hydrological conditions of the site, such as the potential land use changes of the site which can lead to an increase in peak flow discharge, a reduction in dry weather flow or even a change in the stream alignment of the impacted watercourse.

The water quality impact study will provide an understanding of potential impact of construction/operational activities on the water quality of the existing watercourses within/surrounding the site using analytical methods.

8.3 Potential Sources of Hydrology and Surface Water Quality Impacts

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

8.3.1 Construction Phase

Nearby watercourses can be potentially exposed to contamination due to the activities taking place during the Project's construction phase. The sources that could potentially impact on the nearby freshwater 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 Construction Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Site clearance, earthworks and general construction activities at launch/retrieval shafts, the open cut and the C&C works	• Runoff from exposed soil surface, earth work areas, utilities diversion, soil stockpiles; • Stormwater/groundwater pumped out from excavated areas;	Hydrology: • Increased stormwater peak flow contributions to the channel can lead to increased water levels and subsequently flood to the surrounding areas adjacent to

<table>
<tr><th>Activity</th><th>Potential Source of Impacts</th><th>Potential Associated Impacts</th></tr>
<tr><td>(e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, concrete batching plant, spoil handling and transport, building of permanent structures, utilities diversion including diversion of water pipes and stormwater drains along the Project, etc.)</td><td>Release of grouting and cement materials;
Runoff from dust suppression sprays;
Wastewater generated from concrete batching plant;
Elevated suspended solids (e.g. silt and sediment) in site runoff due to heavy rain;
Spoil generation, handling and transport; and
Heavy rain during construction; and
Wastewater generated from tunnelling activities.</td><td rowspan="4">the stream/drain due to the land use change from land clearance;
Alteration of dry weather flow of the watercourse can impact downstream aquatic habitats;
Stormwater runoff from exposed and unstable slopes may cause soil erosion; and
Potential groundwater drawdown due to dewatering process during tunnelling activities (its impact will be assessed in Section 9 – soil and groundwater).
Water contamination:
Wastewater from construction activities can contain elevated levels of suspended solids which can lead to increased turbidity and sedimentation rates in the watercourses, etc;
Wastewater from construction activities can contain high levels of oil, grease, and other chemical substances (e.g. calcium hydroxide) therefore contaminating the watercourses;
Alteration of pH due to runoff generated from concrete batching plant;
Inappropriate storage and disposal of wastewater will generate contaminated runoff and pollute nearby watercourses (e.g. improper discharge of tunnelling wastewater, concrete batching plant wastewater and domestic sewage);
Solid waste generated can lead to elevated levels of suspended solids entering watercourses via runoff or improper handling/disposal. It can also block the temporary drains which can lead to localised flooding and mosquito breeding;
Improper storage, handling, disposal or leakage of toxic waste generated at temporary work areas can lead to water contamination;
Contaminated stormwater due to improper storage/disposal/transport of chemical materials handled and stored on site leading to an increase in the levels of oil, grease and other chemical substances (e.g. calcium hydroxide) in the nearby watercourses; and
Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment can also lead to elevation in levels of oil and grease in the nearby watercourses.</td></tr>
<tr><td>Storage and disposal of solid wastes</td><td>Improper handling, transfer, storage, and disposal of spoil and solid waste (e.g. TBM spoil, excavated earth, construction debris).</td></tr>
<tr><td>Storage and disposal of liquid wastes</td><td>Improper management of sewage effluents from on-site; and
Inappropriate discharge of domestic sewage and poor maintenance of the portable chemical toilet, storage tanks and septic tanks (e.g. overflow or overload).
Inappropriate discharge of wastewater generated from tunnelling activities</td></tr>
<tr><td>Use and storage of chemical substances, and refuelling activities</td><td>Improper handling, transfer, and storage of chemical substances;
Accidental spill and leaks; and
Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment.</td></tr>
</table>

8.3.2 Operational Phase

Watercourses can potentially be exposed to contamination due to the activities taking place during the Project's operational phase. The sources that could potentially impact on nearby surface water quality and quantity include but are not limited to the ones listed in Table 8-4.

Table 8-4 Potential Hydrology and Water Quality Impacts during the Operational Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Stormwater Runoff Generation	• Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to the streams; • Increase of runoff peak flow draining to the stream or drain during storm events due to the increase in urbanised area; • Accidental events (e.g. fires); and • Reduce the baseflow (sub-surface water discharge) due to the change in land use of the new development	Hydrology: • Increased stormwater peak flow contributions to the channel and blockage of channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain; • Alteration of dry weather flow of the watercourse can lead to impacts on downstream aquatic habitats; and • Stormwater runoff from exposed and unstable slopes may cause soil erosion. Stormwater Quality: • Elevated suspended solids (e.g. silt and sediment) and pollutants in the watercourses (e.g. heavy metals and nutrients from human activities including accidental events).

8.4 Identification of Hydrology and Surface Water Quality Sensitive Receptors

Receptor screening for surface water was conducted within Biodiversity Study Area for both construction and operational phases (Figure 8-1). The sensitive receptors for surface water considered for both construction and operational phases were the same. The criteria detailed in Table 6-1 were used to determine the sensitivity of the surface water receptors presented in Table 8-5.

Table 8-5 Classification of Hydrology and Water Quality Sensitive Receptors Identified within the Study Area for Both Construction and Operational Phases

Sensitive Receptor	Description	Water Use	Sensitivity Classification
Turf City			
Earth drain D/S8	The earth drain is a freshwater man-made earth drain. D/S8 is located within CR14 worksite (Base Scenario).	The surface water eventually discharges into Marina Reservoir (refer to Figure 4-9), used for drinking supply.	Priority 1
Concrete Drain D/S15	The concrete drain is freshwater public drains. Presence of aquatic life was not observed during site walkover, likely due to its dry condition during dry weather.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-9), used for drinking supply.	Priority 1

Sensitive Receptor	Description	Water Use	Sensitivity Classification
Naturalised Stream D/S16	The natural stream is a freshwater stream that discharges into public drains. Presence of aquatic life was observed during site walkover.	The surface water will eventually discharge into Marina Reservoir (refer to Figure 4-9), used for drinking supply.	Priority 1
Holland Plain			
Earth drain D/S3	The earth drain is the upstream of a freshwater public drain. Upstream of D/S3 is located within CR15 worksite (Base Scenario).	The surface water eventually discharges into Pandan Reservoir (refer to Figure 4-9), used for drinking supply.	Priority 1
Concrete drain D/S4	The concrete drain is a freshwater public drain. Upstream of D/S4 is located within CR15 worksite (Base Scenario).	The surface water eventually discharges into Pandan Reservoir (refer to Figure 4-9), used for drinking supply.	Priority 1
Roadside concrete drain D/S5	The concrete drain is a freshwater public drain. Nearest distance of D/S5 from CR15 worksite (Base Scenario) is approximately 30 m.	The surface water eventually discharges into Pandan Reservoir (refer to Figure 4-9), used for drinking supply.	Priority 1
Ponds at Site IV	These ponds are freshwater waterbodies. All ponds are located within the CR15 worksite (Base Scenario) and will be drained and backfilled during construction phase.	The surface water is currently not used for any beneficial purpose.	Priority 3
Freshwater Marsh	The Freshwater Marsh is a freshwater waterbody. The waterbody was observed to support fauna during site walkover. The entire waterbody is located within the CR15 worksite (Base Scenario) and will be drained and backfilled during construction phase.	The surface water supports an ecosystem of conservation significant biodiversity (refer to Section 7.5.2).	Priority 1

8.5 Baseline Hydrology and Surface Water Quality

As mentioned in Table 6-2 this report presents the hydrology and water quality findings of the field assessments collected from February 2020 to June 2022.

8.5.1 Baseline Monitoring Results

8.5.1.1 Hydrological Conditions in the Study Area

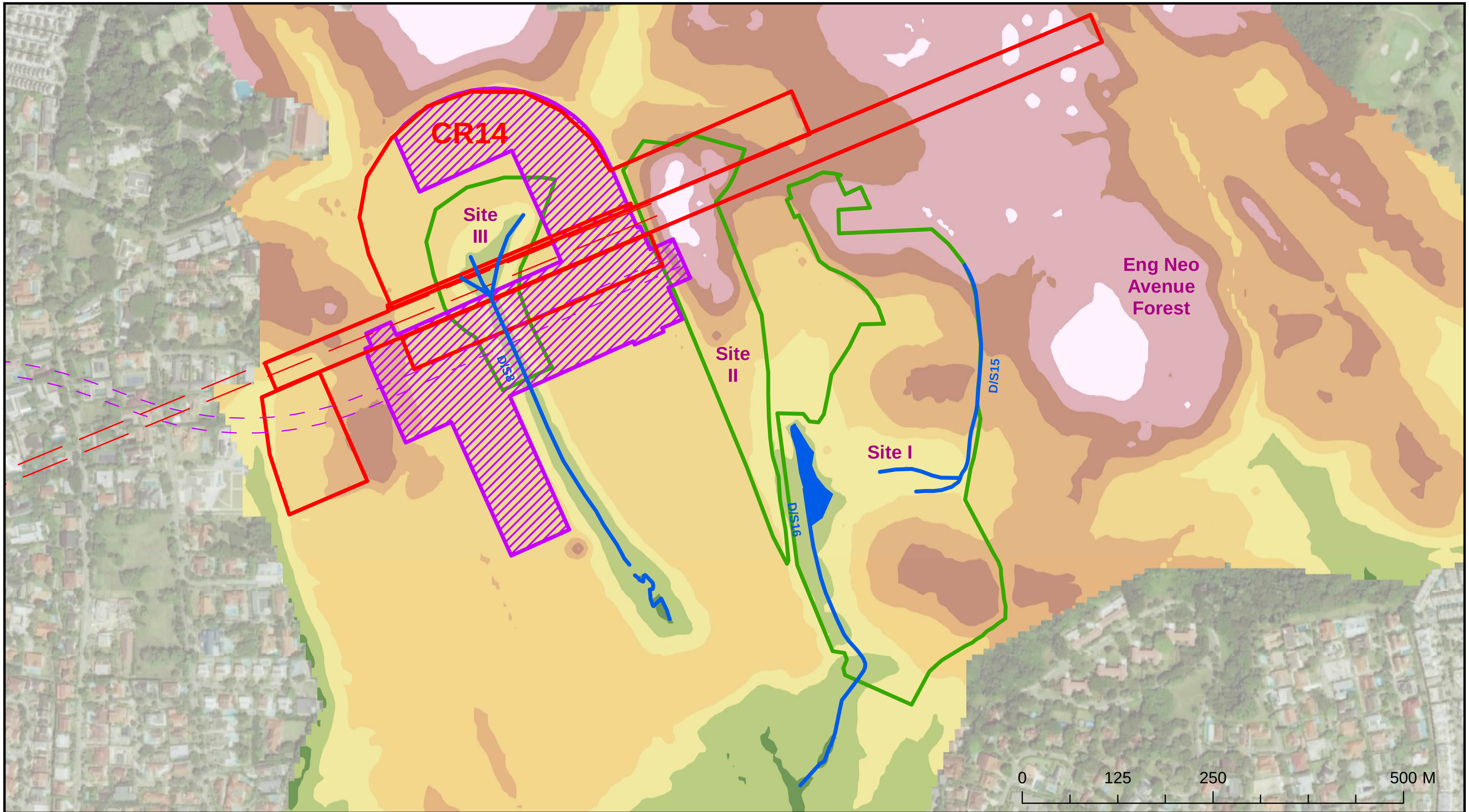
During site reconnaissance, watercourses were identified within and in the vicinity of Turf City (CR14) and Holland Plain (CR15), as shown in Figure 8-1. At Turf City area, the watercourses studied consists of one (1) roadside concrete drain at upstream of a watercourse (D/S15), one (1) man-made earth drain (D/S8) and one (1) naturalised stream (D/S16). Watercourse D/S15 is a partially concretised stream system, where the upstream of D/S15 is an ephemeral concrete drain which subsequently flows westwards into the downstream perennial naturalised section of D/S15. Since the upstream section of D/S15 was surveyed for this baseline study, watercourse D/S15 was considered as an ephemeral concrete drain for Section 8. At Holland Plain, there are one (1) earth drain (D/S3), two (2) concrete drains (D/S4, D/S5), a few waterbodies (ponds at Site IV, Freshwater Marsh at Site V).

The surveyed topographic data was used to generate elevation, slope and catchment maps for Turf City (i.e. Site I, II and III), and subsequently overlaid with surface watercourses using ArcGIS software as shown in Figure 8-3, Figure 8-4 and Figure 8-5. However, due to insufficient available topographic data for Holland Plain, the detailed elevation, slope and catchment maps were not generated and Figure 8-6 presents the general hydrological conditions of Holland Plain (i.e. Site IV and V) based on site observation instead.

Based on the analysis of topographic data of the Turf City area, the CR14 worksite (base scenario) will be located across undulating terrain with uneven slopes. Site I was found to have an undulating terrain along the western half, and the elevation generally decreases from northeast to southwest. During storm events, an ephemeral concrete drain (i.e. D/S15) runs along the boundary of Site I and conducts runoff from the surrounding vegetation and urban area southwards, and subsequently discharges westwards into a central low-lying region where the naturalised stream section of D/S15 is located (Figure 8-3). An elongated zone of low elevation is located at the western boundary of Site I. Given the comparatively lower elevation of this zone, it is unsurprising that a perennial naturalised stream (D/S16) is present in this area. At Site II, the highest elevation point is approximately 25.7 mSHD which is located at the north of this site, and the elevation decreases southwards. A central linear area of low elevation is located in the middle of Site III, where a perennial earth drain (D/S8) is present. This earth drain (D/S8) flows out of Site III, towards the south of the Turf City area. Furthermore, the worksite footprint (base scenario) was initially proposed to span across the hilly terrain of Site II and Eng Neo Avenue Forest, as well as at the north of Site III. After optimisation, the mitigated construction worksite footprint was proposed to skirt around most of the Site III, at urbanised areas with relatively uniform elevation, instead of directly within Site III.

Based on generated elevation and slope analysis for Sites I, Site II, Site III, catchment delineation was conducted to further understand catchment characteristics of the Turf City area. A catchment map was then developed as shown in Figure 8-5. Fourteen (14) catchment areas were identified within the Turf City area. Catchment C7 contributes to the partially concretised stream system (D/S15) with ephemeral flow at its upstream and perennial flow at its downstream, while Catchment C8 feeds the perennial naturalised stream (D/S16). Catchment C9 contributes to perennial man-made earth drain (D/S8). The other catchments, such as Catchment C1, C2, C3, C4, C5, C6, C10, C11, C12, C13, C14, contribute to various natural streams and roadside drains (not shown on map) that lies beyond the Biodiversity Study Area (i.e. Sites I, II and III).

Based on the analysis of the available topographic data of the vicinity of Holland Plain, CR15 worksite was noted to be located at an area with generally higher elevation than its surroundings (i.e. the adjacent forested areas of Site V). The elevation within Site IV decreases from the southwest to the northeast of the site. Elevation within Site V generally decreases from the north to the southwest. The upstream of ephemeral earth drain (D/S3) is located within Site IV and eventually flows southwards. During storm events, this earth drain (D/S3) receives runoff from the surrounding forested areas. Ephemeral roadside concrete Drain (D/S4) is located along the boundary of Site V and runs parallel to Blackmore Drive. The drain (D/S4) also receives runoff from the forested area during storm events. An ephemeral roadside concrete drain (D/S5) is located northwest of Site IV which flows northwards and receives runoff from the surrounding forested areas. There are numerous waterlogged areas within Site IV (refer to details in Section 7.3.2.1.7), which will be denoted as ‘ponds’ in this Study. These ponds receive runoff from the surrounding forested areas within Site IV. A Freshwater Marsh is present within Site V, which was noted to potentially be mostly recharged by both runoff from the forested areas in its immediate vicinity and from precipitation directly over the Marsh area.



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- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Construction Worksite Footprint (Base)
- Construction Worksite Footprint (Mitigated)
- Biodiversity Study Area

Elevation (mSHD)

- <10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- >40

N

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Consultant : AECOM

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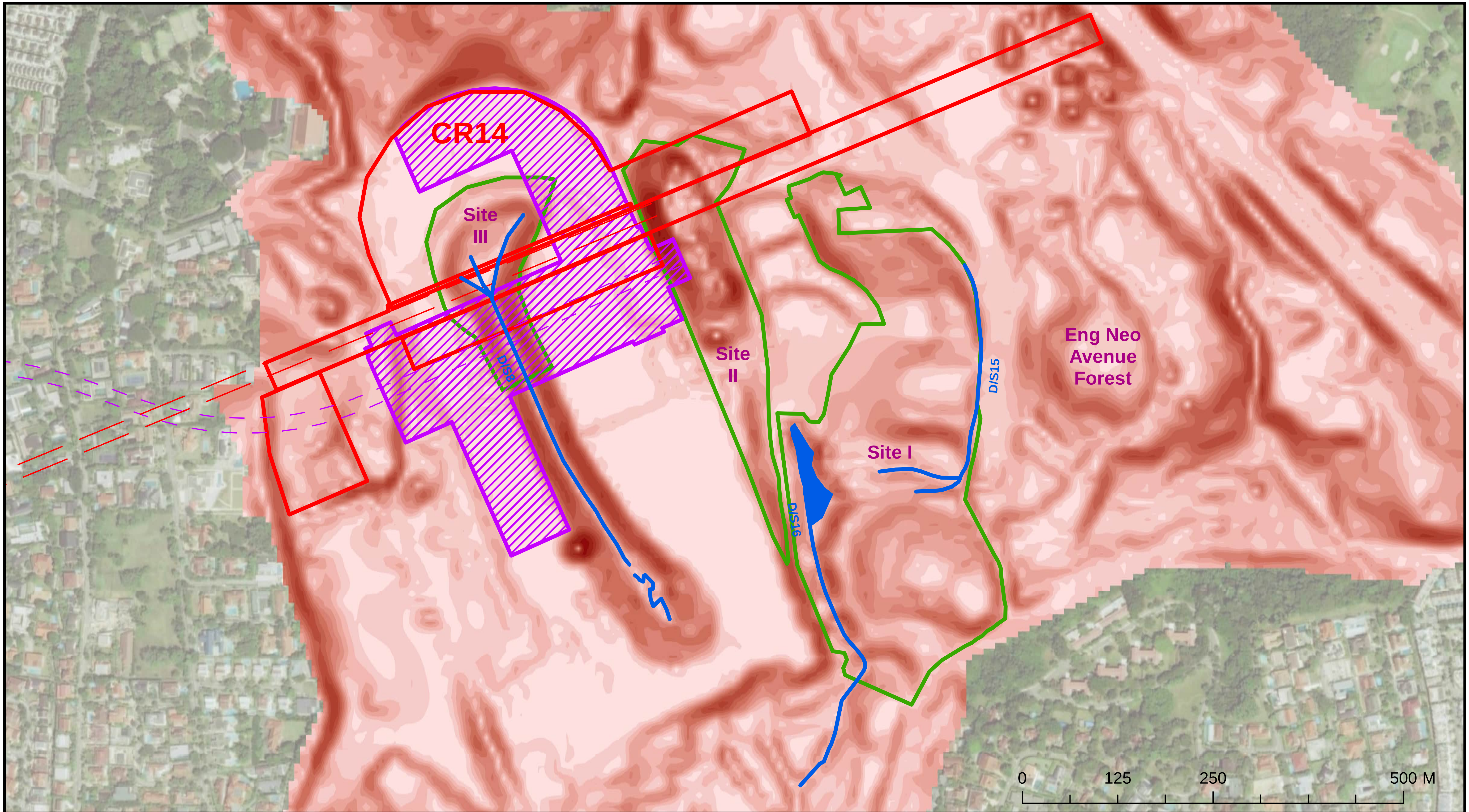
Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :
ELEVATION MAP OF THE VINCINITY OF CR14

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 3	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Construction Worksite Footprint (Base)
- Construction Worksite Footprint (Mitigated)
- Biodiversity Study Area

Slope (%)

- <5
- 5- 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- >60

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

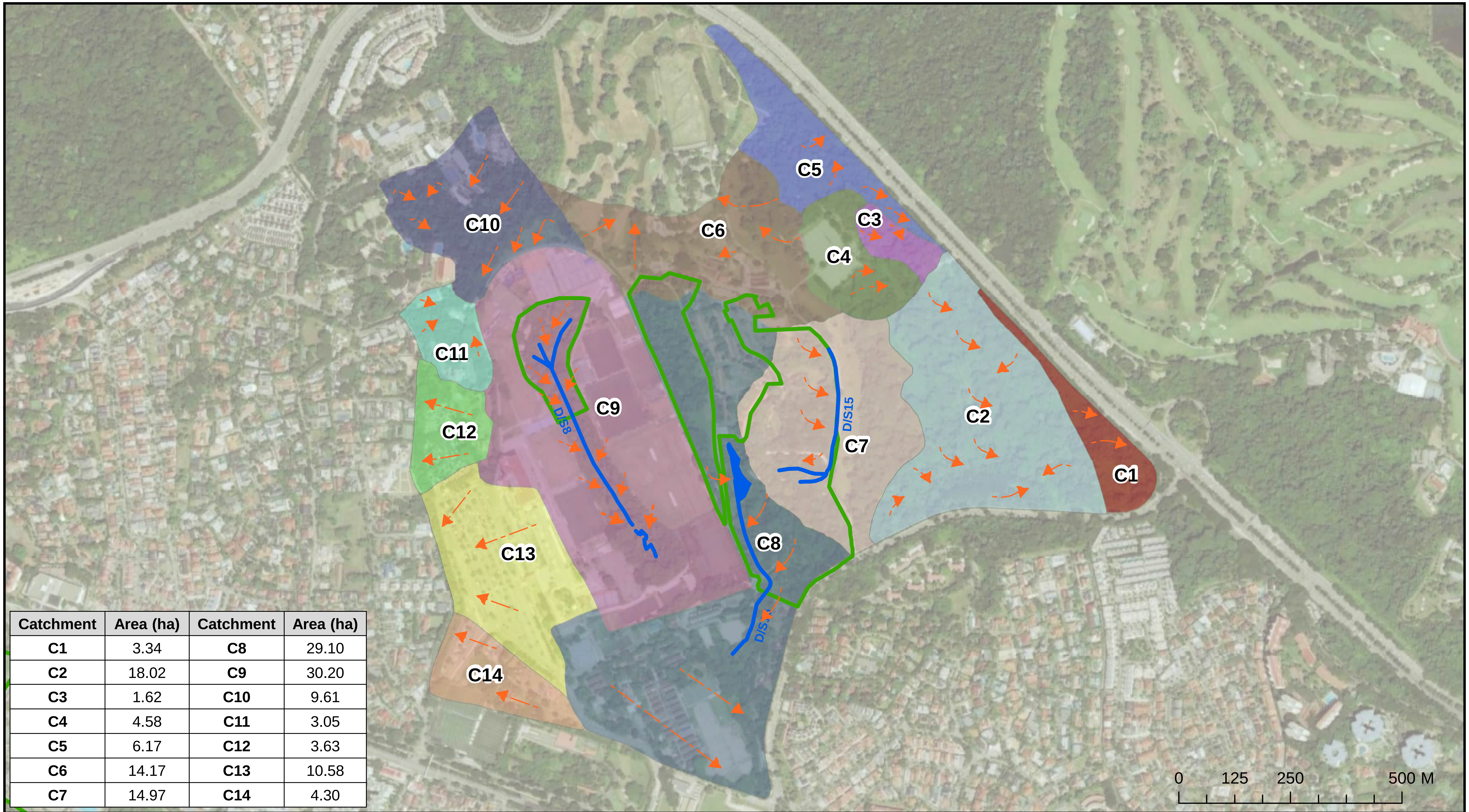
Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :
SLOPE MAP OF THE VICINITY OF CR14

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 4	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map



Catchment	Area (ha)	Catchment	Area (ha)
C1	3.34	**C8**	29.10
C2	18.02	**C9**	30.20
C3	1.62	**C10**	9.61
C4	4.58	**C11**	3.05
C5	6.17	**C12**	3.63
C6	14.17	**C13**	10.58
C7	14.97	**C14**	4.30

Legend

Watercourses

Biodiversity Study Area

Water Flow Direction

Catchment

C1 C6 C11
C2 C7 C12
C3 C8 C13
C4 C9 C14
C5 C10

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :
CATCHMENT MAP OF THE VICINITY OF CR14

Designed	Checked	Approved
CQA	NHT	JAG

Drawn	Date
CQA	AUG 2022

Figure No. : 8 - 5

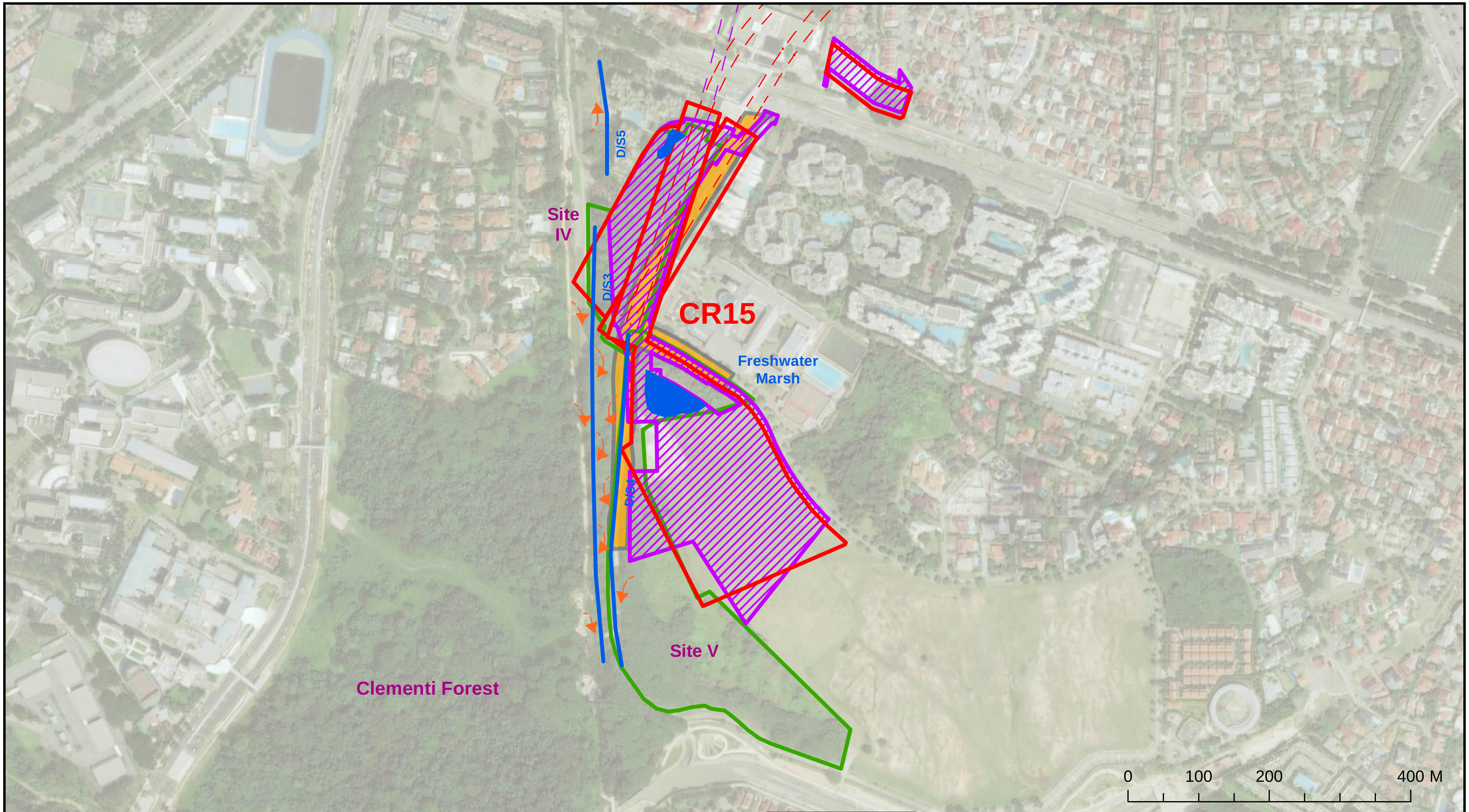
Rev. : -

Sheet : 1 of 1

CAD File Name : NA

A3

Note: Source of basemap - Google Earth Map



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Construction Worksite Footprint (Base)
- Mitigated Secenario Construction Worksite Footprint
- Biodiversity Study Area
- Planned Road Works
- Water Flow Direction

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title : HYDROLOGICAL CONDITIONS IN THE VICINITY OF CR15

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 6	-	1 of 1

	Drawn	Date	CAD File Name :	
	CQA	AUG 2022	NA	A3

Note: Source of basemap - Google Earth Map

Table 8-6 Description of Watercourses with its Water Quality Sampling Points within the Study Area

Watercourses	Bank Characteristics	Water Flow Conditions	Photos
Turf City (CR14)			
D/S8	Earth drain surrounded by dense vegetation Estimated longest continuous drain length is 514 m	Originates from the forested area of Site III and the forested area at the south of Site III Perennial flow **During dry weather condition:** Upstream (WQ8): Stagnant flow was observed Water had approximately 7 cm depth and width of 200 cm at time of survey Water was clear and has no odour Downstream (WQ9): Stagnant flow was observed Water had approximately 40 cm depth and width of 300 cm at time of survey Water was clear and has no odour **During wet weather condition:** Upstream (WQ8): Slow water flow observed of approximately 0.19 m/s Water had approximately 10 - 40 cm depth and width of 300 - 400 cm at time of survey Water was clear and has no odour Downstream (WQ9): Slow water flow observed of approximately 0.15 m/s Water had approximately 40 - 50 cm depth and width of 400 - 500 cm at time of survey Water was clear and has no odour	**WQ8** During Dry Weather  During Wet Weather  **WQ9** During Dry Weather  During Wet Weather 
D/S15	Roadside concrete drain at upstream of D/S15 with artificial banks	• Originates from stormwater runoff from forested area north of Site I • Ephemeral flow	**WQ21** During Dry Weather During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
	Length of drain is estimated to be 286 m	• • **During dry weather condition:** • Almost no flow • • **During wet weather condition:** • Slow water flow observed of approximately 0.12 m/s • Water had approximately 12 cm depth and width of 39 cm at time of survey • Water was turbid and has no odour		
D/S16	Naturalised stream and surrounded by dense vegetation Estimated drain length is 433 m	• Originates from surrounding vegetation in Site I, waterlogged area /swampy ground upstream and a discharge outlet discharging flow from forested areas east of Site I. Flows south of Site I, and out of the Study Area • Perennial flow **During dry weather condition:** • Slow water flow (estimated at 0.037 m/s) • Water had approximately 50 - 56 cm depth and width of 85 - 86 cm at time of survey • Water was clear and has no odour **During wet weather condition:** • Slow surface water flow observed, approximately 0.18 m/s • Water had approximately 76 cm depth and width of 90 - 95 cm at time of survey • Water was turbid and has no odour	**WQ22** During Dry Weather 	During Wet Weather 
Holland Plain (CR15)				
D/S3			**WQ3**	

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
	Earth banks covered by dense vegetation Estimated drain length is 610 m.	• Originates from stormwater runoff from forested areas Site IV • Ephemeral flow during wet weather condition only **During dry weather condition:** • Dry at both upstream and downstream of D/S3. • A puddle of water in the midstream was observed at time of survey **During wet weather condition** • Water puddle became a pond in middle section of D/S3 • Stagnant water observed	During Dry Weather 	During Wet Weather 
D/S4	Concrete roadside drain with artificial banks Estimated drain length is 470 m	• Originates from the forested area of Site V • Ephemeral flow during wet weather condition only **During dry weather condition:** • Almost no flow **During wet weather condition** • Slow wet weather flow observed in 120 cm width drain (estimated 0.2 m/s) • Water had approximately 5 cm depth with width of 30 cm, at time of survey	**WQ4** During Dry Weather 	During Wet Weather 
D/S5	Concrete drain with artificial banks Estimated drain length is 160 m	• Originates from forested area at the east of Site IV • Ephemeral flow during wet weather condition only **During dry weather condition:** • Almost no flow	**WQ5** During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		During wet weather condition • Slow wet weather flow observed in 80 cm width drain (estimated 0.34 m/s) • Water had approximately 13 cm depth with width of 35 cm, at time of survey		
Freshwater Marsh	Freshwater Marsh habitat with earth banks, covered by dense vegetation and surrounded by large trees	• Potentially mainly recharged by direct precipitation over the Marsh area • Perennial waterbody • Area of the Marsh is approximately 0.34 ha. **During both dry and wet weather condition:** • Stagnant • Water depth in the Marsh was approximately 1 - 1.5 m.	**WQ36** During Dry Weather 	During Wet Weather 

8.5.1.2 Water Quality Conditions in the Study Area

Both in-situ and ex-situ water quality analyses were conducted for all water quality stations. The water quality sampling dates for two (2) dry weather events and one (1) wet weather event for in the Study Area is shown in Table 8-7. Note that certain parameters (i.e. chemical oxygen demand [COD], total nitrogen [TN], total phosphorus [TP], nitrate [NO3-N] and orthophosphate [PO4-P]) were not tested for earth drain D/S8 (WQ8, WQ9) as this drain has relatively low ecological significance with low numbers of conservation significant biodiversity (as 7.4.1) and is exposed to human disturbances due to its proximity to recreational and sports facilities. The ponds within Site IV were not surveyed as they have relatively low ecological conservation value, and will be drained and backfilled during construction stage.

The water quality results are presented in Table 8-8 with photos shown in Table 8-9, and were assessed against guidelines listed in Table 8-2. The laboratory results for surface water quality parameters were also included in Appendix L. The evaluation of baseline water quality results against the relevant guidelines serves to provide an assessment of whether the existing water quality is compliant with the identified limits, and also supports the impact assessment as these stream/drains within the Study Area flow into areas with ecological conservation value and public watercourses. If there are no guidelines defined for any of the tested water quality parameters, the baseline survey results will be considered as the minimum criteria to be met during construction and operational phases. It should be noted that the water quality of any water generated from the Project's activities during both construction and operational phases should be treated to comply with the NEA allowable limits for discharge into a controlled watercourse prior to discharge.

Generally, two (2) dry weather (normal conditions) and one (1) wet weather (after a storm event) samples were collected from each water quality station along perennial watercourses (WQ8, WQ9, WQ22, WQ36). Some of the earth/concrete drains (i.e. D/S3, D/S4, D/S5, upstream of D/S15) in the Study Area were only sampled during storm events, as they were mostly dry or had no flow during dry weather conditions. Hence, only wet weather samples were collected at these ephemeral stream/drains, which include WQ3, WQ4, WQ5, and WQ21. Dry weather conditions are defined as 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. A total of sixteen (16) samples were collected from eight (8) water quality sampling stations for this Study as shown in Table 8-7

Table 8-7 Water Quality Monitoring Schedule

Sampling Event / Sampling Location	Dry Weather							Wet Weather		
	5 February 2020	17 March 2020	16 November 2021	26 November 2021	6 May 2022	16 June 2022	13 August 2020	3 September 2020	30 December 2021	11 April 2022
Turf City (CR14)										
WQ8 (D/S8)	Sampled	Sampled	-	-	-	-	-	Sampled	-	-
WQ9 (D/S8)	Sampled	Sampled	-	-	-	-	-	Sampled	-	-
WQ21 (D/S15)	-	-	-	-	-	-	-	-	Sampled	-
WQ22 (D/S16)	-	-	Sampled	Sampled	-	-	-	-	Sampled	-
Holland Plain (CR15)										
WQ3 (D/S3)	-	-	-	-	-	-	Sampled	-	-	-
WQ4 (D/S4)	-	-	-	-	-	-	Sampled	-	-	-
WQ5 (D/S5)	-	-	-	-	-	-	Sampled	-	-	-
WQ36 (Freshwater Marsh)	-	-	-	-	Sampled	Sampled	-	-	-	Sampled

Table 8-8 Surface Water Quality Results

Parameter		WQ21 (D/S15)	WQ22 (D/S16)	WQ8 (D/S8)	WQ9 (D/S8)	WQ3 (D/S3)	WQ5 (D/S5)	WQ4 (D/S4)	WQ36 (Freshwater Marsh)	Average	NEA Trade Effluent Discharge Limits[1]	Criteria for Aquatic Life[2]
Site		Site I and II		Site III		Site IV		Site V				
Waterbody Type		Ephemeral, concrete	Perennial, naturalised	Perennial, Man-made earth	Perennial, Man-made earth	Ephemeral, earth	Ephemeral, concrete	Ephemeral, concrete	Perennial, naturalised			
Temperature (˚C)	Dry Average	-	27.00	27.64	26.72	-	-	-	26.28	26.91	45	-
	Wet	26.56	26.78	27.94	27.28	26.22	27.50	26.17	24.83	26.66		
pH	Dry Average	-	8.17	6.52	6.43	-	-	-	6.21	6.83	6 – 9	6.5 – 9
	Wet	8.73	8.70	6.71	6.75	5.99	7.22	7.12	6.60	7.23		
Conductivity (μS/cm)	Dry Average	-	260.13	120.39	119.55	-	-	-	67.00	141.77	-	-
	Wet	64.60	131.20	298.48	282.42	532.54	293.60	334.56	48.30	248.21		
Dissolved Oxygen, DO (mg/L)	Dry Average	-	3.69	5.69	5.23	-	-	-	0.52	3.78	-	> 4.0
	Wet	7.89	6.59	6.40	7.49	1.92	7.75	7.73	5.19	6.37		
Total Dissolved Solids, TDS (mg/L)	Dry Average	-	163.00	74.50	75.00	-	-	-	43.00	88.88	1000	1000
	Wet	41.00	82.00	184.00	176.00	338.00	182.00	213.00	31.00	155.88		
Turbidity (NTU)	Dry Average	-	49.4	17.8	10.5	-	-	-	15.95	23.4	-	50
	Wet	148.3	98.2	24	14	17	7	10	12	41.3		
Total Suspended Solids, TSS (mg/L)	Dry Average	-	4.05	10.00	4.84	-	-	-	49.65	17.14	30	50
	Wet	70.50	28.00	11.40	12.00	16.00	2.20	5.20	5.60	18.86		
Biochemical Oxygen Demand, BOD_5 (mg/L)	Dry Average	-	< 1	2.71	< 1	-	-	-	< 1	2.71	20	3
	Wet	2.84	3.96	2.07	2.68	4.78	<1	2.12	<1	3.08		
Chemical Oxygen Demand, COD (mg/L)	Dry Average	-	8.00	Not Tested	Not Tested	-	-	-	29.00	18.50	60	25
	Wet	37.00	32.00	Not Tested	Not Tested	14.00	13.00	22.00	41.00	26.50		
Total Nitrogen, TN (mg/L)	Dry Average	-	1.93	Not Tested	Not Tested	-	-	-	0.56	1.25	-	Eutrophic Limit: 1.5mg/L
	Wet	1.90	1.00	Not Tested	Not Tested	2.36	1.16	1.19	0.54	1.36		
Total Phosphorous, TP (mg/L)	Dry Average	-	0.049	Not Tested	Not Tested	-	-	-	0.025	0.037	-	Eutrophic Limit: 0.075mg/L
	Wet	0.031	0.039	Not Tested	Not Tested	0.052	0.076	0.130	0.027	0.059		
Nitrate as NO_3-N (mg/L)	Dry Average	-	0.275	Not Tested	Not Tested	-	-	-	< 0.005	0.275	4.52 (Equivalent to 20 as NO_3)	10 (Equivalent to 44 as NO_3)
	Wet	1.410	0.580	Not Tested	Not Tested	1.540	0.900	0.510	0.120	0.843		

Parameter		WQ21 (D/S15)	WQ22 (D/S16)	WQ8 (D/S8)	WQ9 (D/S8)	WQ3 (D/S3)	WQ5 (D/S5)	WQ4 (D/S4)	WQ36 (Freshwater Marsh)	Average	NEA Trade Effluent Discharge Limits[1]	Criteria for Aquatic Life[2]
Site		Site I and II		Site III		Site IV		Site V				
Waterbody Type		Ephemeral, concrete	Perennial, naturalised	Perennial, Man-made earth	Perennial, Man-made earth	Ephemeral, earth	Ephemeral, concrete	Ephemeral, concrete	Perennial, naturalised			
Orthophosphate as PO_4-P (mg/L)	Dry Average	-	0.035	Not Tested	Not Tested	-	-	-	0.017	0.026	0.65 (Equivalent to 2 as PO_4)	0.033 (Equivalent to < 0.1 as PO_4)
	Wet	0.028	0.036	Not Tested	Not Tested	0.034	0.038	0.051	0.017	0.034		

Note:

a. NEA Trade Effluent Discharge Limits are for controlled watercourses.
b. The sources of water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-20], United States Environmental Protection Agency [R-21], Australian & New Zealand [R-28], Canada [R-29], Philippines [R-18], and Malaysia [R-30].
c. Red values mean data exceeding the NEA limits; Blue values mean data exceeding the aquatic life criteria; Purple values mean data exceeding both NEA limits and aquatic life criteria.
d. "-" indicates samples were only collected for wet weather conditions, thus dry weather data were not available.
e. < 1 means lower than 1 mg/L of level of detection limit, etc.
f. Not Tested means that LTA's EIS baseline data did not test for the specific water quality parameter.

Table 8-9 Water Quality Photos at Each Sampling Station

Water Sampling Station	During Dry weather	During Wet weather
Turf City (CR14)		
WQ8		
WQ9		
WQ15		
WQ16		
Holland Plain (CR15)		

Water Sampling Station	During Dry weather	During Wet weather
WQ3		
WQ4		
WQ5		
WQ36		

As described in Section 8.5.1.1, some drains/streams in the Study Area had ephemeral flow and thus, are unlikely to support aquatic life. Hence, water quality data of these ephemeral watercourses were compared to NEA allowable limits for trade effluent discharge regulations into controlled watercourses. Apart from the abovementioned NEA criteria, for natural/ naturalised watercourses supporting ecosystems, their baseline water quality results were compared to international water quality standards that were defined for conditions that support aquatic life, in order to evaluate their competency in supporting aquatic life. The water quality of the identified watercourses in the Study Area is described as below.

8.5.1.2.1 *Turf City: Sites I, II and III*

At Site I and II, two (2) water quality stations were sampled at the ephemeral concrete drain (i.e. D/S15) and perennial stream (i.e. D/S16).

During wet weather, drain D/S15 had TSS levels of 70.5 mg/L that exceeded the NEA guidelines (i.e. 30 mg/L). This observed high TSS level was likely due to the runoff originating from soil, vegetated and urbanised areas which may have contributed the particles into the watercourse.

The perennial naturalised stream D/S16 (WQ22) in Site I was within the limits of the aquatic life criteria for most parameters during dry weather, with a slight exceedance in PO_4-P levels. It is noted that the water quality in this naturalised stream is greatly impacted after storm events. During wet weather, elevated BOD_5 and turbidity were observed in this watercourse (WQ22). The turbidity level in this naturalised stream (WQ22) was 98.2 NTU, exceeding the aquatic life criteria (i.e. 50 NTU). This may be due to the flushing of solids from urban areas and from surrounding vegetation. It may also be due to the turbulent effects of the increased flow in the drain, leading to the suspension of solids in the drain during wet weather sampling. These suspended solids may have likely contributed to the increased BOD_5 levels of 4.0 mg/L in the naturalised stream as well, which exceeded the aquatic life criteria of 3 mg/L. The *Enterococcus* counts and lead (Pb) concentration were measured for the concurrent study carried out by AECOM in the vicinity. It was found that there was a 300 times increase in *Enterococcus* counts from 295 CFU/100 ml to 89,000 CFU/100 ml during wet weather shows that the storm runoff flowing into the drain likely contained human or animal faecal matter, implying a possible contamination source from the adjacent/ upstream urban areas outside of Site I. Pb concentrations during dry and wet weather were lower than the NEA limits and aquatic life criteria (i.e. below the detection limit and 2.55 µg/L, respectively), and thus are within safe levels for aquatic life. This increase in concentrations could be due to the contamination of runoff from anthropogenic activities in the vicinity of Site I. Despite the relatively poor water quality during wet weather in this perennial stream D/S16, biodiversity survey findings indicated that there is aquatic life within this watercourse. Furthermore, there were sightings of freshwater fishes during the time of dry weather water quality survey as well. Like other natural streams, nutrient levels of PO_4-P were found to have exceeded the aquatic life criteria during dry and wet weather, suggesting possible unfavourable conditions for aquatic life. However, as mentioned above, aquatic life could have adapted to such elevated nutrient conditions.

At Site III, two (2) sampling stations were surveyed along upstream and downstream of the perennial earth drain D/S8 (WQ8, WQ9).

Relatively low pH value of 6.43 was recorded in the downstream (WQ9) of the perennial earth drain D/S8, which is below the range of aquatic life criteria (i.e. pH 6.5 – pH 9). This might be due to the presence of higher concentrations of humic acid from decomposing forest debris contributed by the surrounding vegetation during dry weather. Overall, the earth drain had water quality that is suitable to support aquatic life, which is aligned with the biodiversity survey findings which recorded the presence of aquatic life (refer to Section 7.4.1).

8.5.1.2.2 *Holland Plain: Sites IV and V*

At Site IV, a total of four (4) water quality sampling stations were sampled. These stations are located along one (1) ephemeral earth drain (D/S3), two (2) ephemeral concrete drain (D/S4, D/S5) and freshwater marsh.

The stormwater runoff during wet weather in ephemeral earth drain (D/S3) was found to have a low pH value of pH 5.99, which exceeds the NEA guidelines (i.e. pH 6 – pH 9). Given its natural earth bank conditions, the low pH may be due to the presence of higher concentrations of humic acid from decomposing forest debris that was flushed down from the surrounding vegetation by the runoff. All other water quality parameters were well within the NEA guidelines.

The water quality in both ephemeral concrete drains (D/S4, D/S5) were found to be well within the NEA guidelines for all water quality parameters.

The freshwater marsh had a low pH (i.e. pH 6.21), extremely low DO (i.e. 0.52 mg/L) and high COD (i.e. 29 mg/L) which all exceeded the aquatic life criteria (i.e. pH 6.5 – pH 9; 4 mg/L; 25 mg/L) and had TSS levels (i.e. 49.65 mg/L) that exceeded the NEA guidelines during dry weather conditions. COD similarly exceeded the aquatic life criteria during wet weather conditions (i.e. 41 mg/L). While the water quality results indicate an unfavourable condition for aquatic life in the freshwater marsh, the marsh area was found to support an ecosystem of conservation significant biodiversity, which include marsh-specific odonates and birds.

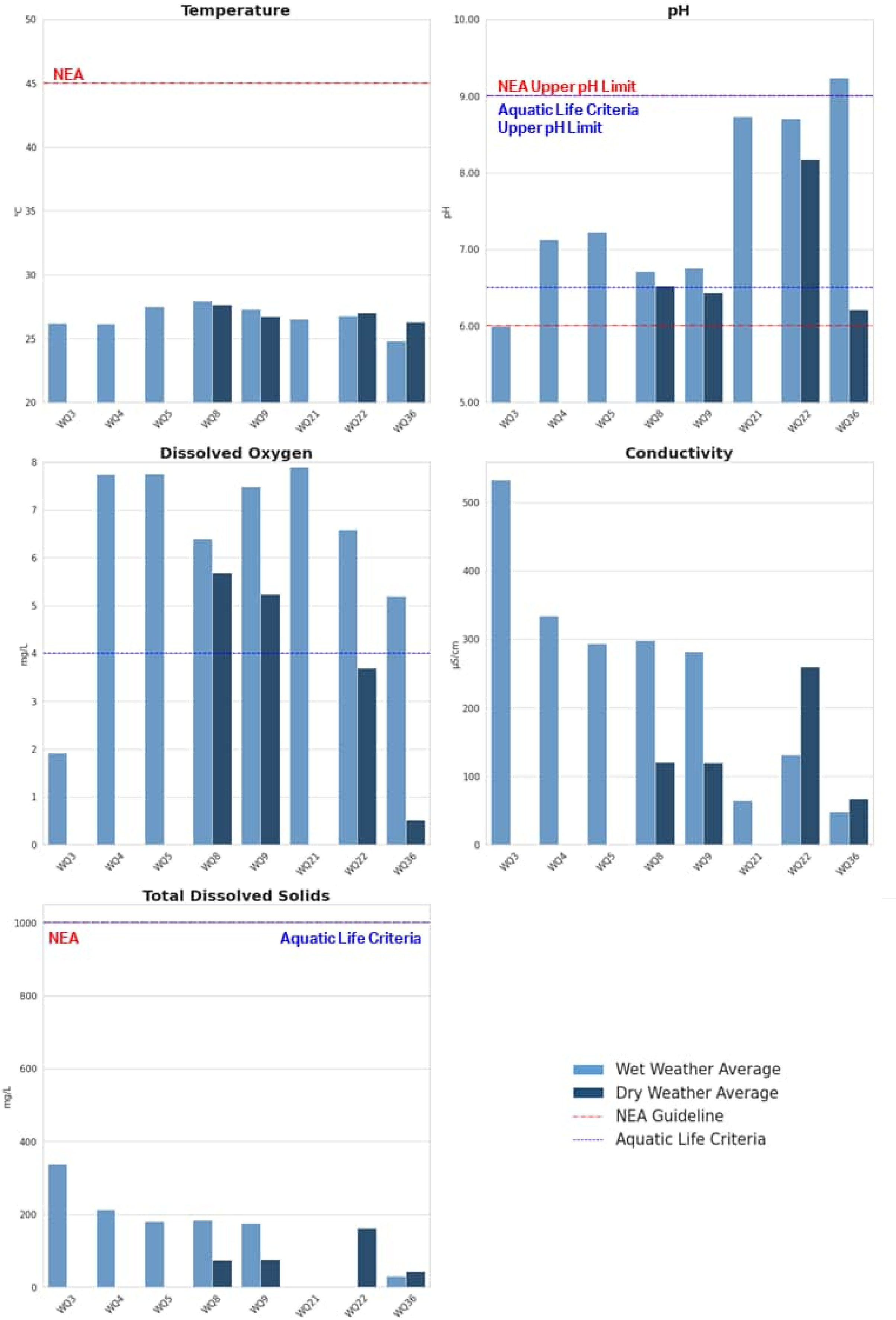


Figure 8-7 Average Monitoring Results of In-situ Parameters for Dry and Wet Weather Conditions

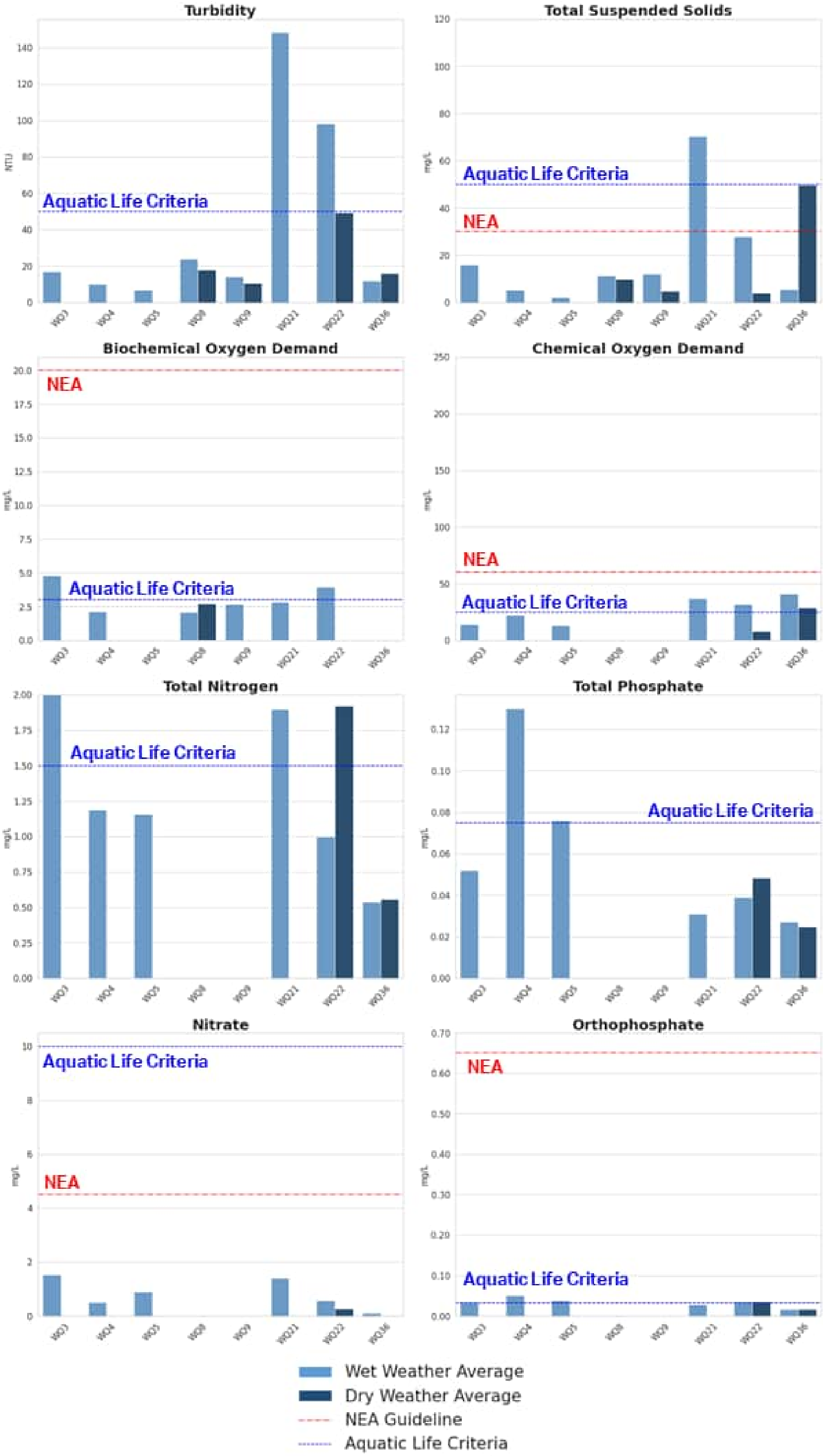


Figure 8-8 Average Monitoring Results of Ex-situ Parameters for Dry and Wet Weather Conditions

8.6 Minimum Control for Potential Impacts

This section proposes minimum controls, or standard practices, commonly implemented in Singapore for similar construction and operation 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 0 for construction phase.

Table 8-10 Minimum Controls during the Construction Phase Applicable to Hydrology and Water Quality Impact Assessment

Environmental Parameter	Activity	Minimum Control
Solid & Toxic Waste Generation	Site clearance, earthworks and general construction activities at launch/retrieval shafts, the open cut and the C&C works (e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, spoil handling and transport, building of permanent structures, utilities diversion including diversion of water pipes and stormwater drains along the Project, etc.)	Development of a Standard Operation Procedure (SOP) for safe handling, transfer, storage and disposal of solid waste; Effective ECM and monitoring implemented as required 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 Public Utilities Board of Singapore's (PUB) 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.); and Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector.
Liquid Effluent Generation and Stormwater Runoff	Construction wastewater resulting from site clearance, excavation, tunnelling etc.	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. Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purpose; ECM tanks/ponds will be designed in sufficient capacity to hold the turbid stormwater prior to treatment at the ECM facility;

Environmental Parameter	Activity	Minimum Control
		Temporary storage volumes should be provided for overflow situations. Temporary storage with sufficient capacity will capture any expected additional volumes to 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 both 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; The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited (e.g. natural stream within Site I); 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 (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 the 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 watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses; and A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management.
	Storage and disposal of domestic liquid wastes	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 watercourses; Inspections and audits to ascertain the hygienic conditions onsite; The toilet facilities will be placed at least 30 m away from any nearby watercourse;

Environmental Parameter	Activity	Minimum Control
		Training of workers on the best practices to contribute in environmental protection; and 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.
	Storage and disposal of construction solid wastes	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; Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into 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, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses (i.e. canals, drains, streams), etc. Implementation of CCTV including a SIDS at the public drain to monitor the surface runoff discharges from the sites as per the PUB circular on Preventing Muddy Waters from the Construction Sites (October 2015); Runoff within, upstream of, and adjacent to the worksite will be effectively drained away without causing flooding in the vicinity; 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 onsite; 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; and 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.
	Stormwater Runoff Generation	Stormwater 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 (i.e. canals, drains, 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 surface 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.; and 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. Hydrology: Runoff within, upstream of, and adjacent to the worksite will be effectively drained away without causing flooding in the vicinity;

Environmental Parameter	Activity	Minimum Control
		Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks/ponds within the Study Area. Detention tanks/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; and The design engineers for detailed design may need to ensure that Earth Retaining Stabilisation structures (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.
Improper Management of Chemical Substances	Use, storage and disposal of chemical substances Refuelling activities	Development of 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; and Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector.

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 Water Quality Impact Assessment

Environmental Parameter	Activity	Minimum Control
Stormwater Runoff	Stormwater Runoff Generation	Stormwater Quality: Adequate drainage, piping and/or channelling of stormwater runoff to be assured through detailed design [such as Active, Beautiful, Clean Water (ABC) Water Design approach] for capture and treatment 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.; and Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. Hydrology: Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention ponds/tanks within the Study Area. Detention ponds/tanks can capture

Environmental Parameter	Activity	Minimum Control
		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; Active, Beautiful, Clean Water (ABC) Water Design approach can be considered to reduce the peak-flow as well; and Geotechnical aspect of the site's slope stability (such as ERSS) will be included in detailed design engineering for the operational stage.

8.7 Prediction and Evaluation of Hydrology and Surface Water Quality Impacts

8.7.1 Construction Phase

As described in Sections 8.3 and 8.6, three (3) major sources of hydrology and surface water quality impacts were identified, including solid & toxic waste generation, liquid effluent and stormwater runoff, as well as management of chemical substances. Among them, the generation of liquid effluent and stormwater runoff may have impacts on both hydrology and surface water quality of the watercourses in the Study Area, while the other two sources tend to impact on surface water quality only. The following sections present the prediction and evaluation of hydrological and surface water quality impacts during the construction phase to the identified watercourses for assessment.

8.7.1.1 Solid & Toxic Waste Generation (Water Quality)

In the Turf City area, naturalised stream D/S16 within Site I is located near the proposed road works and the upstream of earth drain D/S8 in Site III would be occupied by the CR14 worksite footprint (base scenario) and proposed road works (Figure 8-3). The quantity of solid and toxic waste stored on-site (e.g. chemical waste, construction debris, etc.) is expected to be limited and would be periodically disposed of by licensed waste management contractors as stipulated in the minimum control measures, and hence limited quantities of solid and toxic waste would be discarded into these watercourses. Since naturalised stream D/S16 has relatively high ecological importance (refer to Section 7.5.1), any contamination by solid & toxic waste from the construction sites would have High impact intensity on this naturalised stream. On the other hand, since earth drain (D/S8) has a relatively low ecological significance, the impact intensity of water quality contamination from solid & toxic waste would be Medium. Given both watercourses are considered Priority 1 sensitive receptors, the impact consequence would also be High and Medium, respectively (based on the Impact Consequence Matrix in Table 6-6). The discharge of suspended solids into naturalised stream D/S16 and earth drain D/S8 would be limited, since the implementation of ECM tanks/ponds within the construction site will allow for the sedimentation and thus removal of these suspended particles. Water soluble parameters such as TDS, nutrients, heavy metals, etc. will be monitored and the treatment targeting these parameters will be put in place before the effluent is released into the watercourses. By providing that all minimum control measures detailed in Table 8-10 (such as the use of silt screens) and precautionary management controls are implemented on site (such as regular inspection, use of silt screen, housekeeping, and training of workers), it was assessed that the likelihood for the spills or contaminated runoff from the waste stored onsite would flow into earth drain D/S8 is Rare and into naturalised stream D/S16 is Regular. Therefore, the significance will be Major at naturalised stream D/S16 and Minor at earth drain D/S8 based on Table 6-8. The impact intensity of solid and toxic waste on drain D/S15 would be Medium and the consequence would be Medium as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Since the CR14 worksite footprint (base scenario) and proposed road works are located outside of the catchment area of concrete drain D/S15, with the implementation of effective ECM and monitoring as required in the Code of Practice on Surface Water Drainage, the impact likelihood on drain D/S15 would be Unlikely and the impact significance would be Negligible according to Table 6-8.

At Holland Plain, the CR15 worksite would encroach into the upstream sections of both earth drain D/S3 (in Site IV) and concrete drain D/S4 (in Site V), and thus solid and toxic waste generated at the construction site may easily enter both watercourses. Given that drains D/S3 and D/S4 are Priority 1 sensitive receptors and the impact intensity on water quality on these watercourses was Medium, the impact consequence was expected to be Medium (based on the Impact Consequence Matrix in Table 6-6). With the provision of all minimum control measures detailed in Table 8-10 and the implementation of precautionary management controls site, it was assessed that the contamination from solid & toxic waste would be Rare, and thus the impact significance would be Minor for drains D/S3 and D/S4. For concrete drain D/S5, the impact intensity of solid and toxic waste on drain D/S5 would be Medium and the consequence would be Medium as the watercourses are Priority 1 sensitive receptors as per Table 6-6. Once effective ECM and monitoring are implemented as required in the Code of Practice on Surface Water Drainage, the impact likelihood on drain D/S5 would be Rare since the drain is located away from the CR15 worksite. Thus, the impact significance would be Minor according to Table 6-8.

8.7.1.2 Liquid Effluent and Stormwater Run-off Generation (Hydrology and Water Quality)

8.7.1.2.1 *Hydrology*

Land use modification due to land clearing during the construction phase may affect existing hydrology condition of Study Area. Due to the land use changes with less vegetation and exposed earth, it may lead to increased surface runoff volume and water level in existing channel, and subsequent flooding of surrounding areas adjacent to the streams and drains. With minimum controls as mentioned in Table 8-10, adequate drainage, piping and/or channelling of stormwater runoff, as well as installation of temporary storage volumes can prevent overflow situations at site. Temporary storage with sufficient capacity will capture any additional volumes that may be expected due to proposed construction site. Flooding can be minimised at streams and drains if they will not be occupied as CCTV will be implemented at existing drain to monitor the surface runoff discharges from the sites.

At the Turf City area, the CR14 worksite is expected to span across the forested area of Site III and the road works will also encroach onto the forested area of Site I. As such, earth drain D/S8 would be significantly impacted since there will be a change in land use within the northern forested area of Site III, which is the main catchment area of D/S8 at its upstream (Figure 8-5). Hence, it is expected to have a Medium impact intensity on earth drain D/S8 with. As the naturalised stream D/S16 will be blocked by the proposed road works for CR14, its hydrological impact intensity is expected to be High due to its high ecological importance. As both watercourses D/S8 and D/S16 are Priority 1 sensitive receptors, the impact consequence on watercourses D/S8 and D/S16 would be High and Medium respectively, based on Table 6-6. As the peak flow at D/S8 could be changed Regularly due to storm events, the impact significance on it would be Moderate. The naturalised stream D/S16 will be blocked throughout the construction phase Continuously, its impact significance would be Major. Since CR14 worksite and proposed road works are outside of the catchment area of the concrete drain D/S15, the impact intensity to this watercourse is Negligible. Given that this drain D/S15 is a Priority 1 receptor, the impact consequence is expected to be Very Low. Given that there is limited change in land use, the likelihood of the occurrence of flooding is Unlikely. Hence, based on Table 6-8, the impact significance would be Negligible.

At Holland Plain, majority of the CR15 worksite would be constructed over forested areas of Site IV and Site V, which will cover almost the whole catchment area of all ponds in Site IV and marsh in Site V, while part of catchment area of roadside drains D/S3, D/S4 and D/S5. Hence, the hydrological impact will be Medium for ponds within Site IV and marsh in Site V, while Low for the roadside drains D/S3, D/S4 and D/S5. As ponds in Site IV and marsh in Site V are Priority 3 and Priority 1 receptors, respectively, the impact consequence on both would be Very Low and Medium, respectively. With the minimum controls as mentioned above in place, the flooding within the worksite areas (i.e. where the ponds and marsh are fully occupied) is Rare and final impact significance are negligible and Minor for ponds and marsh, respectively. As all the roadside drains are Priority 1 receptors, the impact consequence is also Low. With the minimum controls as mentioned above in place, the flooding potential will be Rare and final impact significance will be Minor for roadside drains D/S3, D/S4 and D/S5.

8.7.1.2.2 *Water Quality*

Liquid effluents generated from the construction activities commonly include extracted groundwater, sanitary discharges, and stormwater run-off from exposed and unstable slopes. For sanitary discharges, portable toilets will be installed as part of the minimum control provided by the project and sanitary effluents from portable toilets will be collected every week by the appointed contractor for disposal. Management controls are also expected to be implemented, such as regular inspection and housekeeping. To avoid additional stormwater run-off flowing from site's unstable slope to adjacent forested slopes during the construction phase, it is also recommended that geotechnical aspect of slope stability should be well-planned before the construction.

At Turf City, naturalised stream D/S16 in Site I is within the road works footprint, while earth drain D/S8 is within both the CR14 worksite and road works footprint (Figure 8-3). With proper application of the minimum controls described in Table 8-10, such as the implementation of containment pond/kerbs to hold the wastewater generated from construction activities, impacts to the surface water quality from the construction site surface runoff can be reduced. For the extracted groundwater as part of tunnelling wastewater, contractor will need to seek approval from both relevant authorities (i.e. PUB & NEA) if the wastewater were to be disposed to public sewer as per the Sewerage and Drainage (Trade Effluent) Regulations, or if the treated trade effluent will be disposed to surface watercourses as per the Trade Effluent Discharge Limits to Controlled Watercourse. If extracted groundwater is approved to be discharged into surface watercourses, in the event that exceedance of the Trade Effluent Discharge Limits to Controlled Watercourse was detected during monthly monitoring, NEA and PUB should be immediately notified. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. The turbid stormwater runoff generated from construction site will be channelled to ECM tanks/ponds. Such treated stormwater runoff from CR14 worksite could be discharged into earth drain D/S8. Given the high ecological significance of natural stream D/S16 and the relatively lower ecological significance of earth drain D/S8, any spill or leakage of untreated liquid effluent and stormwater generated from construction site with contaminants could have High and Medium impact intensity on the naturalised stream D/S16 and earth drain D/S8 respectively. Given that both watercourses are Priority 1 receptors, the impact consequence is expected to be High for naturalised stream D/S16 and Medium for the earth drain D/S8. With all minimum control measures detailed in Table 8-10 in place, precautionary management controls implemented on site and additional measures (such as routine monitoring, maintenance of ECM treatment plant, and installation of silt curtains, etc),), it was assessed that the likelihood for liquid effluent and/or stormwater runoff flowing into earth drain D/S8 is Rare and into naturalised stream D/S16 is Regular. Thus, the overall impact significance on naturalised stream D/S16 and earth drain D/S8 is Major and Minor, respectively. The impact intensity of liquid effluent and stormwater contamination on the drain would be Medium and the consequence would be Medium as the drain is a Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6Since the CR14 worksite footprint (base scenario) and proposed road works are located outside of the catchment area of concrete drain D/S15, the likelihood of liquid effluent contamination on this drain D/S15 would be Unlikely, the impact significance would be Negligible according to Table 6-8.

At Holland Plain, the CR15 worksite would occupy the area surrounding the upstream of concrete drains D/S3 and D/S4 and will also encroach on these drains as well. The spills and leakages of untreated liquid effluent and contaminated stormwater from the construction sites could have Medium impact intensity on these drains. Given that these watercourses are Priority 1 receptors, the impact consequence would be Medium. With the implementation of minimum controls, it is expected that the likelihood of occurrence of contamination by liquid effluent and stormwater runoff would be Rare, and hence would have a Minor impact significance to drains D/S3 and D/S4. Furthermore, the impact intensity of liquid effluent and stormwater runoff from the construction sites on concrete drain D/S5 would be Medium and the consequence would be Medium. Since concrete drain D/S5 is located further away from the CR15 worksite, the likelihood of liquid effluent contaminating the water quality in drain D/S5 would be Rare, the impact significance would be Minor according to Table 6-8.

8.7.1.3 Improper Management of Chemical Substances (Water Quality)

Chemical substances will be stored on concrete surfaces with containment bunds or on spill control palettes. Moreover, SOP is expected to be developed to ensure the proper handling, transfer and storage of these substances, which will also contribute to reduce the frequency and impact of chemical spillage.

In Turf City area, naturalised stream D/S16 in Site I is within the road works footprint, while earth drain D/S8 is within both the CR14 worksite and road works footprint (Figure 8-3). The minimum control measures described in Table 8-10 will be implemented, such as periodically conducting lead detection tests. As such, considering the naturalised stream D/S16 has high ecological value based on biodiversity findings (refer to Section 7.5.1), any spill and leakage of chemical substances generated from CR14 construction site would have a High impact intensity on the naturalised stream D/S16. Given that this stream is a Priority 1 receptor, it would have a High impact consequence, based on the Impact Consequence Matrix as in Table 6-6. For earth drain D/S8, the impact intensity would be Medium and consequence would also be Medium, as it is a Priority 1 sensitive receptor, according to Table 6-6. Since all minimum control measures detailed in Table 8-10 are in place, the likelihood of occurrence of a spill being washed off as runoff into naturalised stream D/S16 would be Regular and D/S8 would be Rare. Thus, the impact significance would be Major for naturalised stream D/S16 and Minor for earth drain D/S8 (based on Table 6-8). As for drain D/S15, the impact intensity on it would be Medium and the consequence would be Medium, since drain D/S15 is a Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Since the CR14 worksite footprint (base scenario) and proposed road works are located outside of the catchment area of concrete drain D/S15, the likelihood of water quality contamination due to improper chemical substances management would be Unlikely impact likelihood, the impact significance would be Negligible according to Table 6-8.

At Holland Plain, the CR15 worksite would encroach on the upstream of concrete drains D/S3 and D/S4. Hence, any spillage and/or leakage of chemicals and fuel form construction activities can have a Medium impact intensity on these drains. Given that these watercourses are Priority 1 receptors, the impact consequence would be Medium. With the implementation of minimum controls, it is expected that the likelihood of occurrence of contamination by such spillage and leakages of chemicals would be Rare, and hence would have a Minor impact significance to drains D/S3 and D/S4. Furthermore, the impact intensity of chemical spills and leakages from the construction sites on concrete drain D/S5 would be Medium as well, and the consequence would be Medium as the drain is a Priority 1 sensitive receptors. Since concrete drain D/S5 is located further away from the CR15 worksite, the likelihood of liquid effluent contamination on drain D/S5 is Rare, and thus the impact significance would be Minor according to Table 6-8.

Table 8-12 Summary of Impact Evaluation during Construction Phase

Potential Source of Impact	Receptor Sensitivity[8]	Ecologically Sensitive Site	Impact Intensity	Consequence	Likelihood	Significance
Solid & Toxic Waste Generation (Water Quality)	Priority 1 (D/S15)	Site I and II	Medium	Medium	Unlikely	Negligible
	Priority 1 (D/S16)		High	High	Regular	Major
	Priority 1 (D/S8)	Site III	Medium	Medium	Rare	Minor
	Priority 1 (D/S3)	Site IV	Medium	Medium	Rare	Minor
	Priority 1 (D/S5)		Medium	Medium	Rare	Minor
	Priority 1 (D/S4)	Site V	Medium	Medium	Rare	Minor
Liquid Effluent Generation and Stormwater Run-off (Hydrology)	Priority 1 (D/S15)	Site I and II	Negligible	Very Low	Unlikely	Negligible
	Priority 1 (D/S16)		High	High	Continuous	Major
	Priority 1 (D/S8)	Site III	Medium	Medium	Regular	Moderate
	Priority 1 (D/S3)	Site IV	Low	Low	Rare	Minor
	Priority 1 (D/S5)		Low	Low	Rare	Minor
	Priority 3 (Waterbody at Site IV)		Medium	Very Low	Rare	Negligible
	Priority 1 (D/S4)	Site V	Low	Low	Rare	Minor
	Priority 1 (Freshwater Marsh)		Medium	Medium	Rare	Minor
Liquid Effluent Generation and Stormwater Run-off (Water Quality)	Priority 1 (D/S15)	Site I and II	Medium	Medium	Unlikely	Negligible
	Priority 1 (D/S16)		High	High	Regular	Major
	Priority 1 (D/S8)	Site III	Medium	Medium	Rare	Minor
	Priority 1 (D/S3)	Site IV	Medium	Medium	Rare	Minor
	Priority 1 (D/S5)		Medium	Medium	Rare	Minor
	Priority 1 (D/S4)	Site V	Medium	Medium	Rare	Minor
Improper Management of Chemical Substances (Water Quality)	Priority 1 (D/S15)	Site I and II	Medium	Medium	Unlikely	Negligible
	Priority 1 (D/S16)		High	High	Regular	Major
	Priority 1 (D/S8)	Site III	Medium	Medium	Rare	Minor
	Priority 1 (D/S3)	Site IV	Medium	Medium	Rare	Minor

[8] Receptor locations are shown in Figure 8-2.

Potential Source of Impact	Receptor Sensitivity[8]	Ecologically Sensitive Site	Impact Intensity	Consequence	Likelihood	Significance
	Priority 1 (D/S5)	Site V	Medium	Medium	Rare	Minor
	Priority 1 (D/S4)		Medium	Medium	Rare	Minor

8.7.2 Operational Phase

As described in Section 3.1.2, some parts of the CR14 and CR15 worksites will eventually be replaced with the aboveground station structures, such as vent shafts and station entrances. Permanent roads for CR15 that were constructed will serve as access roads CR15 stations during operational phase; a future road under study has the potential to be used for access for CR14 during operation. The alignments of the road under study has been assumed to be along the tentative alignment of the construction access roads for the purpose of this study.

8.7.2.1 Stormwater Run-off Generation (Hydrology and Water Quality)

8.7.2.1.1 *Hydrology*

The increase in stormwater runoff peak flow and soil erosion may occur due to land use change of Study Area during operation stage. Due to the land use changes (i.e. reduced vegetation surface cover and reduced pervious area), it may lead to increased surface runoff volume and there an increased water level in existing channels, which can result in subsequent flooding of surrounding areas adjacent to the streams and drains.

At Turf City, the proposed CR14 station will mainly change the majority catchment area of earth drain D/S8, while the future road under study will permanently block the naturalised stream D/S16. The proposed CR14 will have Medium and High impact intensity on D/S8 and D/S16, respectively. As both D/S8 and D/S16 are Priority 1 sensitive receptors, the impact consequences on both receptors are Medium and High, respectively. As the minimum controls, adequate drainage, piping and/or channelling of stormwater runoff will be designed per PUB's Code of Practice on Surface Water Drainage. As the peak flow at D/S8 could be changed Regularly due to storm events, the impact significance on it would be Moderate. The naturalised stream D/S16 will be blocked throughout the operational phase Continuously, its impact significance would be Major. Since CR14 station and proposed road are outside of the catchment area of the concrete drain D/S15, the impact intensity to this watercourse is Negligible. Given that this drain D/S15 is a Priority 1 receptor, the impact consequence is expected to be Very Low. Given that there is limited change in land use, the likelihood of the occurrence of flooding is Unlikely. Hence, based on Table 6-8, the impact significance would be Negligible.

In Holland Plain, majority of the CR15 station would be constructed over forested areas of Site IV and Site V, which will cover only small part of catchment area of roadside drains D/S3, D/S4 and D/S5 based on site observation. Hence, the hydrological impact will be Low for the roadside drains D/S3, D/S4 and D/S5. As all the roadside drains are Priority 1 receptors, the impact consequence is also Low. With the minimum controls (e.g. adequate drainage, piping and/or channelling of stormwater runoff will be designed per PUB's Code of Practice on Surface Water Drainage), the flooding potential will be rare and final impact significance will be Minor for roadside drains D/S3, D/S4 and D/S5. Given that the ponds in Site IV and Freshwater Marsh are completed backfilled during the construction phase, these waterbodies were not considered as sensitive receptors for the impact assessment during operational phase.

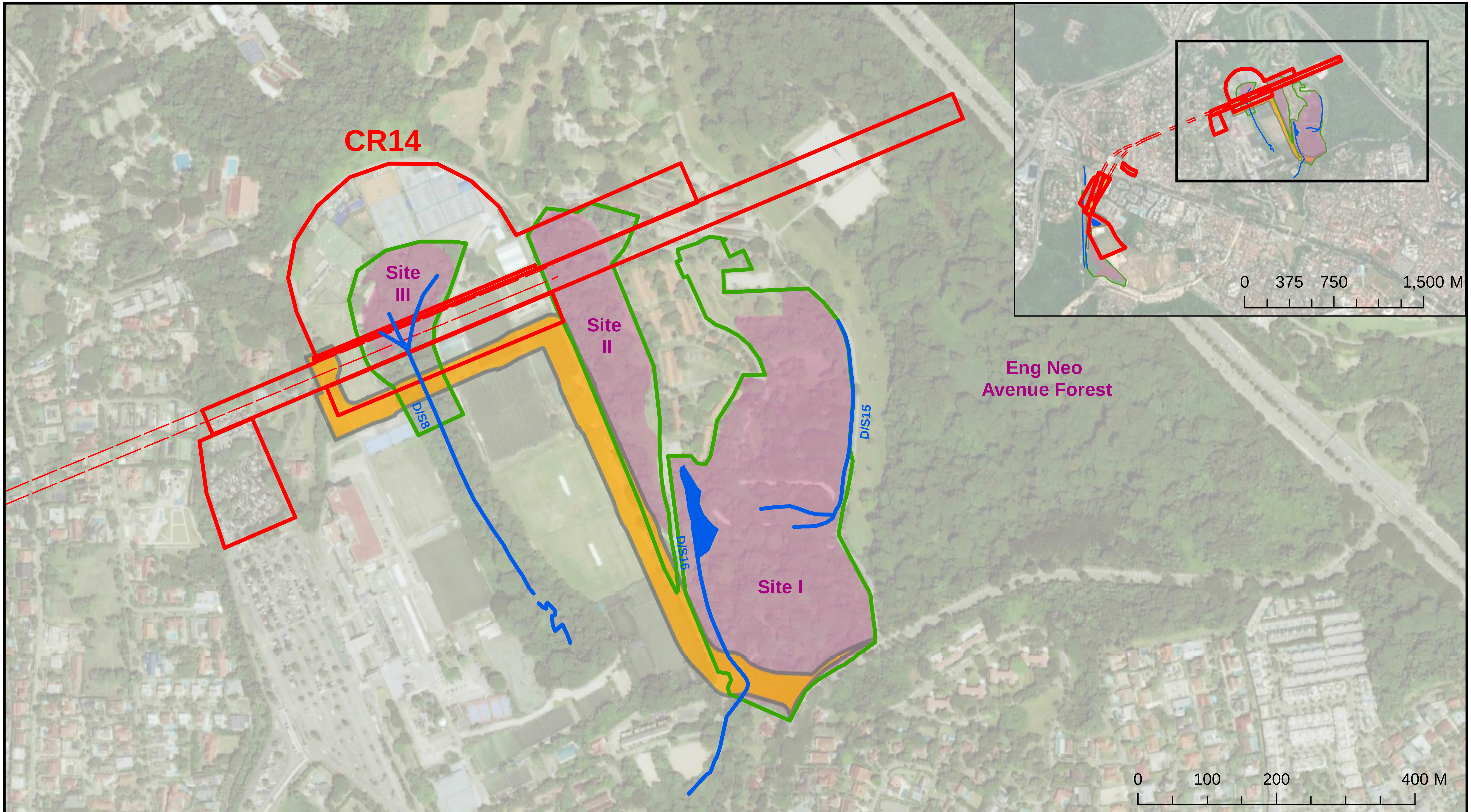
8.7.2.1.2 *Water Quality*

Stormwater runoff generated from the development site typically has good water quality with negligible contaminants. With proper application of the minimum controls described in Table 8-11, (e.g. ABC water design approach for capture and treatment before discharge into surface water and regular dedicated procedures for the inspection and maintenance of stormwater systems, etc.), the impact intensity of potential contamination from stormwater runoff would be Negligible for freshwater receptors. As all the freshwater receptors are Priority 1, the impact consequence of the watercourses due to the potential contamination was classified as Very Low based on Table 6-6. Although the likelihood of normal storm event was expected to occur Occasionally for concrete drain D/S4, earth drain D/S8, naturalised stream D/S16, the overall significance of stormwater runoff impact to water quality was assessed to be Minor impact based on Table 6-8. With a Rare impact likelihood of water quality contamination in earth drain D/S3 and concrete drains D/S5, D/S15 during operational phase, the impact significance would be Negligible according to Table 6-8. Given that the waterbody in Site IV and Freshwater Marsh are completed backfilled during the construction phase, these two waterbodies are not considered as sensitive receptors for the impact assessment during operational phase.

Table 8-13 Summary of Impact Evaluation during Operational Phase

Potential Source of Impact	Receptor Sensitivity[9]	Ecologically Sensitive Site	Impact Intensity	Consequence	Likelihood	Significance
Stormwater Run-off (Hydrology)	Priority 1 (D/S15)	Site I and II	Negligible	Very Low	Unlikely	Negligible
	Priority 1 (D/S16)		High	High	Continuous	Major
	Priority 1 (D/S8)	Site III	Medium	Medium	Regular	Moderate
	Priority 1 (D/S3)	Site IV	Low	Low	Rare	Minor
	Priority 1 (D/S5)		Low	Low	Rare	Minor
	Priority 1 (D/S4)	Site V	Low	Low	Rare	Minor
Stormwater Run-off (Water Quality)	Priority 1 (D/S15)	Site I and II	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S16)		Negligible	Very Low	Occasional	Minor
	Priority 1 (D/S8)	Site III	Negligible	Very Low	Occasional	Minor
	Priority 1 (D/S3)	Site IV	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S5)		Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S4)	Site V	Negligible	Very Low	Occasional	Minor

9 Receptor locations are shown in **Figure 8-2**.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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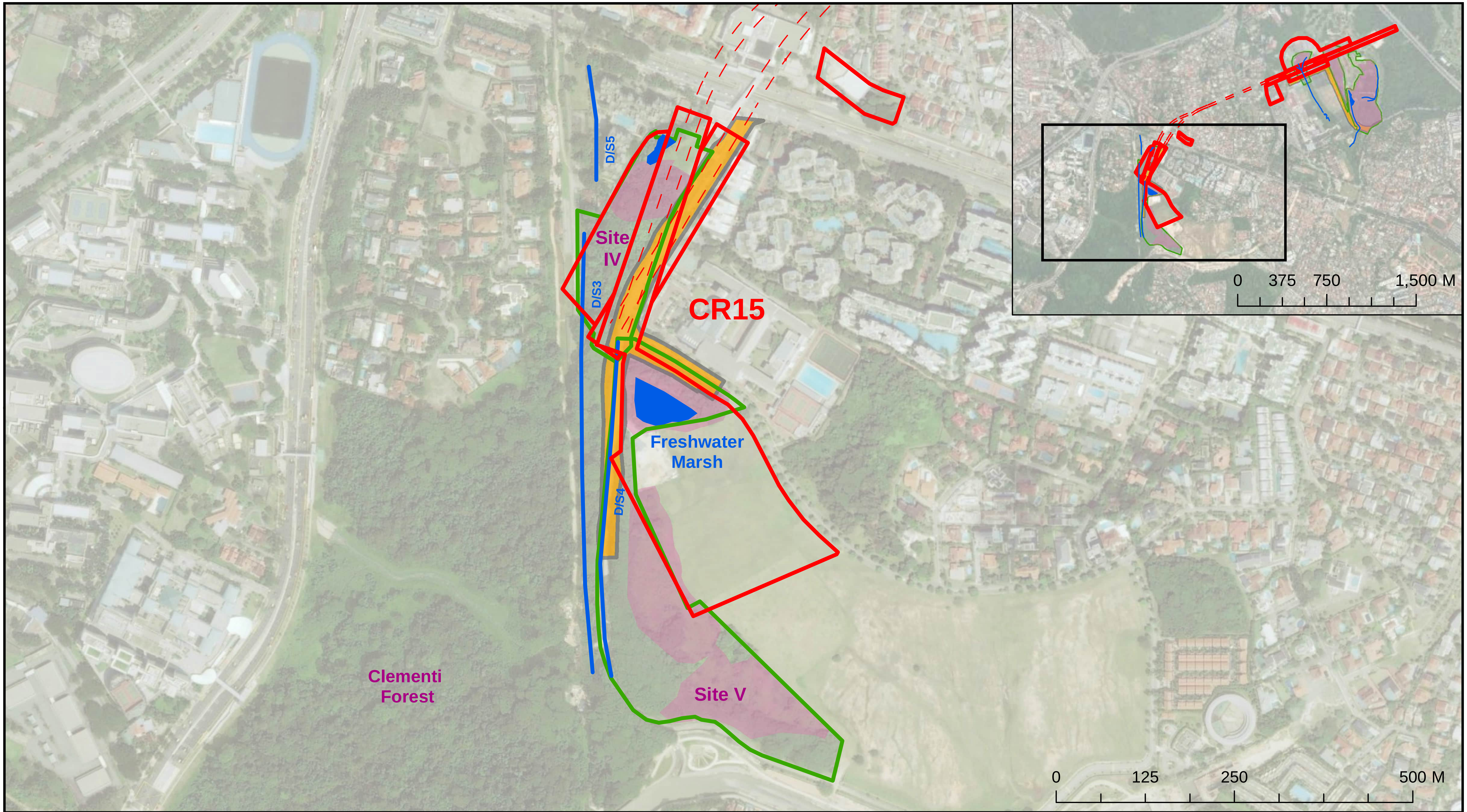
Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :
SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF CR14 DURING CONSTRUCTION PHASE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 9	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

Rev.	Date	By	Description	Chk'd	App'd
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ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :

SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF CR15 DURING CONSTRUCTION PHASE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 10	-	1 of 1

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	CQA	AUG 2022	NA	A3

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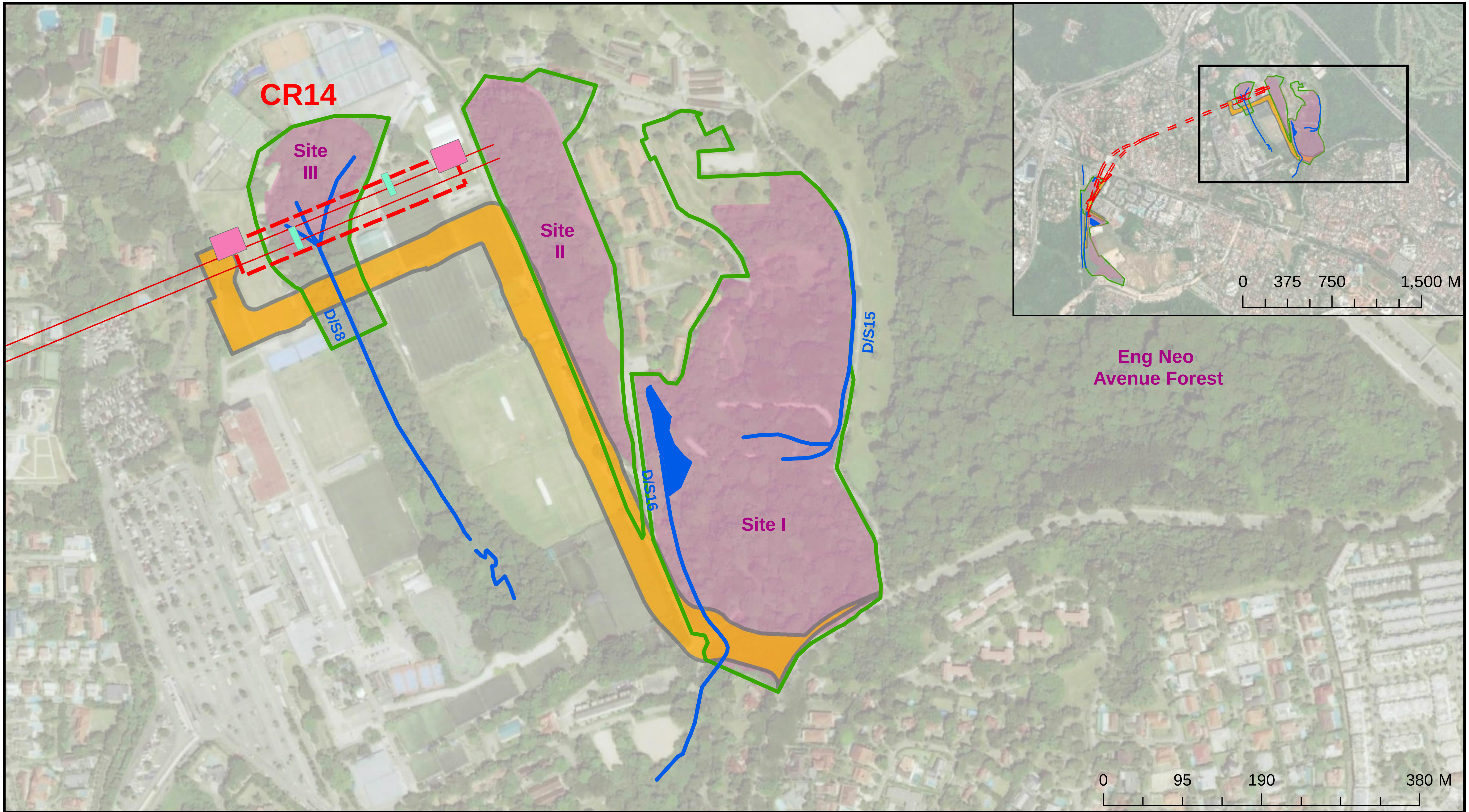

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- CR14 Underground Structures (Base Scenario)
- CR14 Vent Shafts (Base Scenario)
- CR14 Entrances (Base Scenario)
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

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Qualified Person Endorsement : NA

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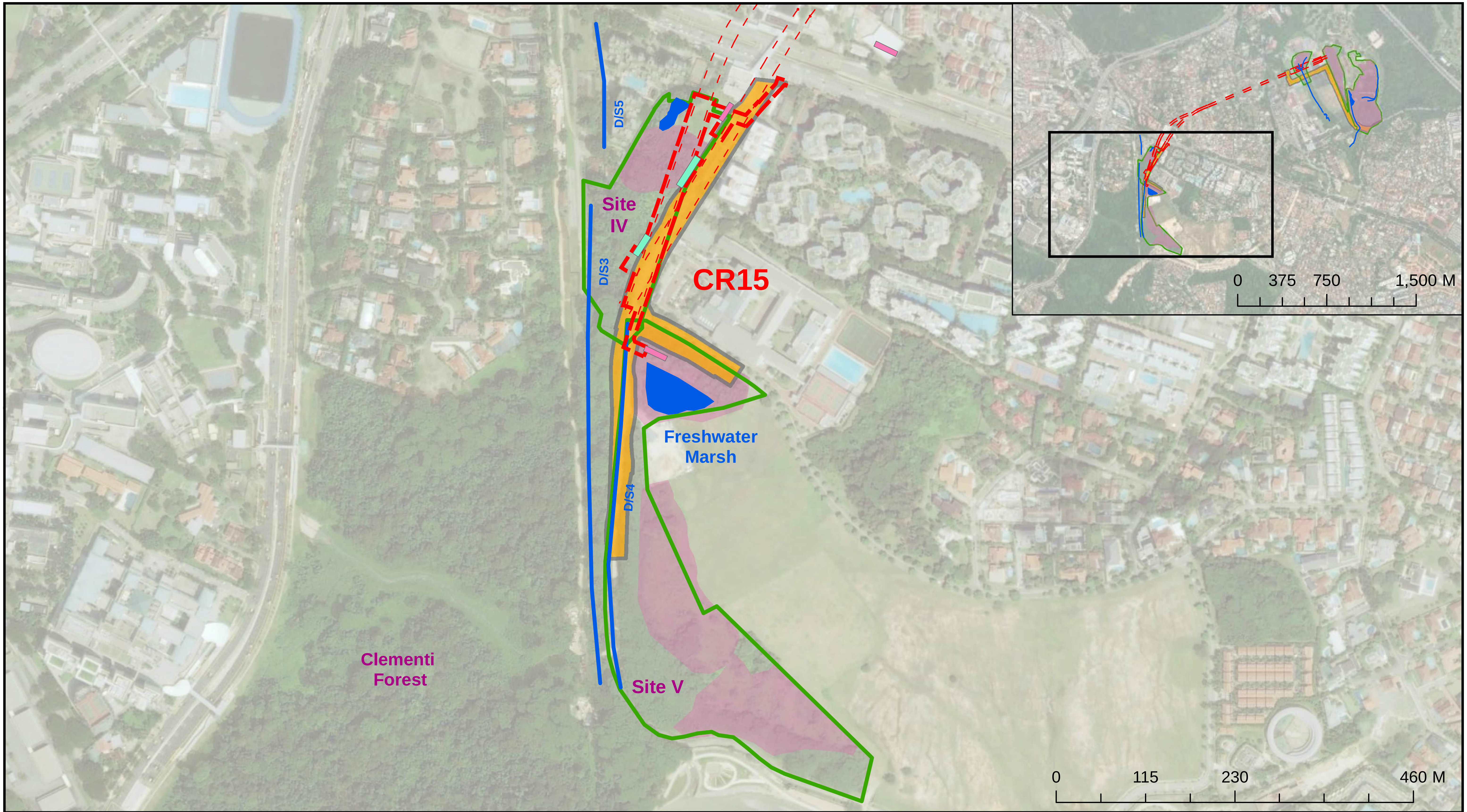
Figure Title :

SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF CR14 DURING OPERATIONAL PHASE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 11	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- CR15 Underground Structures (Base Scenario)
- CR15 Vent Shafts (Base Scenario)
- CR15 Entrances (Base Scenario)
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

Rev.	Date	By	Description	Chk'd	App'd
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Qualified Person Endorsement : NA

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF CR15 DURING OPERATIONAL PHASE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 12	-	1 of 1

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8.8 Recommended Mitigation Measures

In this section, mitigation measures are proposed to further minimise the adverse impacts on the environment as there is an impact significance on sensitive receptors were assessed to be Moderate or Major.

8.8.1 Construction Phase

As shown in Table 8-12, even with minimum controls implemented, the proposed construction activities were assessed to have Major impacts on the hydrology and water quality of naturalised stream D/S16 and Moderate impacts on the hydrology of earth drain D/S8. In addition, the biodiversity findings from Section 7.8 shows that the CR14 and CR15 worksites could pose Major impact on the biodiversity of Turf City, Eng Neo Avenue Forest and Holland Plain, which have high ecological importance. Hence, it was recommended to optimise the CR14 and CR15 worksites to preserve the identified areas of high conservation value as much as possible. In order to achieve this, LTA optimised the CR14 worksite such that the worksite would avoid the Biodiversity Study Areas and areas of high conservation value as much as possible, and is now mostly within existing urbanised areas.

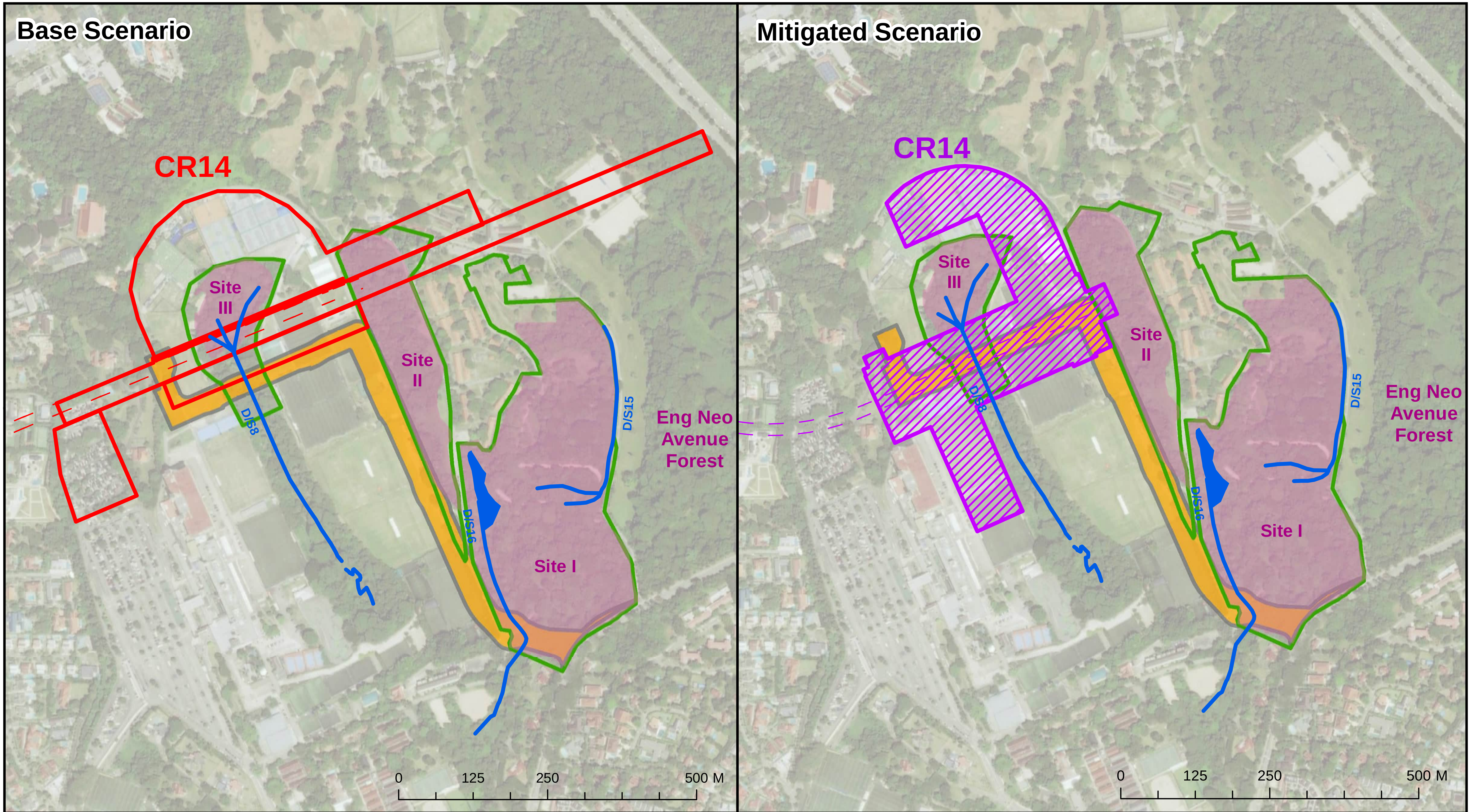
The impact significance on hydrological and water quality impacts on concrete drain at the upstream of D/S15 were assessed to be Minor with minimum controls. Hence, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction plans are required.

At Holland Plain, LTA optimised CR15 construction worksite to reduce the overall size of the construction footprint, allowing for additional patches of forested area with high conservation value to be retained. The mitigated CR15 worksite footprint during construction phase is shown in Figure 8-14. There are no changes in impacts to the watercourses and waterbodies within Holland Plain (i.e. concrete drain D/S4, D/S5, earth drain D/S3, ponds at Site IV and Freshwater Marsh).

8.8.1.1 Minimisation

The mitigated CR14 worksite (Figure 8-13) was found to result in a complete blockage of flow from upstream and downstream of earth drain D/S8. Hence, flow diversion or the construction of a culvert (subject to Contractor's design at a later stage) is recommended as an additional mitigation measure to connect the upstream and downstream of earth drain D/S8. The flow diversion should obtain PUB's approval and follow PUB's Code of Practice on Surface Water Drainage [R-23] to ensure the proposed diversion cater for sufficient flow capacity during construction phase. It is also recommended to discharge treated runoff in to earth drain D/S8, which has been treated to meet NEA Trade Effluent Discharge Limits) to maintain its existing flow. However, when constructing the diverted drain, it would be difficult to completely avoid the contamination of water quality at the immediate adjacent sections of the earth drain D/S8. Thus, the water quality impact of earth drain D/S8 by the mitigated CR14 worksite footprint would be Moderate.

The planned road works should not obstruct the flow of naturalised stream D/S16, so as to ensure the perennial flow is maintained. If diversion is required, it is recommended that the diversion of affected sections of the watercourses will be carried prior to the start of construction. The diversion should follow PUB's Code of Practice on Surface Water Drainage. However, similarly, it will be difficult to completely avoid the contamination of the naturalised stream D/S16 during the construction activities. Hence, the recommended mitigation measures will help to reduce the hydrological impacts on drain D/S16 to Minor impact significance and lead to water quality impacts of Moderate impact significance.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Construction Site Footprint (Mitigated)
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :
COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF CR14 WITH WATERCOURSES NEARBY DURING CONSTRUCTION PHASE

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CQA	NHT	JAG
	Drawn CQA	Date AUG 2022

Figure No. :	Rev.	Sheet
8 - 13	-	1 of 1

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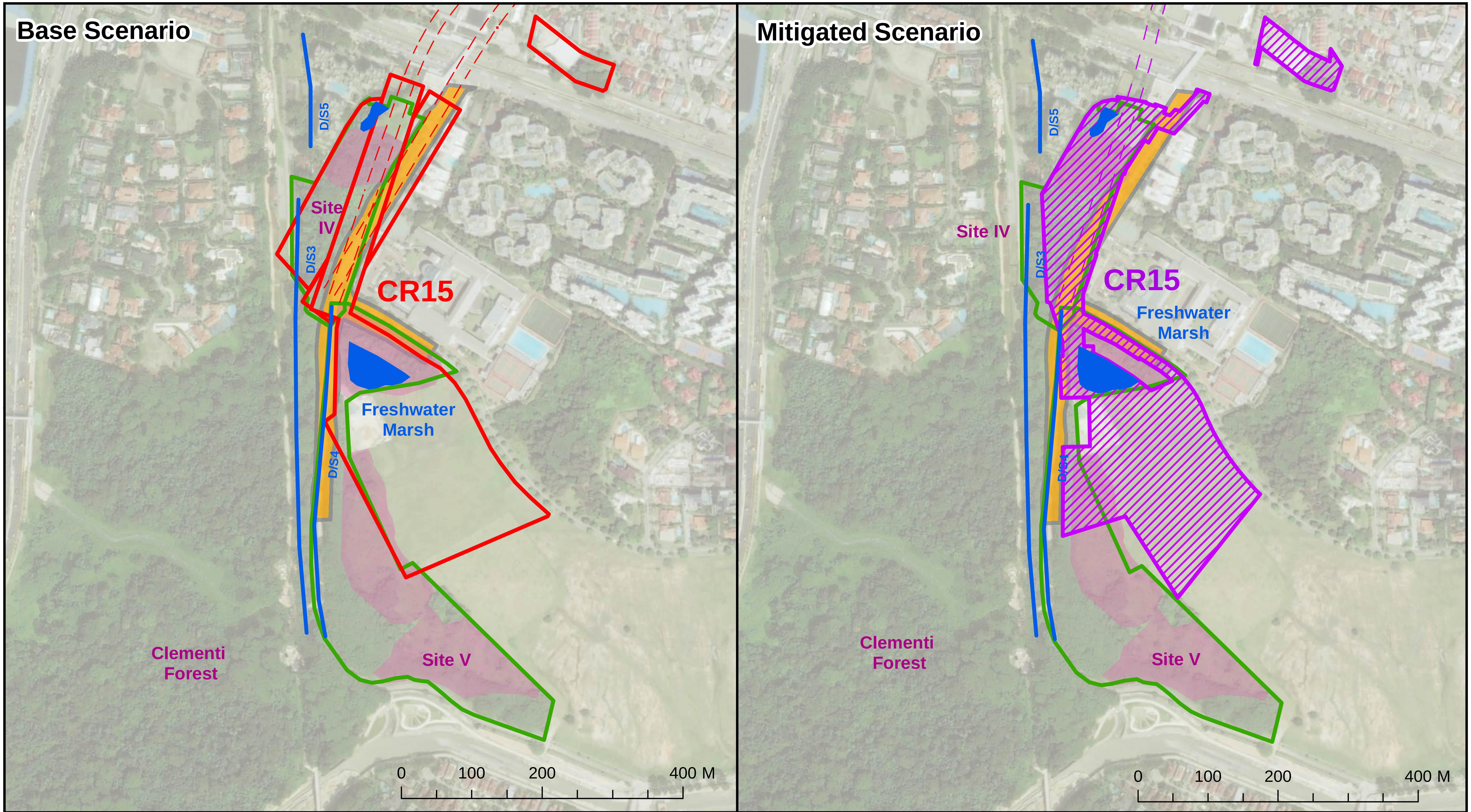
Note: Source of basemap - Google Earth Map



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Construction Site Footprint (Mitigated)
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

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Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title : COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF CR15 WITH WATERCOURSES NEARBY DURING CONSTRUCTION PHASE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 14	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

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8.8.2 Operational Phase

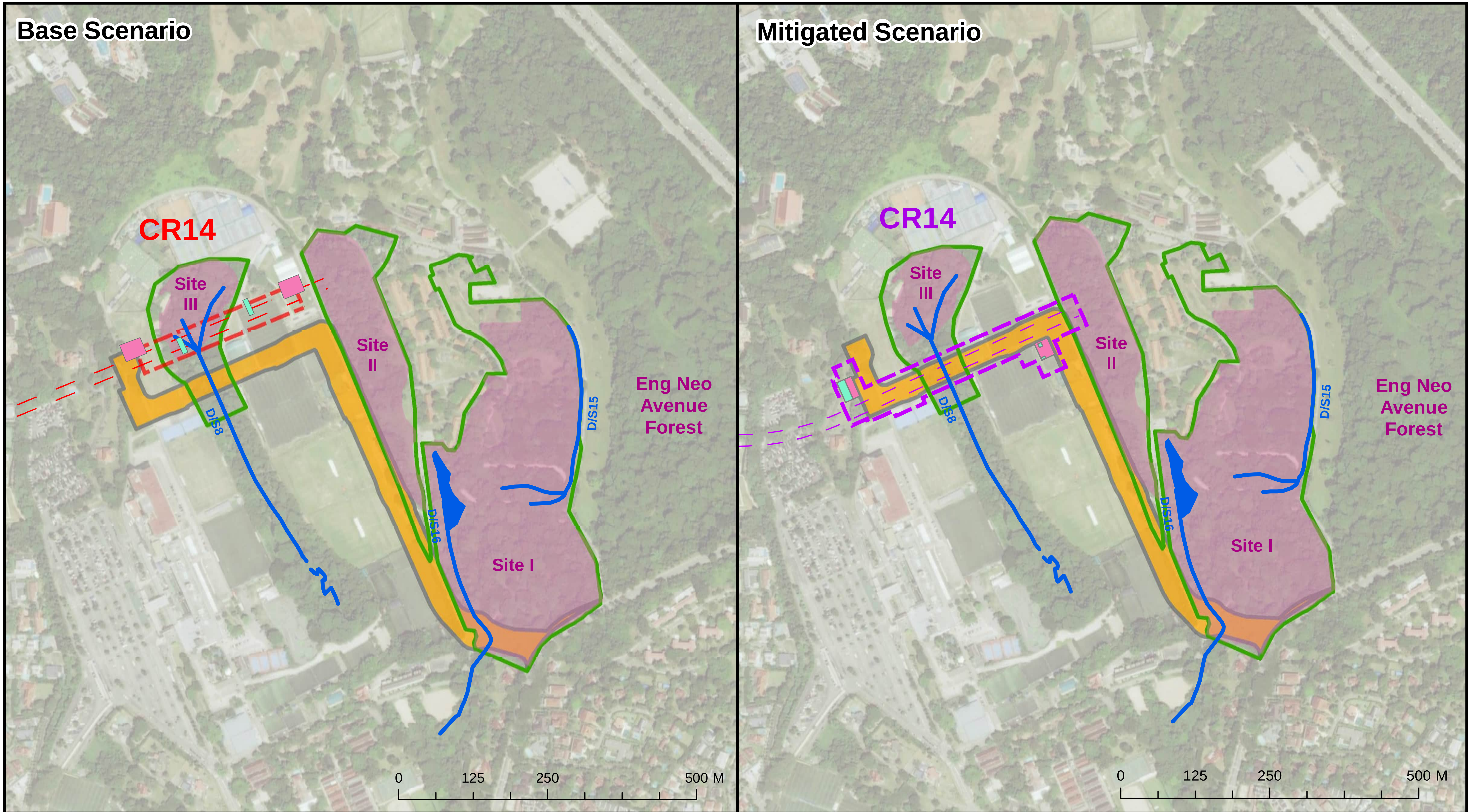
As shown in Table 8-13, the proposed operational activities were assessed to have Moderate and Major impacts on hydrology of earth drain D/S8 and naturalised stream D/S16, respectively, despite the implemented minimum controls. In addition, the biodiversity findings from Section 7.8 shows that the CR14 station entrances could pose Major impact on the biodiversity of Site III, which has high ecological importance. Hence, it was recommended to shift the CR14 station entrances outside of Site III to preserve this forested area as much as possible. As such, the CR14 station entrances were relocated to existing urban areas as described in Section 3.1.2 and presented in Figure 8-15.

At Holland Plain, LTA also optimised the CR15 station entrance and vent shafts during operational phase, as presented in Figure 8-16. There are no changes in impacts to the watercourses and waterbodies within Holland Plain (i.e. concrete drain D/S4, D/S5, and earth drain D/S3) during construction phase.

The hydrological and water quality impacts on the rest of the watercourses were assessed to be Minor, when considering the implemented minimum controls. Hence, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the operational plans are required.

8.8.2.1 Minimisation

As detailed in Section 8.8.1, flow diversion or the construction of a culvert (subject to Contractor's design at a later stage) is recommended to minimise the impacts to earth drain D/S8. Given that such mitigation measures are in place during operational phase, hydrological impacts to earth drain D/S8 is reduced to Minor. Furthermore, given that the box culvert will be installed at the naturalised stream D/S16, the hydrological impacts along this stream is reduced to Minor as well.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Facility (Underground)
- Mitigated Scenario Construction Worksite Footprint
- Vent Shafts
- Entrances
- Area of High Conservation Value
- Biodiversity Study Area
- Future Road Under Study

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :
COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF CR14 WITH WATERCOURSES NEARBY DURING OPERATIONAL PHASE

Designed	Checked	Approved
CQA	NHT	JAG
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Figure No. : 8 - 15
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Sheet : 1 of 1

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A3

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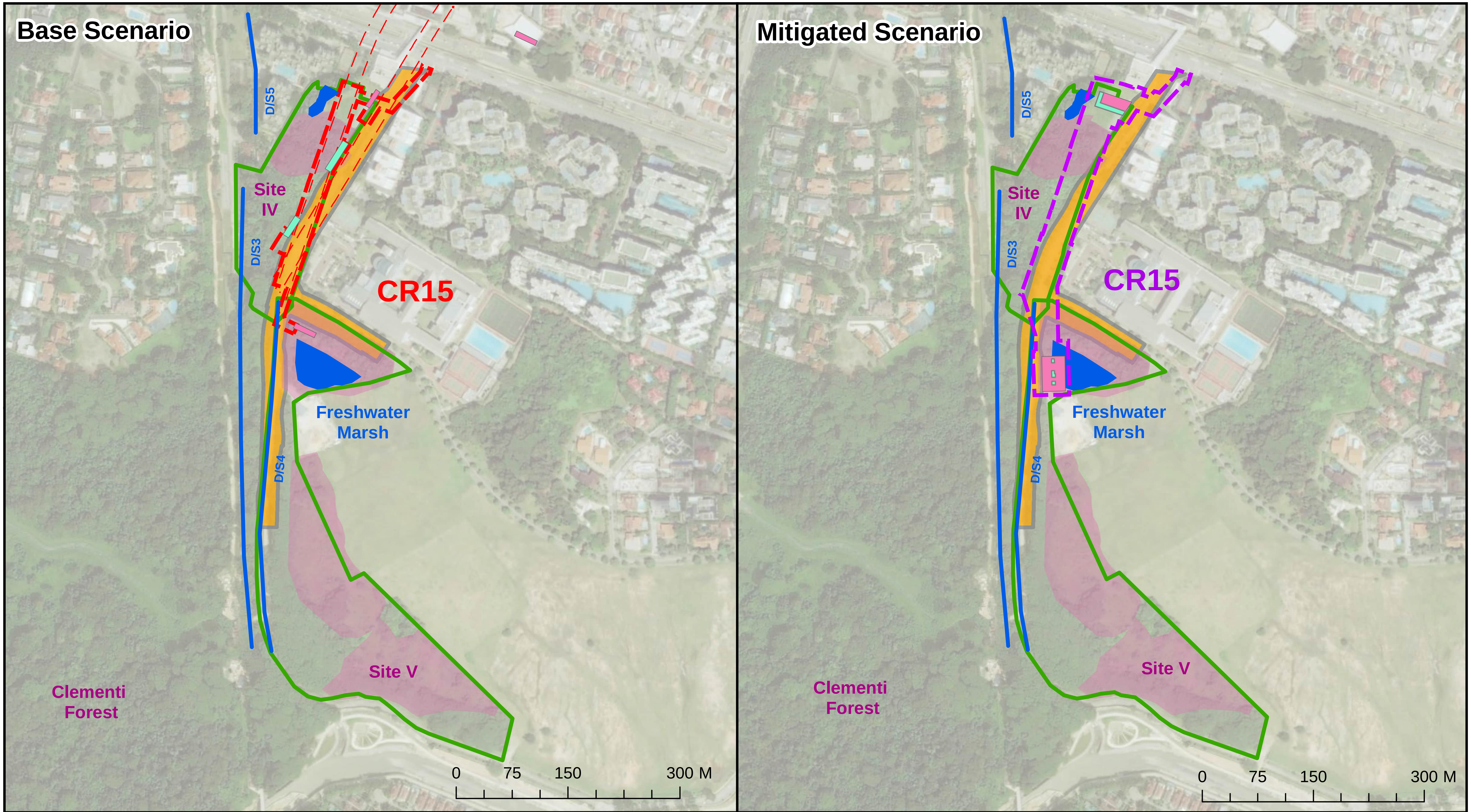

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Operational Site
- Mitigated Scenario Operational Site
- Vent Shafts
- Entrances
- Biodiversity Study Area
- Area of High Conservation Value
- Planned Road Works

N

Rev.	Date	By	Description	Chk'd	App'd
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Qualified Person Endorsement : NA

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF CR15 WITH WATERCOURSES NEARBY DURING OPERATIONAL PHASE

Designed	Checked	Approved	Drawn	Date
CQA	NHT	JAG	CQA	AUG 2022

Figure No. : 8 - 16 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - Google Earth Map

8.9 Residual Impacts

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

During construction phase, given that the proposed mitigation measures are implemented for earth drain D/S8, the hydrological impact is reduced from Moderate to Minor, and the water quality impacts would be Moderate. As for naturalised stream D/S16, the mitigation measures of a culvert construction would reduce the hydrological impacts from Major to Minor, and the water quality impacts would be Moderate as well.

During operational phase, the residual hydrological impacts on earth drain D/S8 and naturalised stream D/S16 are both reduced from Major/Moderate to Minor.

Table 8-14 Summary of Residual Impacts and its Mitigation Measures During Construction Phase

Activity	Receptor Sensitivity	Biodiversity Study Area	Impacts	Impact Significance (without Mitigation Measures)	Mitigation Measures	Significance of Residual Impact (with Mitigation Measures)
During construction phase: • Land clearing, earthworks and excavation activities; • Storage and disposal of solid, liquid and toxic wastes; and • Use and storage of chemical substances, and refuelling activities	D/S8 (Priority 1)	Sites I, II, III	During construction phase: • Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as Sites I, Site II and Site III will be occupied by the construction worksite during construction phase. • Reduction of baseflow due to land use change • Habitat disruption of flora and fauna along the stream	• Hydrology: Moderate for D/S8; Major for D/S16 • Water Quality: Major for D/S16. During construction phase, after considering the mitigated CR14 worksite: • Hydrology: Moderate for D/S8; Major for D/S16 • Water Quality: Moderate for D/S8; Major for D/S16.	The construction worksites and road works should not obstruct the flow of naturalised stream D/S16 and earth drain D/S8, so as to ensure the perennial flow is maintained. If diversion is required, the contractor shall provide diversion of affected sections of these watercourses prior to the start of construction. The diversion should follow PUB's Code of Practice on Surface Water Drainage. Discharge treated runoff into earth drain D/S8 (i.e. treated to meet NEA Trade Effluent Discharge Limits) to maintain its existing flow.	Minor (Hydrology) Moderate (Water Quality)
	D/S16 (Priority 1)					Minor (Hydrology) Moderate (Water Quality)
Residual impacts of other watercourses were not assessed as their impact pre-mitigated impact significance were Negligible to Minor.						

Table 8-15 Summary of Residual Impacts and its Mitigation Measures During Operational Phase

Activity	Receptor Sensitivity	Biodiversity Study Area	Impacts	Impact Significance (without Mitigation Measures)	Mitigation Measures	Significance of Residual Impact (with Mitigation Measures)
During operational phase: • Stormwater runoff generation.	D/S8 (Priority 1)	Sites I, II, III	During operational phase: • Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as Sites III will be occupied by the CR14 station vent shaft and road under study during operational phase.	Hydrology: Moderate for D/S8; Major for D/S16.	• The construction worksites and road works should not obstruct the flow of naturalised stream D/S16 and earth drain D/S8, so as to ensure the perennial flow is maintained. If diversion is required, the contractor shall provide diversion of affected sections of these watercourses prior to the start of construction. The diversion should follow PUB's Code of Practice on Surface Water Drainage. • Discharge treated runoff into earth drain D/S8 (i.e. treated to meet NEA Trade Effluent Discharge Limits) to maintain its existing flow.	Minor (Hydrology)
	D/S16 (Priority 1)					Minor (Hydrology)
Residual impacts of other watercourses were not assessed as their impact pre-mitigated impact significance were Negligible to Minor.						

8.10 Cumulative Impacts from Other Major Concurrent Developments

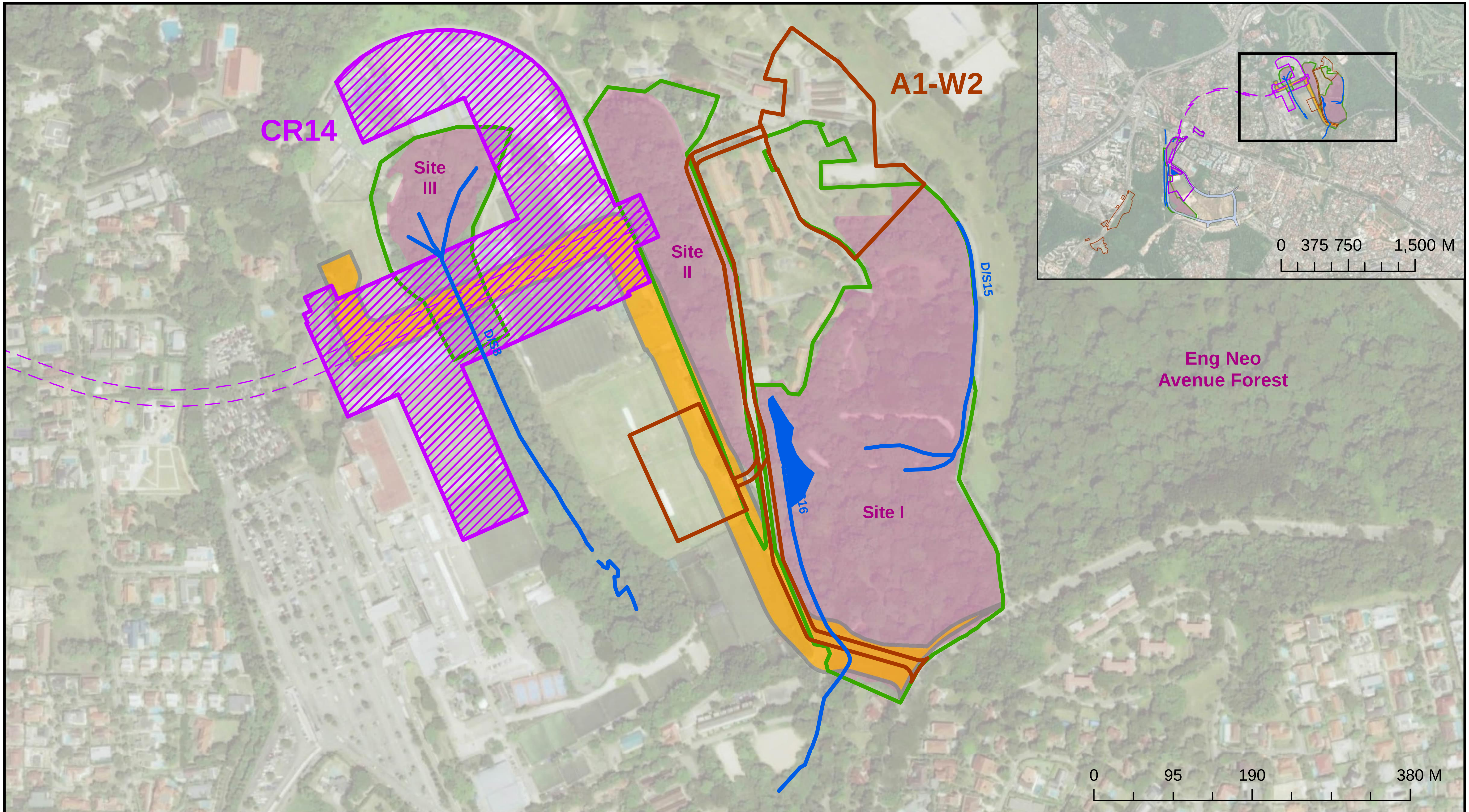
This section focuses on assessing cumulative impacts of the construction and operational activities from identified concurrent developments on the watercourses. It should be noted that since the detailed construction and operational activities were not available at the time of writing this report, only qualitative cumulative impact assessment was carried out.

8.10.1 Construction Phase

At Turf City, the A1-W2 launch shaft worksite and temporary access road will be constructed concurrently during the construction phase of CR14 with an overlapping construction period of 96 months. As presented in Figure 8-17, the two A1-W2 worksites are located to the east and south of the mitigated CR14 worksite and the temporary access road is located along this Project’s planned road works. It is assumed that the best management practices and minimum controls are provided by its developer accordingly during its construction phase. Hence, it is expected that this concurrent project will not significantly increase the extent of impacts on the hydrology and water quality of watercourses in Site I.

At Holland Plain, numerous road works will be constructed concurrently during the construction period of CR15 worksite with an overlapping construction duration of approximately 30 months and during the construction of CR15 permanent road works for about 12 months. As shown in Figure 8-18, the concurrent road network construction project is relatively near the concrete drain D/S4 in Site V. Given that it is assumed that the worksites would have adequate drainage capacity designed for the drainage system in construction worksites, the hydrological impacts on the concrete drain D/S4 would be Minor. With the assumption that the best management practices and minimum controls will be provided by its developer during its construction phase and given the low ecological sensitivity of this watercourse, this concurrent project would only have Minor water quality impacts on concrete drain D/S4.

Three (3) concurrent projects will be carried out within Clementi Forest near the CR15 worksite during its construction period. The construction of CR16 is expected to overlap with the construction duration of CR15 as it is expected to take place around 2022 to 2032. The Old Jurong Line Nature Trail is expected to overlap with the construction period of CR15 from Q4 2023 to Q1 2026, and the construction of Clementi Nature Trail will overlap from Q2 2023 to Q4 2023. As these three concurrent projects are located sufficiently far from Site IV and Site V that the projects are neither located at the upstream of any watercourse studied in this Study nor located within the catchment area of these watercourses, hence, these concurrent projects are unlikely to increase the impact extent on the surrounding hydrology and water quality throughout their respective construction phases.



Legend

- Watercourses
- Proposed CRL Alignment (Mitigated)
- Construction Worksite Footprint (Mitigated)
- A1-W2 Worksite
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

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-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

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Figure Title :
CONCURRENT DEVELOPMENTS
WITH WATERCOURSES AT CR14
DURING CONSTRUCTION PHASE

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CQA	NHT	JAG	8 - 17	-	1 of 1

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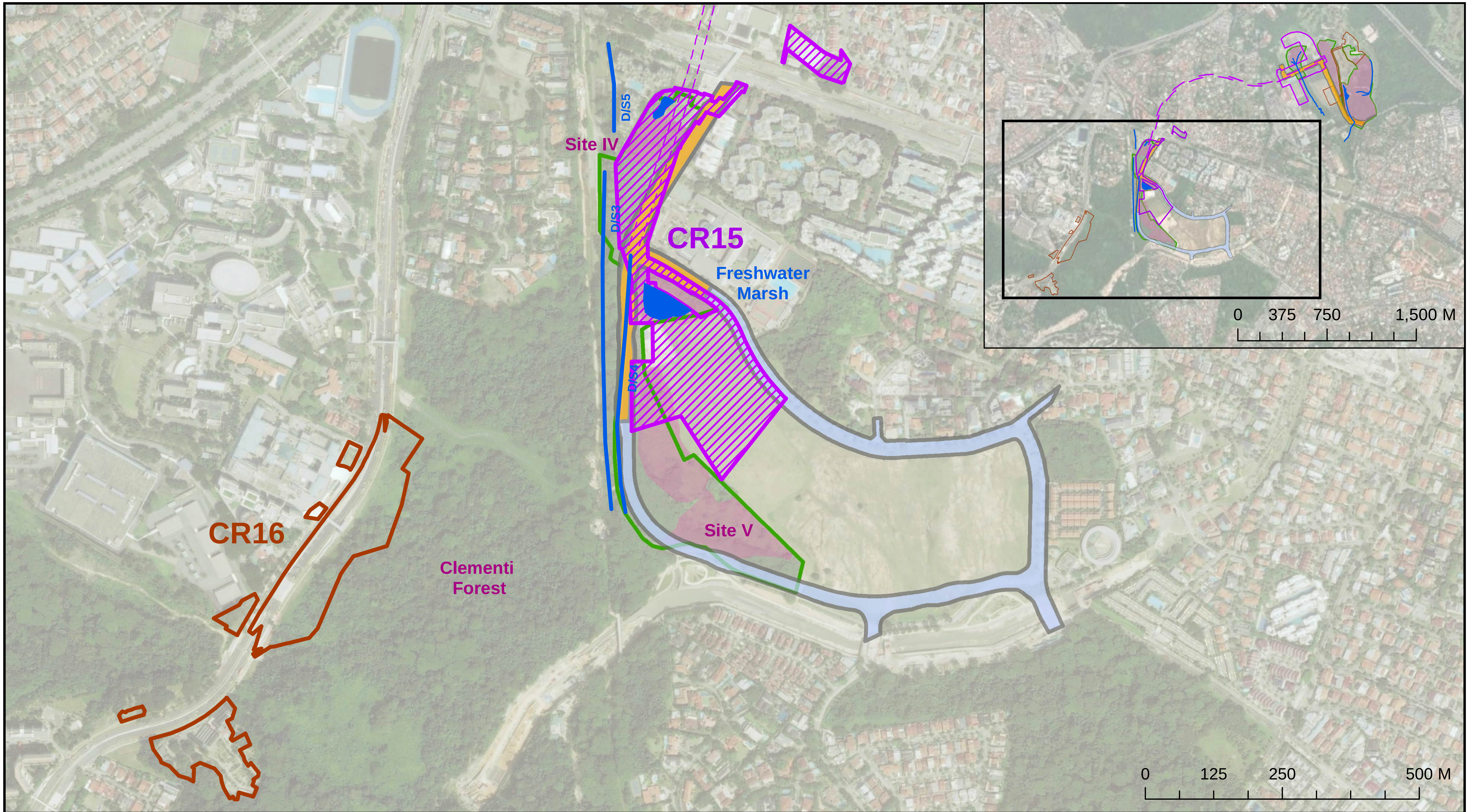

Legend

- Watercourses
- Proposed CRL Alignment (Mitigated)
- Construction Site Footprint (Mitigated)
- CR16 Mitigated Worksite
- Concurrent Project Roadworks at CR15
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :

CONCURRENT DEVELOPMENTS WITH WATERCOURSES AT CR15 DURING CONSTRUCTION PHASE

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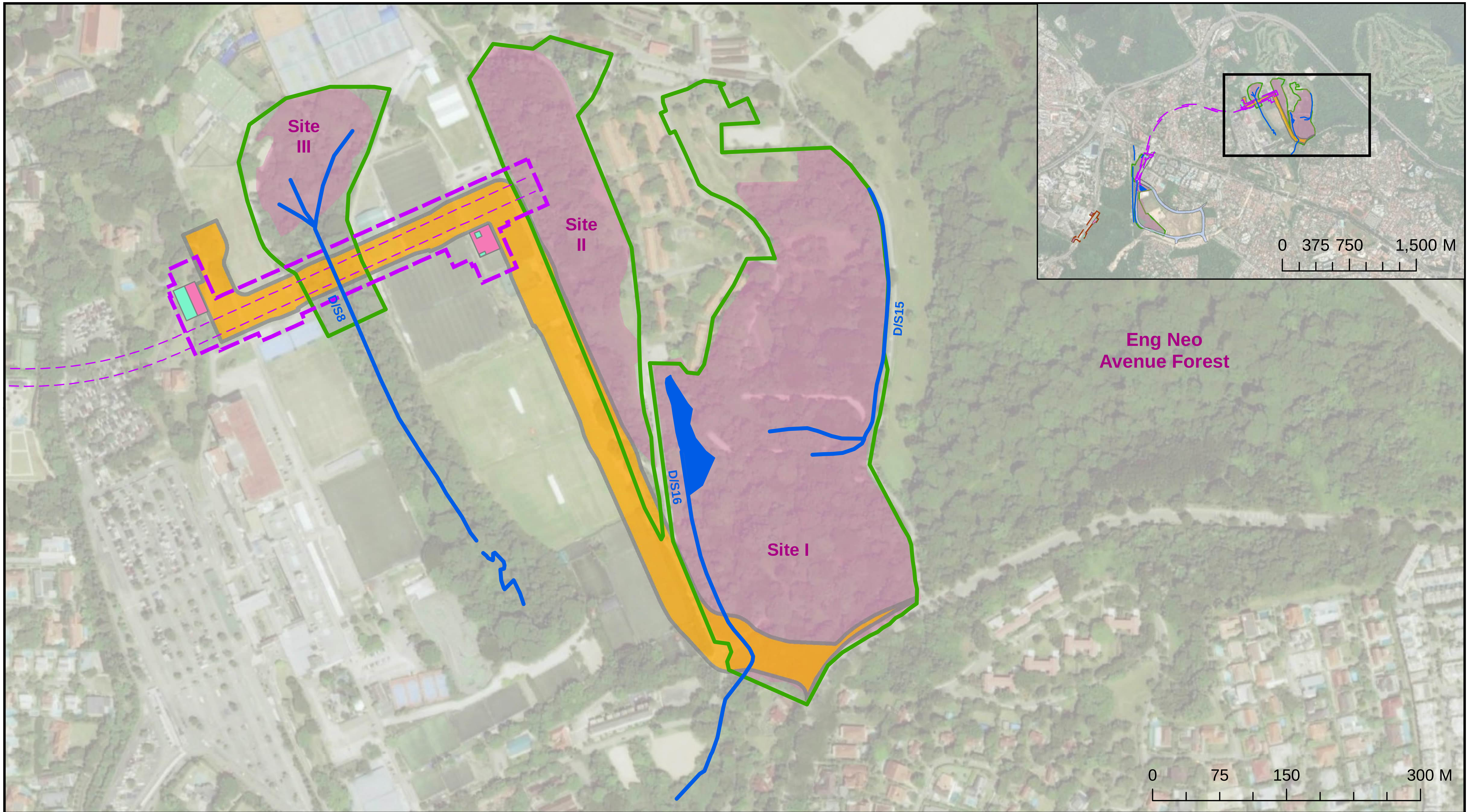
CQA	NHT	JAG	8 - 18	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

8.10.2 Operational Phase

At Turf City, the A1-W2 worksite area and temporary access roads will be reinstated (Figure 8-19), and thus there are no concurrent impacts to the watercourses in Turf City during the operational phase.

At Holland Plain, the road network supporting the Holland Plain development will be operational (refer to Figure 8-20). The change in land use is minor, and thus the impacts to hydrology and water quality of the watercourses near Site V is likely to be insignificant. Furthermore, CR16 station and vent shafts will be operational during the operational phase of CR15 station. As the CR16 station is located sufficient far from Site IV and Site V that the project is neither located at the upstream of any watercourse studied in this Study nor located within the catchment area of these watercourses, hence, this concurrent project is unlikely to increase the impact extent on the surrounding hydrology and water quality.



Legend

- Watercourses
- Proposed CRL Alignment (Mitigated)
- CR14 Station Box (Mitigated)
- CR14 Vent Shafts
- CR14 Entrances
- Future Road Under Study
- Biodiversity Study Area
- Area of High Conservation Value

N

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-	AUG 2022	CQA	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

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(TURF CITY AND HOLLAND PLAIN)

Figure Title :

CONCURRENT DEVELOPMENTS WITH WATERCOURSES AT CR14 DURING OPERATIONAL PHASE

Designed	Checked	Approved
CQA	NHT	JAG
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Figure No. :	Rev.	Sheet
8 - 19	-	1 of 1

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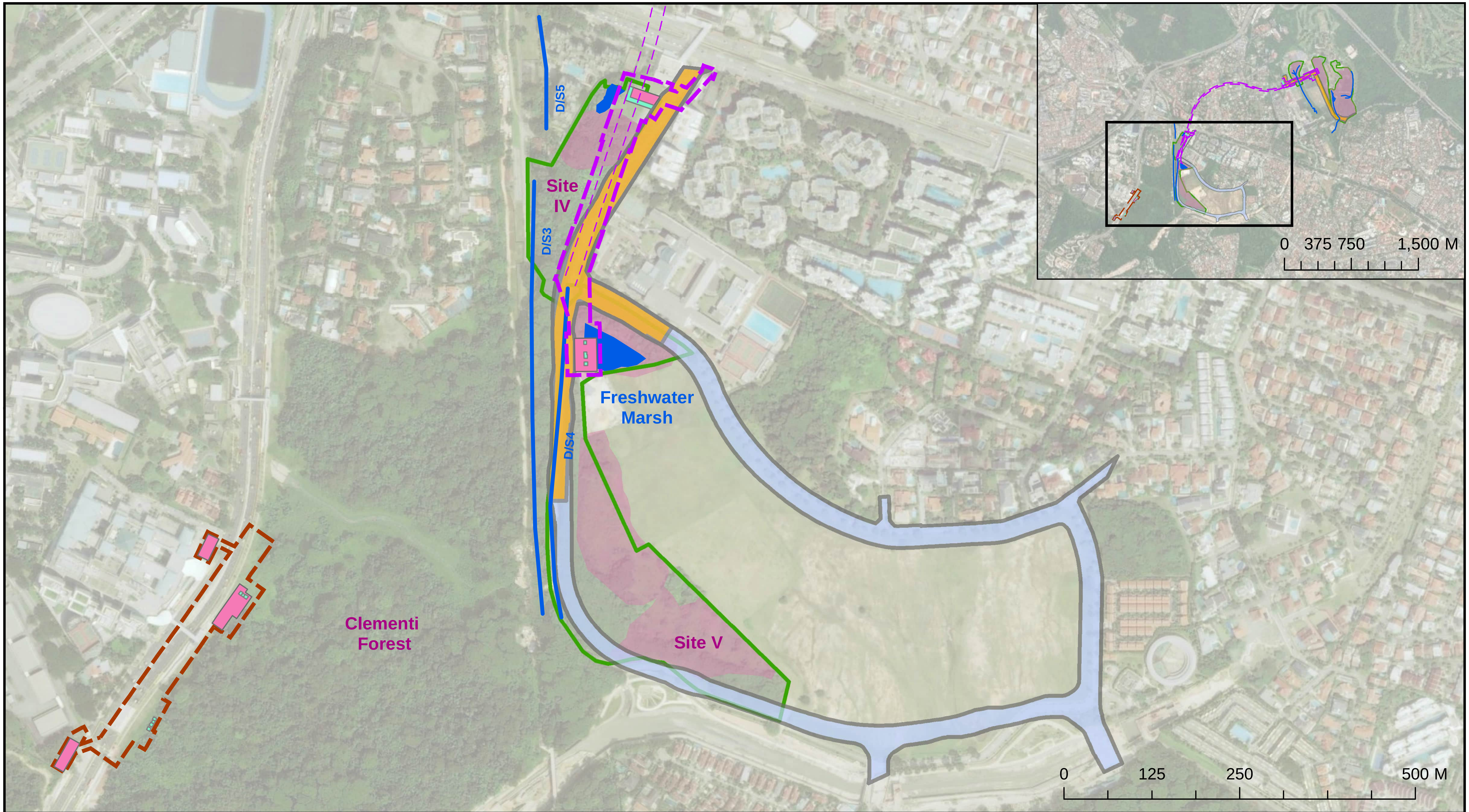

Legend

- Watercourses
- Proposed CRL Alignment (Mitigated)
- CR15 Station Box (Mitigated)
- CR16 Station Box (Mitigated)
- Vent Shafts
- Entrances
- Concurrent Project Roadworks at CR15
- Planned Road Works
- Biodiversity Study Area
- Area of High Conservation Value

N

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Figure Title :
CONCURRENT DEVELOPMENTS WITH WATERCOURSES AT CR15 DURING OPERATIONAL PHASE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
CQA	NHT	JAG	8 - 20	-	1 of 1
	Drawn CQA	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

8.11 Summary of Key Findings

The hydrological baseline survey was aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics. Based on available topographic data, secondary baseline data from concurrent study carried out by AECOM in the vicinity, site surveys as well as PUB water catchment map, water catchment areas within the vicinity of the Biodiversity Study Area at Turf City (i.e. Site I, II and III) mainly contribute to the three (3) watercourses, and water catchment areas within the vicinity of Biodiversity Study Areas at Holland Plain (i.e. Site IV and V) and its vicinity contribute to three (3) watercourses and numerous waterbodies. Water from the identified drains/streams in Turf City will eventually flow into Marina Reservoir, while water from the identified drains/streams/waterbodies in Holland Plain will eventually flow into Pandan Reservoir. Both reservoirs store water to be treated for drinking water purposes.

At Turf City, the watercourses studied consists of one (1) roadside concrete drain at the upstream of D/S15, one (1) man-made earth drain (D/S8), and one (1) naturalised stream (D/S16). At Holland Plain, the watercourse studied include one (1) earth drain (D/S3), two (2) concrete drains (D/S4, D/S5) and waterbodies (ponds at Site IV, freshwater marsh). It should be noted that D/S15 has segments that are both concretised and natural along the same watercourse. The concrete section of D/S15 was assessed in this Study. The naturalised stream D/S16 at Turf City was found have high ecological significance, and currently supports the surrounding ecological systems. Hence, it is very important to understand how the potential environmental impacts arising from the Project activities can impact this stream.

To study water quality within the identified drains/streams, two (2) dry and/or one (1) wet weather samples were taken from each of the eight (8) water quality stations at the watercourses from Turf City and Holland Plain. Most water samples were tested for both physical and chemical parameters relevant for sustenance of aquatic life including Temperature, pH, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Turbidity, Total Suspended Solids (TSS), Biochemical Oxygen Demands (BOD_5), Chemical Oxygen Demand (COD), Total Phosphorous (TP), Orthophosphates (PO_4-P), Total Nitrogen (TN), and Nitrates (NO_3-N). Parameters such as COD, TP, PO_4-P, TN and NO_3-N were excluded from WQ8 and WQ9 as the earth drain D/S8 had relatively lower ecological significance (refer to Section 7.4.1). Analysis of the water quality results have shown that the water quality of the watercourses is relatively consistent with its ecological significance.

The water quality in the ephemeral concrete drain (D/S15) in Site I was found to have high TSS, as the runoff likely contained solids that were flushed from surrounding soil, vegetation and urban areas. The perennial naturalised stream (D/S16) was found to have relatively good water quality during dry weather. However, the naturalised stream is slightly impacted by storm events, as the water quality deteriorates during wet weather conditions. Despite the variation in water quality, this watercourse was found to support aquatic life and has a high ecological value (Section 7.4.1). The perennial man-made earth drain (D/S8) in Site III had water quality that is suitable to support aquatic life, but was considered to be of low ecological value due to human disturbance (Section 7.4.1). Ephemeral earth drain (D/S3) in Site IV was found to have relatively low pH, which was attributed to the flushing of humic acid from its earth banks. Two (2) ephemeral concrete drains (D/S4, D/S5) in Site IV and V were found to have relatively good water quality. The freshwater marsh had relatively poor water quality, as compared to the aquatic life criteria, which indicates that the marsh has unfavourable conditions for aquatic life during dry weather. However, the marsh was found to support an ecosystem of conservation significant biodiversity, which include marsh-specific odonates and birds (Section 7.4.2).

Based on the assessment of the hydrology and surface water quality related impacts on the various sensitive receptors, the assessment findings have been summarised in Table 8-12 and Table 8-13. At Turf City (i.e., Site I, II and III), the mitigated scenario construction worksite and planned road works would cause Moderate hydrological impacts on earth drain D/S8 and Major hydrological and water quality impacts on naturalised stream D/S16. As such, mitigation measures were proposed, such as flow diversion or culvert construction (subject to Contractor's design at a later stage) to connect the upstream and downstream of earth drain D/S8 and the discharge of treated runoff into drain D/S8 to maintain its existing flow (i.e., runoff is treated to meet NEA Trade Effluent Discharge Limits). For stream D/S16, the installation of box culvert to ensure continuous perennial flow the stream and flow diversion (i.e. follows PUB Code of Practice on Surface Water Drainage) prior to culvert integration are recommended. Therefore, this reduced the hydrology and water quality impact significance to **Minor** and **Moderate**, respectively.

During operational phase, the mitigated station entrance, vent shafts and a road under study for CR14 station was found to have Moderate hydrological impacts on earth drain D/S8 and Major hydrological impacts on naturalised stream D/S16. Given that the abovementioned mitigation measures are in place during operational phase, the impacts to the watercourses during operational phase is reduced to **Minor**.

For the rest of the watercourses, they were assessed to cause only Negligible to Minor impacts during both construction and operational phases. Thus, apart from the minimum controls identified for the Minor impacts, no additional management or mitigation measures are required.

Assessing the cumulative impacts from concurrent developments identified in the vicinity of the Project in Turf City, it was concluded that the concurrent project of the launch shaft worksite would not significantly increase the impact extent on hydrology and water quality of watercourses at Sites I during construction phase. In Holland Plain, with the assumption that there would be adequate drainage capacity designed for the worksites and that the best management practices and minimum controls will be provided by its developer, the concurrent road network construction works would have minor impacts on the hydrology and water quality on the nearby concrete drain D/S4. The three (3) concurrent projects of construction of CR16 station, Old Jurong Line Nature Trial and Clementi Nature Trail in Clementi Forest are situated far away from Site IV and Site V, and therefore are unlikely to contribute cumulative impacts.

Table 8-16 Summary of Hydrology and Water Quality Impact Assessment

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I and Site II	Negligible to Major	Minor to Moderate
Site III	Minor to Moderate	Minor to Moderate
Site IV	Negligible to Minor	Negligible to Minor
Site V	Minor	Minor
Operational Phase		
Site I and Site II	Negligible to Major	Minor
Site III	Minor to Moderate	Minor
Site IV	Negligible to Minor	Negligible to Minor
Site V	Minor	Minor

9. Soil and Groundwater

9.1 Introduction

Construction and operational activities, if not managed properly, can lead to the potential contamination of soil and groundwater. Furthermore, during the land preparation and excavations for construction works there is also a potential to encounter historically contaminated soils. This section presents the assessment undertaken to define the nature and scale of the potential impacts on soil and groundwater associated with the construction and operational phase of the Project. The section will also outline appropriate control and mitigation measures.

9.2 Methodology and Assumption

This section outlines the methodology adopted for the soil and groundwater impact assessment for both construction and operational phases. The purpose of soil and groundwater baseline study was to determine the soil profile of the Study Area, hydrogeological conditions of the aquifer, soil and groundwater chemistry which may potentially have adverse impacts on the identified sensitive receptors. Furthermore, the baseline study should ascertain the presence of possible historical pollutants in the underlying soil that may also cause adverse impacts during construction and operational phases. Baseline conditions were established based on available secondary data, primarily Historical Land Use Survey (HLUS) report and previous soil and/ or groundwater investigation studies as detailed in Section 9.2.1 and Section 9.2.2, respectively.

9.2.1 Historical Land Use

Historical land use information of the study is extracted from the CR2001 Historical Land Use Survey (HLUS) reports [R-4, R-5] for the purpose of this report. The HLUS identifies potentially counterinitiative land uses and areas where deep excavation would occur due to the Project works. This information is analysed to produce an environmental borehole and monitoring well location plan.

9.2.2 Soil and Groundwater Baseline

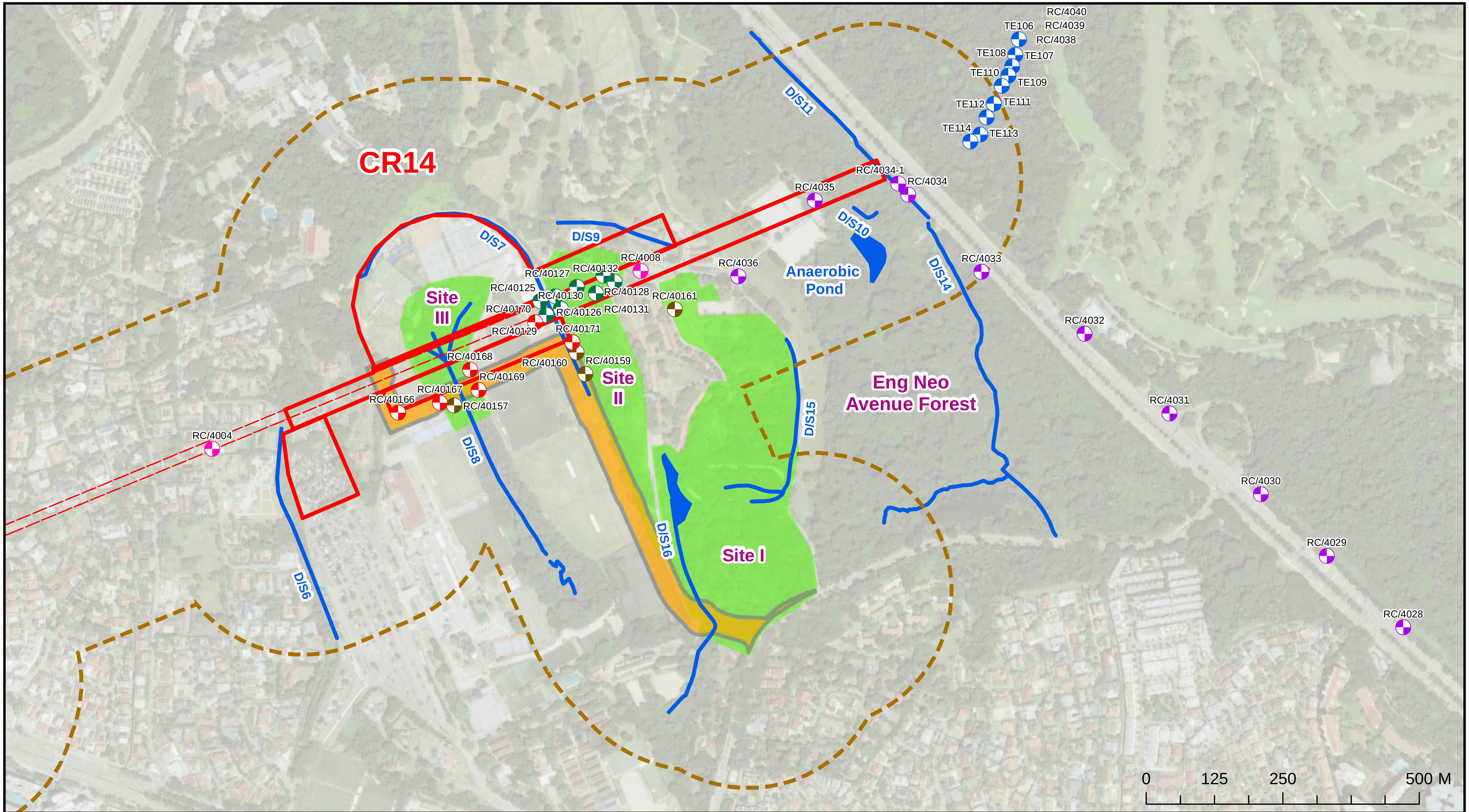
Besides the HLUS and publicly-available secondary data, as a part of soil and groundwater baseline study, AECOM also reviewed previous soil and/ or groundwater investigation studies carried out within the Study Area. These included both Soil Investigation (SI) reports (focusing on geotechnical characteristics of soil) [R-74, R-75, R-77, R-78, R-79, R-80, R-81] and soil and groundwater baseline studies (focusing on physico-chemical parameters of soil and groundwater [R-71, R-76] (refer to Figure 9-1 and Figure 9-2).

9.2.2.1 Soil and Groundwater Baseline Assessment Criteria

The Dutch Intervention Values (DIV) in the Dutch Environmental Guidelines Soil Remediation Circular [R-42] were 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 and groundwater. The DIV is referenced in the latest Code of Practice for Pollution Control [R-8] (COPPC) by the National Environmental Agency (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 in at least 25 cubic metres (m^3) of soil-volume, or groundwater concentration in at least 100 m^3 of pore-saturated soil-volume, exceeds the DIV. It is noted that the intervention values for groundwater are not based on a separate risk assessment with regards to the contaminants present in the groundwater but are calculated based on partitioning of chemicals at concentrations equivalent to the intervention values in soil/sediment.

It is recognised that the Dutch Guidelines were developed to assess the acceptability of impacted soil and groundwater 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 COPCs were below these criteria, it would be reasonable to conclude that the concentrations are not of concern.



Legend

- Study Area
- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Roadworks
- Biodiversity Study Area

Previous Studies

- 1W11
- 1W15
- 1W54
- 1W88
- 1W92
- C1040

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	SAG	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

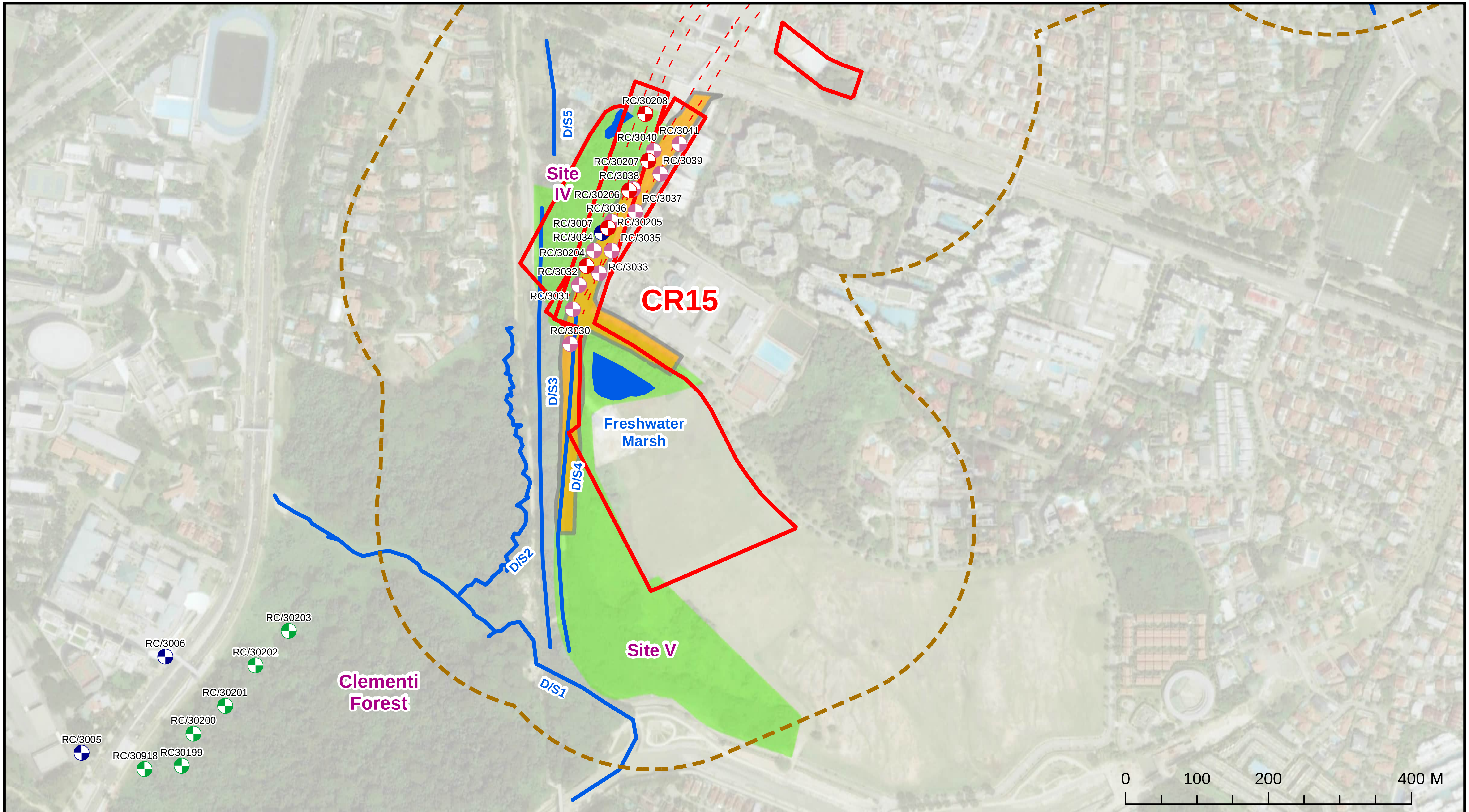
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

LOCATION OF BOREHOLES FROM PREVIOUS STUDIES AT TURF CITY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SAG	NHT	JAG	9 - 1	-	1 of 1
	Drawn SAG	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map



Legend

- Study Area
- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Roadworks
- Biodiversity Study Area

Previous Studies

- 1W05
- 1W34
- 1W91
- 1W92

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	SAG	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

LOCATION OF BOREHOLES FROM PREVIOUS STUDIES AT HOLLAND PLAIN AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SAG	NHT	JAG	9 - 2	-	1 of 1
	Drawn SAG	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

9.2.3 Prediction and Evaluation of Impact Assessment

The Study Area adopted for the assessment will follow the HLUS Study Area of 250 m from both sides of the alignment/ station and other construction sites footprint. Soil and groundwater impact assessment was carried out qualitatively based on the HLUS study findings. Furthermore, where applicable, impact assessment was also based on the soil and groundwater baseline data collected as part of previous soil and/ or groundwater investigations.

9.3 Identification of Soil and Groundwater Sensitive Receptors

The receptor screening for groundwater was conducted within the 250 m study area and classified based on methodology defined inTable 6-1.

It is understood that presently groundwater in Singapore is not directly extracted for beneficial use i.e. as a source for potable water, industrial water or irrigation purposes, and hence should be considered as Priority 3, as shown in Table 9-1 below. Streams with biodiversity conservation significance where groundwater flow is partially supporting the stream ingress from the Project is also shown in Table 9-1 as a Priority 2 receptor for the purpose of this Report.

Table 9-1 Classification of Receptor Sensitivity

Sensitive Receptor	Description	Receptor Sensitivity	Sensitivity Classification
Soil and Groundwater within the Project Site	The soil and groundwater within the project site were expected not to pose unacceptable risks to future workers and human receptors.	Not sensitive groundwater (i.e. not directly extracted for any purposes such as drinking or commercial/industrial use)	Priority 3
Watercourses with biodiversity conservation significance where groundwater flow is partially supporting the streams ingress from the construction worksite and operational footprint	Groundwater baseflow to the watercourses near construction worksite and operational footprint to the streams was expected to be affected	Groundwater partially supporting the watercourses with biodiversity conservation significance (refer to Figure 8-1).	Priority 2

9.4 History of Land Contamination

The historical land use within the study area (250 m from both sides of the alignment) was reviewed in detail in the HLUS reports [R-4, R-5].

Potentially contaminating activities can be deduced to have occurred based on the land use at a site, noting possible contamination at some point during the history of the land usage. Based on the HLUS reports, the hotspots and contamination severity are shown in Table 9-2 below with the respective project worksites where HLU denotes historical land use.

Table 9-2 Land Use Hotspots

No.	Hotspot	Type	Nearest Associated Worksite	Severity of Contamination
1	Pan-Island Expressway (PIE)	Existing Road	CR14	Low
2	Dunearn Road	Existing Road	CR15	Low
3	Bukit Timah Road	Existing Road	CR15	Low
4	Sian Tuan Avenue Substation	Utility Facilities	CR15	Low
5	Hua Guan Garden Substation	Utility Facilities	CR15	Low

No.	Hotspot	Type	Nearest Associated Worksite	Severity of Contamination
6	Hock Seng Garden Substation	Utility Facilities	CR15	Low
7	Methodist Girls' School No 1 Substation	Utility Facilities	CR15	Low
8	Methodist Girls' School No 2 Substation	Utility Facilities	CR15	Low
9	Bukit Timah Railway (HLU)	Transport Facilities	CR15	Low
10	Bukit Timah Railway Station (HLU)	Transport Facilities	CR15	Medium
11	Rubber Factory	Industrial Facilities	CR15	Low
12	General Electric Factory	Industrial Facilities	CR15	Low
13	Industrial Gases (Malaya)	Industrial Facilities	CR15	Low
14	Golf courses (Island Golf Course, Bukit Golf Course)	Recreational Facilities	CR14	Medium
15	Medical and veterinary clinics along Sin Ming Avenue and Binjai Park	Medical Facilities	CR15	Low
16	Esso petrol station (Yarwood)	Petrol Station	CR15	High
17	Mayfair Gardens | Modern Condominium	Future Developments	CR15	Medium

Note:

1. HLU denotes historical land use.
2. The contamination severity level was extracted from the HLUS reports [R-4, R-5] where it categorises using a Contamination Severity Matrix, which considers the degree of toxicity of contaminants present on site (with respect to dermal contact and inhalation) and the spatial extent of potential contamination within HLUS's study area whether is it localised (1-5%), medium (6-40%) or pervasive (>40%).

9.5 Soil and Groundwater Baseline Findings

9.5.1 Soil Profile

Based on the information obtained from soil and groundwater investigation studies carried out within the Study Area, the encountered soil profile at Turf City area (i.e., CR14 worksite and its vicinity) generally consisted of sandy silt with intrusions of other soil types such as sandy clay, sand and silty sand. At Holland Plain area (i.e., CR15 worksite and its vicinity), the encountered soil profile also generally consisted of sandy silt. Furthermore, layers of sandy to gravelly clay, silty to clay sand were also observed.

9.5.2 Soil Baseline Results

As most of the available soil and groundwater investigation studies within Study Area were carried out with focus on geotechnical characteristics of soil, the available data regarding soil and groundwater baseline quality are limited. Available data and location of boreholes are shown in Figure 9-3 and Figure 9-4.

Metals, including arsenic, antimony, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel and zinc were detected in most soil samples at concentrations above their respective levels of reporting (LOR). Total Petroleum Hydrocarbons (TPH) were also detected in some soil samples at both Turf City and Holland Plain area. These detections were all below their respective DIVs, with the exception of arsenic in soil sample taken at approximately 0.5 m below ground level (m bgl) at RC/40166 (at CR14, refer to Figure 9-3). Reported concentration of arsenic in this sample was 88.16 mg/kg, which exceeds the DIV for arsenic (i.e., 76 mg/kg).

Photoionization detector (PID) readings recorded were ranging from 0 parts per million (ppm) up to 12.1 ppm at Turf City area, while at Holland Plain area they were less than 2.6 ppm. These values indicate negligible concentration of VOCs. No visual or olfactory evidence of contamination of soil was noted during the field activities.

Faecal Coliforms, TN, TP, manganese and vanadium were additionally tested in soil samples collected at the CR14 worksite area. Faecal Coliforms were detected in the majority of soil samples, with maximum reported detection at

460 cfu/g at RC/40167 and RC/40168. Reported concentrations of TN and TP in soil samples ranged from 17.2 mg/kg to 730 mg/kg and from 1.59 mg/kg to 572 mg/kg, respectively. Manganese reported concentrations that ranged from 2.44 mg/kg to 103 mg/kg.

Reported detections of vanadium ranged between 0.48 mg/kg to 55.9 mg/kg. These values are below the indicative levels for severe soil contamination as per Dutch Environmental Guidelines Soil Remediation Circular [R-42].

Manganese and Methyl – Tertiary Butyl Ether (MTBE) were additionally tested in soil samples collected at the CR15 worksite area. Manganese concentrations ranged from 1.13 mg/kg to 769 mg/kg, while MTBE was below LOR.

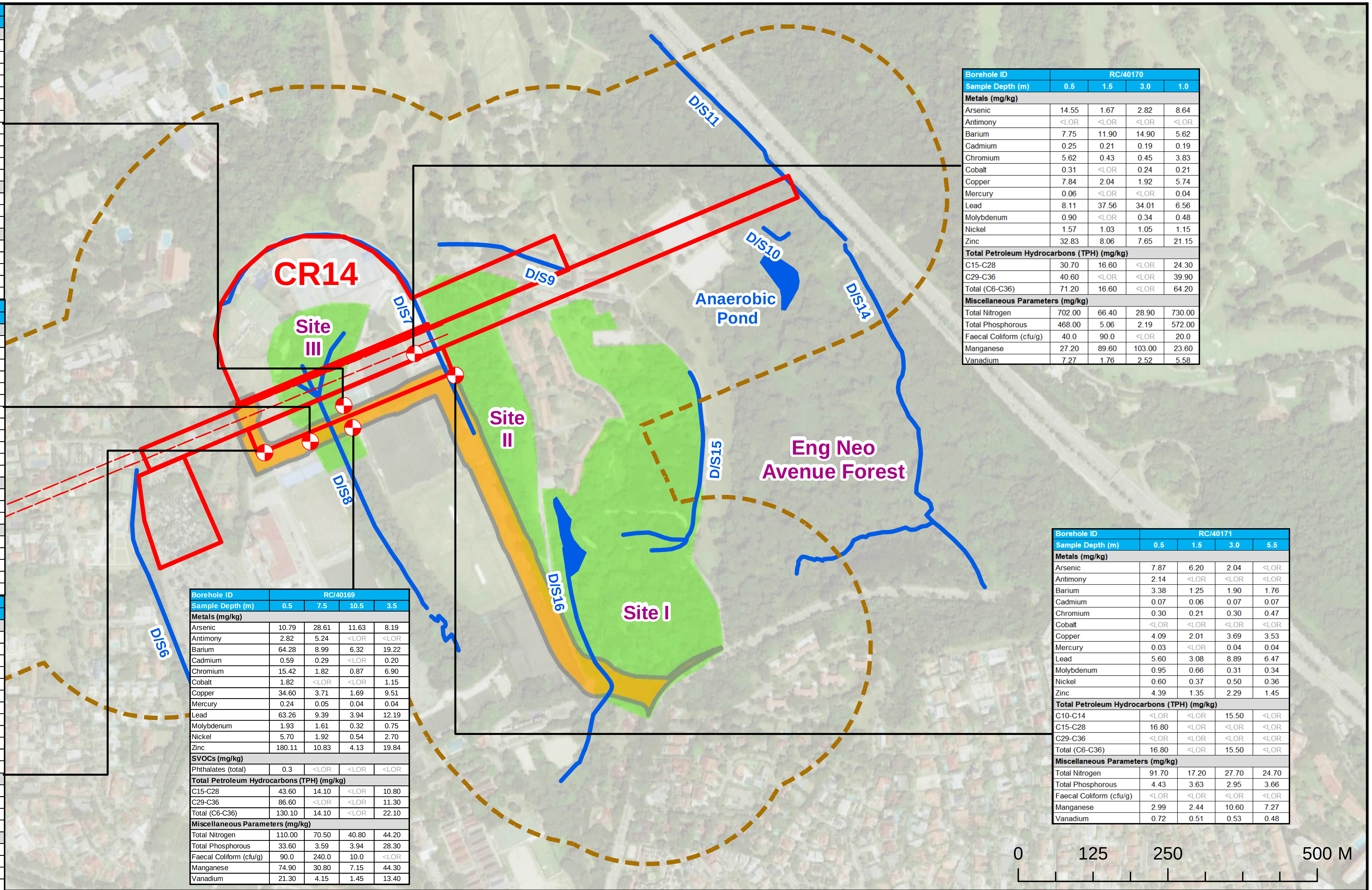
The source(s) of parameters detected above their respective LORs in soil samples could not be conclusively ascertained. Presence of metals, heavy metals and TPH is a common and well-documented occurrence in urban soils that are exposed to anthropogenic activities. Also, many of the detected parameters (i.e., metals, phosphorus, nitrogen) are naturally occurring elements in the environment. However, currently there are no comprehensive studies that provide the information on the background concentrations of these parameters in soil in Singapore. The concentration of faecal coliforms is commonly used parameter to indicate the pollution of the analysed media with the faecal material of humans and/or other animal species. Considering the proximity of the green areas surrounding CR14 worksite (i.e., Site I, Site II and Site III) it is possible that the faecal matter originating from the surrounding fauna leached into the soil.

As mentioned earlier, concentration of arsenic (i.e., 88.16 mg/kg) in near-surface soil sample taken at RC/40166 (at the CR14 worksite) exceeded the DIV for arsenic (i.e. 76 mg/kg). Therefore, Tier 1 Risk Based Assessment [R-71] was carried out which identified that the construction workers could potentially be exposed via dermal contact and incidental ingestion. Further analysis (i.e., by using American Society for Testing and Material [ASTM] Standard Guide for Risk-Based Corrective Action and USEPA Screening Levels) showed that the concentration of arsenic is below screening level and therefore does not present unacceptable risk to human health for future construction workers.

Borehole ID	RC/40168			
Sample Depth (m)	0.5	7.5	10.5	7.0
Metals (mg/kg)				
Arsenic	10.80	17.72	35.11	20.63
Antimony	<LOR	1.80	2.34	2.01
Barium	24.39	4.14	3.62	10.12
Cadmium	0.31	0.10	0.10	0.19
Chromium	8.93	2.35	2.06	7.14
Cobalt	1.52	<LOR	0.17	0.45
Copper	15.96	0.84	2.31	6.30
Mercury	0.11	0.07	0.04	0.13
Lead	21.36	3.65	6.58	15.97
Molybdenum	0.81	1.14	2.00	1.68
Nickel	3.76	0.81	0.96	1.78
Zinc	63.55	4.01	3.43	18.55
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	<LOR	<LOR	11.60	28.80
C29-C36	21.80	<LOR	10.20	45.90
Total (C6-C36)	21.80	<LOR	21.90	74.70
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	245.00	104.00	43.00	172.00
Total Phosphorous	39.60	4.68	5.35	22.50
Faecal Coliform (cfu/g)	10	20	460	460
Manganese	74.50	12.20	16.10	34.30
Vanadium	18.00	6.04	2.71	12.80

Borehole ID	RC/40167			
Sample Depth (m)	0.5	6.0	9.0	1.5
Metals (mg/kg)				
Arsenic	4.27	17.64	18.70	11.24
Antimony	<LOR	1.48	1.36	<LOR
Barium	12.02	1.15	1.97	25.58
Cadmium	0.17	0.23	0.15	0.20
Chromium	7.09	29.89	11.09	5.65
Cobalt	0.73	0.56	0.48	2.33
Copper	7.89	13.90	4.72	14.17
Mercury	0.11	0.06	0.11	0.05
Lead	7.78	3.71	1.86	21.69
Molybdenum	2.11	0.33	1.76	1.47
Nickel	2.20	1.74	1.30	2.79
Zinc	15.59	4.31	3.48	34.35
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	17.90	<LOR	<LOR	49.80
C29-C36	29.20	<LOR	<LOR	42.40
Total (C6-C36)	47.00	<LOR	<LOR	92.20
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	85.90	74.00	116.00	43.30
Total Phosphorous	11.10	2.88	2.56	32.20
Faecal Coliform (cfu/g)	<LOR	460.0	<LOR	<LOR
Manganese	28.40	3.64	3.94	46.60
Vanadium	14.80	55.90	18.80	11.50

Borehole ID	RC/40166			
Sample Depth (m)	1.5	3.0	4.5	0.5
Metals (mg/kg)				
Arsenic	15.11	9.62	11.16	88.16
Antimony	6.83	1.98	2.54	2.86
Barium	3.50	3.05	2.69	25.91
Cadmium	0.52	0.22	0.22	0.41
Chromium	19.74	14.69	27.59	32.09
Cobalt	1.15	0.53	0.65	0.49
Copper	11.64	10.99	11.11	88.59
Mercury	0.05	0.04	<LOR	0.87
Lead	11.68	8.51	10.56	44.03
Molybdenum	0.43	0.23	0.23	0.29
Nickel	4.17	1.80	1.76	3.49
Zinc	16.50	8.93	13.11	70.43
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	520.60	<LOR	<LOR
C15-C28	<LOR	907.70	10.7	14.90
C29-C36	<LOR	307.20	<LOR	15.30
Total (C6-C36)	<LOR	1735.50	10.7	30.20
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	42.90	38.30	47.70	169.00
Total Phosphorous	1.59	1.66	2.02	16.50
Manganese	6.16	3.31	3.96	32.60
Vanadium	35.80	31.70	47.20	45.70



Borehole ID	RC/40170			
Sample Depth (m)	0.5	1.5	3.0	1.0
Metals (mg/kg)				
Arsenic	14.55	1.67	2.82	8.64
Antimony	<LOR	<LOR	<LOR	<LOR
Barium	7.75	11.90	14.90	5.62
Cadmium	0.25	0.21	0.19	0.19
Chromium	5.62	0.43	0.45	3.83
Cobalt	0.31	<LOR	0.24	0.21
Copper	7.84	2.04	1.92	5.74
Mercury	0.06	<LOR	<LOR	0.04
Lead	8.11	37.56	34.01	6.56
Molybdenum	0.90	<LOR	0.34	0.48
Nickel	1.57	1.03	1.05	1.15
Zinc	32.83	8.06	7.65	21.15
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	30.70	16.60	<LOR	24.30
C29-C36	40.60	<LOR	<LOR	39.90
Total (C6-C36)	71.20	16.60	<LOR	64.20
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	702.00	66.40	28.90	730.00
Total Phosphorous	468.00	5.06	2.19	572.00
Faecal Coliform (cfu/g)	40.0	90.0	<LOR	20.0
Manganese	27.20	89.60	103.00	23.60
Vanadium	7.27	1.76	2.52	5.58

Borehole ID	RC/40169			
Sample Depth (m)	0.5	7.5	10.5	3.5
Metals (mg/kg)				
Arsenic	10.79	28.61	11.63	8.19
Antimony	2.82	5.24	<LOR	<LOR
Barium	64.28	8.99	6.32	19.22
Cadmium	0.59	0.29	<LOR	0.20
Chromium	15.42	1.82	0.87	6.90
Cobalt	1.82	<LOR	<LOR	1.15
Copper	34.60	3.71	1.69	9.51
Mercury	0.24	0.05	0.04	0.04
Lead	63.26	9.39	3.94	12.19
Molybdenum	1.93	1.61	0.32	0.75
Nickel	5.70	1.92	0.54	2.70
Zinc	180.11	10.83	4.13	19.84
SVOCs (mg/kg)				
Phthalates (total)	0.3	<LOR	<LOR	<LOR
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	43.60	14.10	<LOR	10.80
C29-C36	86.60	<LOR	<LOR	11.30
Total (C6-C36)	130.10	14.10	<LOR	22.10
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	110.00	70.50	40.80	44.20
Total Phosphorous	33.60	3.59	3.94	28.30
Faecal Coliform (cfu/g)	90.0	240.0	10.0	<LOR
Manganese	74.90	30.80	7.15	44.30
Vanadium	21.30	4.15	1.45	13.40

Borehole ID	RC/40171			
Sample Depth (m)	0.5	1.5	3.0	5.5
Metals (mg/kg)				
Arsenic	7.87	6.20	2.04	<LOR
Antimony	2.14	<LOR	<LOR	<LOR
Barium	3.38	1.25	1.90	1.76
Cadmium	0.07	0.06	0.07	0.07
Chromium	0.30	0.21	0.30	0.47
Cobalt	<LOR	<LOR	<LOR	<LOR
Copper	4.09	2.01	3.69	3.53
Mercury	0.03	<LOR	0.04	0.04
Lead	5.60	3.08	8.89	6.47
Molybdenum	0.95	0.66	0.31	0.34
Nickel	0.60	0.37	0.50	0.36
Zinc	4.39	1.35	2.29	1.45
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	<LOR	15.50	<LOR
C15-C28	16.80	<LOR	<LOR	<LOR
C29-C36	<LOR	<LOR	<LOR	<LOR
Total (C6-C36)	16.80	<LOR	15.50	<LOR
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	91.70	17.20	27.70	24.70
Total Phosphorous	4.43	3.63	2.95	3.66
Faecal Coliform (cfu/g)	<LOR	<LOR	<LOR	<LOR
Manganese	2.99	2.44	10.60	7.27
Vanadium	0.72	0.51	0.53	0.48

Legend

- Study Area
- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
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- Biodiversity Study Area

Previous Study

- 1W92

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	SAG	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

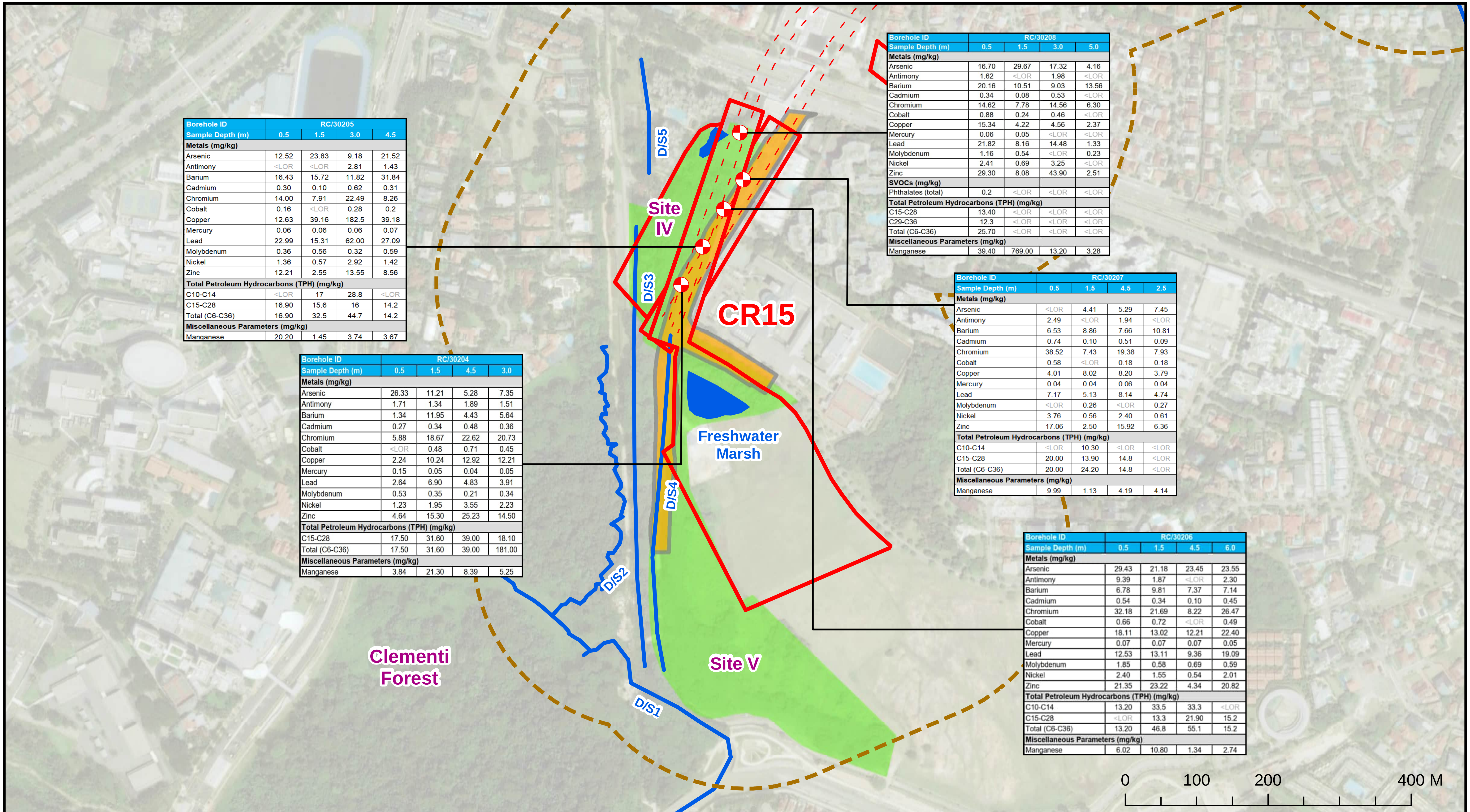
Figure Title :

AVAILABLE SOIL ANALYTICAL RESULTS AT TURF CITY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SAG	NHT	JAG	9 - 3	-	1 of 1

Drawn	Date	CAD File Name :	A3
SAG	AUG 2022	NA	

Note: Source of basemap - Google Earth Map



Borehole ID	RC/30205			
Sample Depth (m)	0.5	1.5	3.0	4.5
Metals (mg/kg)				
Arsenic	12.52	23.83	9.18	21.52
Antimony	<LOR	<LOR	2.81	1.43
Barium	16.43	15.72	11.82	31.84
Cadmium	0.30	0.10	0.62	0.31
Chromium	14.00	7.91	22.49	8.26
Cobalt	0.16	<LOR	0.28	0.2
Copper	12.63	39.16	182.5	39.18
Mercury	0.06	0.06	0.06	0.07
Lead	22.99	15.31	62.00	27.09
Molybdenum	0.36	0.56	0.32	0.59
Nickel	1.36	0.57	2.92	1.42
Zinc	12.21	2.55	13.55	8.56
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	17	28.8	<LOR
C15-C28	16.90	15.6	16	14.2
Total (C6-C36)	16.90	32.5	44.7	14.2
Miscellaneous Parameters (mg/kg)				
Manganese	20.20	1.45	3.74	3.67

Borehole ID	RC/30204			
Sample Depth (m)	0.5	1.5	4.5	3.0
Metals (mg/kg)				
Arsenic	26.33	11.21	5.28	7.35
Antimony	1.71	1.34	1.89	1.51
Barium	1.34	11.95	4.43	5.64
Cadmium	0.27	0.34	0.48	0.36
Chromium	5.88	18.67	22.62	20.73
Cobalt	<LOR	0.48	0.71	0.45
Copper	2.24	10.24	12.92	12.21
Mercury	0.15	0.05	0.04	0.05
Lead	2.64	6.90	4.83	3.91
Molybdenum	0.53	0.35	0.21	0.34
Nickel	1.23	1.95	3.55	2.23
Zinc	4.64	15.30	25.23	14.50
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	17.50	31.60	39.00	18.10
Total (C6-C36)	17.50	31.60	39.00	181.00
Miscellaneous Parameters (mg/kg)				
Manganese	3.84	21.30	8.39	5.25

Borehole ID	RC/30208			
Sample Depth (m)	0.5	1.5	3.0	5.0
Metals (mg/kg)				
Arsenic	16.70	29.67	17.32	4.16
Antimony	1.62	<LOR	1.98	<LOR
Barium	20.16	10.51	9.03	13.56
Cadmium	0.34	0.08	0.53	<LOR
Chromium	14.62	7.78	14.56	6.30
Cobalt	0.88	0.24	0.46	<LOR
Copper	15.34	4.22	4.56	2.37
Mercury	0.06	0.05	<LOR	<LOR
Lead	21.82	8.16	14.48	1.33
Molybdenum	1.16	0.54	<LOR	0.23
Nickel	2.41	0.69	3.25	<LOR
Zinc	29.30	8.08	43.90	2.51
SVOCs (mg/kg)				
Phthalates (total)	0.2	<LOR	<LOR	<LOR
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	13.40	<LOR	<LOR	<LOR
C29-C36	12.3	<LOR	<LOR	<LOR
Total (C6-C36)	25.70	<LOR	<LOR	<LOR
Miscellaneous Parameters (mg/kg)				
Manganese	39.40	769.00	13.20	3.28

Borehole ID	RC/30207			
Sample Depth (m)	0.5	1.5	4.5	2.5
Metals (mg/kg)				
Arsenic	<LOR	4.41	5.29	7.45
Antimony	2.49	<LOR	1.94	<LOR
Barium	6.53	8.86	7.66	10.81
Cadmium	0.74	0.10	0.51	0.09
Chromium	38.52	7.43	19.38	7.93
Cobalt	0.58	<LOR	0.18	0.18
Copper	4.01	8.02	8.20	3.79
Mercury	0.04	0.04	0.06	0.04
Lead	7.17	5.13	8.14	4.74
Molybdenum	<LOR	0.26	<LOR	0.27
Nickel	3.76	0.56	2.40	0.61
Zinc	17.06	2.50	15.92	6.36
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	10.30	<LOR	<LOR
C15-C28	20.00	13.90	14.8	<LOR
Total (C6-C36)	20.00	24.20	14.8	<LOR
Miscellaneous Parameters (mg/kg)				
Manganese	9.99	1.13	4.19	4.14

Borehole ID	RC/30206			
Sample Depth (m)	0.5	1.5	4.5	6.0
Metals (mg/kg)				
Arsenic	29.43	21.18	23.45	23.55
Antimony	9.39	1.87	<LOR	2.30
Barium	6.78	9.81	7.37	7.14
Cadmium	0.54	0.34	0.10	0.45
Chromium	32.18	21.69	8.22	26.47
Cobalt	0.66	0.72	<LOR	0.49
Copper	18.11	13.02	12.21	22.40
Mercury	0.07	0.07	0.07	0.05
Lead	12.53	13.11	9.36	19.09
Molybdenum	1.85	0.58	0.69	0.59
Nickel	2.40	1.55	0.54	2.01
Zinc	21.35	23.22	4.34	20.82
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	13.20	33.5	33.3	<LOR
C15-C28	<LOR	13.3	21.90	15.2
Total (C6-C36)	13.20	46.8	55.1	15.2
Miscellaneous Parameters (mg/kg)				
Manganese	6.02	10.80	1.34	2.74

Legend

- Study Area
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Land Transport Authority
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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

AVAILABLE SOIL ANALYTICAL RESULTS AT HOLLAND PLAIN AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SAG	NHT	JAG	9 - 4	-	1 of 1
	Drawn SAG	Date AUG 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

9.5.3 Groundwater Baseline Results

9.5.3.1 Groundwater Elevation

Based on groundwater elevation data collected as part of previous soil and/ or groundwater investigations carried out within the Study Area, the average groundwater level at Turf City area ranged from +11.23 mSHD to +33.76 mSHD. Within the CR14 construction footprint, and based on the available data, groundwater is expected to be from 0.23 m below ground level (m bgl), down to 12.63 m bgl.

The average groundwater level at Holland Plain area ranged between +10.44 mSHD and +21.76 mSHD, with groundwater observed from 1.18 m bgl to 3.90 m bgl. Overall, groundwater levels are expected to fluctuate as a result of rainfall percolating into the ground and due to seasonal variations.

9.5.3.2 Groundwater Flow Direction and Velocity

The hydraulic gradient was calculated using the EPA On-Line Tools for Site Assessment. Subsequently, the linear velocity of groundwater flow was calculated based on the Darcy's Equation as follows.

The hydraulic gradients (for averaged groundwater levels) calculated using the EPA On-Line Tools for Site Assessment were 0.03947 meter / meter (m/m) and 0.08728 m/m for Turf City and Holland Plain area, respectively. The linear velocity of the groundwater flow was calculated based on the Darcy's Equation as follows:

$$V = \frac{(Ki)}{n}$$

Where	V =	Groundwater flow velocity;
	K =	Theoretical Hydraulic Conductivity;
	n =	Effective porosity; and
	i =	Hydraulic gradient.

The average gradient of groundwater in Turf City area (i.e., CR14 worksite and its vicinity) was calculated to be 0.03947 meter/ meter (m/m). Theoretical hydraulic conductivity and effective porosity of the dominant soil type (i.e., sandy silt) were assumed to be 1×10^{-5} cm/s and 0.43, respectively. Therefore, the calculated velocity of groundwater was 0.29 m per year. Based on groundwater level data collected during gauging and / or sampling events, the inferred regional groundwater flow direction is generally towards Site III where the lowest groundwater levels were observed. Locally, it can be observed that groundwater follows the surrounding topography and flows towards the watercourses. It should be noted that there is limited data pertaining the groundwater flow within Site I and Site II, as the available data is mostly concentrated in the northern sections of these two sites (refer to Figure 9-1).

The average gradient of groundwater in Holland Plain area (i.e. CR15 worksite and its vicinity) was calculated to be 0.08728 m/m. As the dominant soil type in this area is also sandy silt, theoretical hydraulic conductivity and effective porosity were also assumed to be 1×10^{-5} cm/s and 0.43, respectively. Therefore, the calculated velocity of groundwater was 0.64 m per year. Based on groundwater level data collected during gauging and / or sampling events, the inferred groundwater flow direction is generally northeast within Site IV. It should be noted that no soil and groundwater data was available for Site V.

Groundwater seepage velocity varies depending on varying clay, silt and sand contents at a specific location. For that reason, above assessed velocity data should only be used as a guide.

9.5.3.3 Groundwater Quality

Available groundwater analytical results, as presented in soil and groundwater investigation study carried out by SECS [R-71] (refer to Figure 9-5 and Figure 9-6), showed detections of metals such as arsenic, antimony, barium, chromium, cobalt, copper, lead, mercury, molybdenum, zinc as well as detections of TPH.

Parameters, such as barium and TPH were detected in all of the groundwater samples collected in the Turf City area (i.e. northern part of Site II and Site III and their vicinity). Additionally, detections of arsenic, antimony, chromium, molybdenum and zinc were detected in the majority of the samples, while cobalt, copper, lead and mercury were detected in a limited amount of samples. These detections were all below their respective DIVs.

Groundwater analytical results for samples collected in the Holland Plain area (i.e. Site IV) showed detections of metals such as barium, chromium, lead, molybdenum and zinc as well as TPH. Beforementioned metals were detected in majority of the groundwater samples, with exception of molybdenum which was detected only in a sample collected at RC/30208 (below its DIV). The concentrations of the remaining metals were also all below their respective DIVs, with the exception of lead which reported exceedances of its DIV (i.e., 75.2 µg/kg) in RC/30204 and RC/30205 (i.e. 75.2 µg/kg and 95.4 µg/kg, respectively).

Tier 1 Risk Based Assessment [R-71] was carried out for the parameters that exceeded DIV (i.e., lead). The assessment was carried out for conservative scenario that the construction workers could potentially be exposed to groundwater via incidental ingestion. Further analysis (i.e., by using American Society for Testing and Material [ASTM] Standard Guide for Risk-Based Corrective Action and USEPA Screening Levels) showed that the concentration of lead is below screening level and therefore does not present unacceptable risk to human health for future construction workers.

Additionally, the groundwater samples collected at CR14, and its vicinity were also analysed for concentrations of TN, TP, Faecal Coliforms and vanadium. Reported concentrations of TN and TP ranged from 0.11 mg/L to 3.03 mg/L and from 0.094 mg/L to 0.18 mg/L, respectively. Faecal Coliforms were detected at concentrations from 48 cfu/100ml to 1,600 cfu/100ml. Concentration of vanadium was below LOR.

The groundwater samples were also tested for and compared to parameters defined in the NEA Trade Effluent Discharge limits for controlled watercourse, watercourse and public sewer. The majority of the parameters detected were below their respective trade effluent discharge limits.

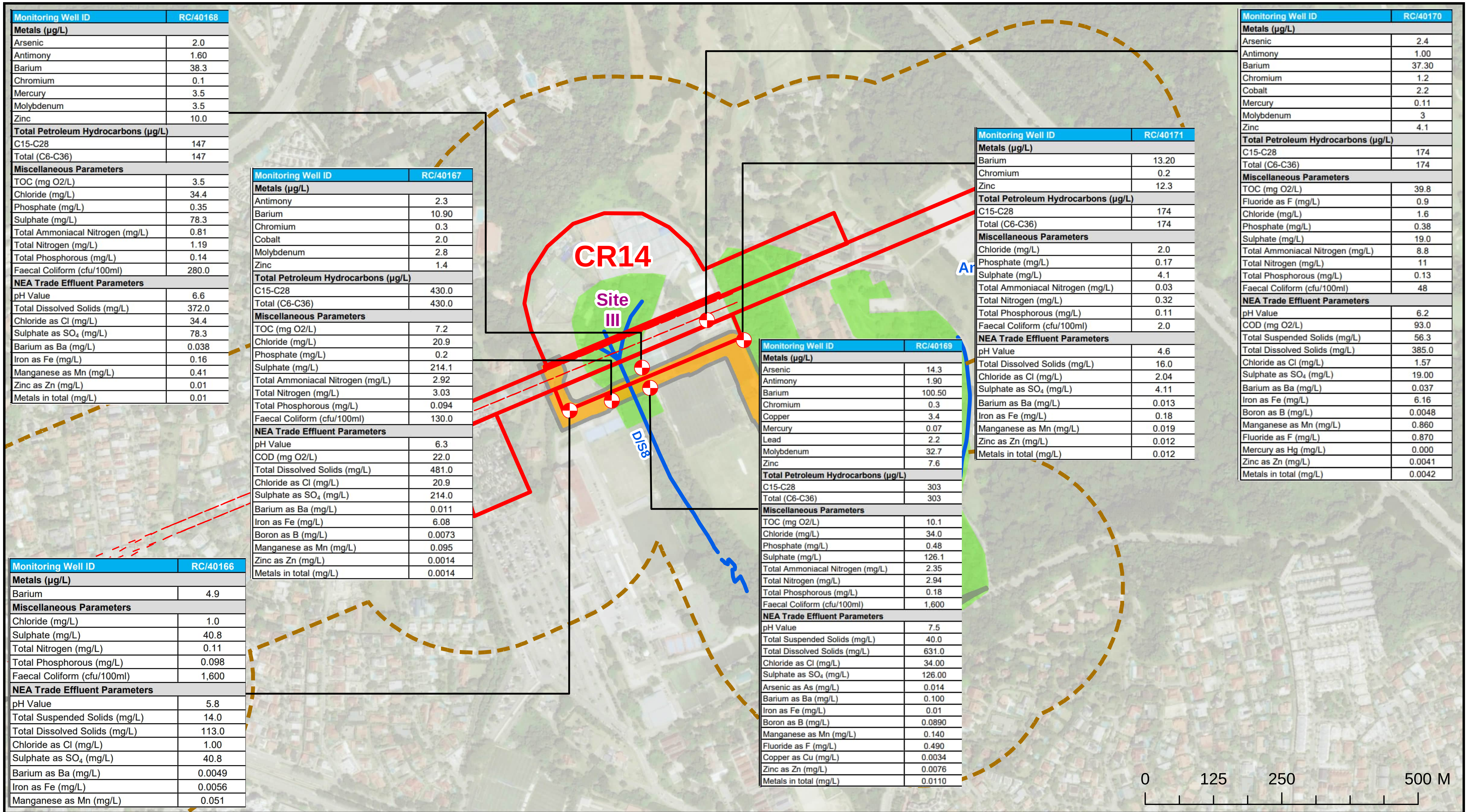
Review of groundwater analytical results from samples collected at the CR14 worksite and its vicinity showed the following exceedances:

- pH value in RC/40166 (i.e. 5.8) and RC/40171 (i.e. 4.6) were slightly below limits for pH value (i.e. 6-9);
- COD in RC/40171 (i.e. 93 mg O_2/L) exceeded the limit for Controlled Watercourse (i.e. 60 mg O_2/L);
- TSS in RC/40169 (i.e. 40 mg/L) exceeded limit for Controlled Watercourse (i.e. 30 mg/L) while TSS in RC/40170 (i.e. 56.3 mg/L) exceeded limits for both Watercourse and Controlled Watercourse (i.e. 50 mg/L and 30 mg/L);
- Sulphate as SO_4 in RC/40167 (i.e., 214 mg/L) exceeded the limit for Controlled Watercourse (i.e. 200 mg/L);
- Arsenic as in RC/40169 (i.e. 0.014 mg/L) exceeded the limit for Controlled Watercourse (i.e. 0.01 mg/L);
- Iron as Fe in RC/40167 (i.e., 6.08 mg/L) RC/40169 (i.e. 6.16 mg/L) exceeded the limit for Controlled Watercourse (i.e. 1 mg/L); and
- Manganese as Mn in RC/40170 (i.e., 0.86 mg/L) exceeded the limit for Controlled Watercourse (i.e. 0.5 mg/L).

No exceedances were reported in groundwater analytical results from samples collected at the CR15 worksite and its vicinity.

The source(s) of parameters detected above their respective LORs in groundwater samples could not be conclusively ascertained. Presence of metals, chloride, phosphates, TN and TP is a common occurrence in groundwaters due to the naturally-occurring processes (e.g. leachate and migration from soil) and anthropogenic activities. The presence of Faecal Coliforms in certain groundwater samples is possible to have originated from faecal matter of faunal species from the surrounding environment (e.g., Site I, Site II, Site III).

Based on physicochemical measurements of groundwater during the field activities carried out as part of soil and groundwater investigation [R-71] the groundwater beneath the CR14 and CR15 worksites can be described as generally acidic. Furthermore, during well development and sampling events presence of non-aqueous phase liquid (NAPL) was not observed.



Monitoring Well ID	RC/40168
Metals (µg/L)	
Arsenic	2.0
Antimony	1.60
Barium	38.3
Chromium	0.1
Mercury	3.5
Molybdenum	3.5
Zinc	10.0
Total Petroleum Hydrocarbons (µg/L)	
C15-C28	147
Total (C6-C36)	147
Miscellaneous Parameters	
TOC (mg O2/L)	3.5
Chloride (mg/L)	34.4
Phosphate (mg/L)	0.35
Sulphate (mg/L)	78.3
Total Ammoniacal Nitrogen (mg/L)	0.81
Total Nitrogen (mg/L)	1.19
Total Phosphorous (mg/L)	0.14
Faecal Coliform (cfu/100ml)	280.0
NEA Trade Effluent Parameters	
pH Value	6.6
Total Dissolved Solids (mg/L)	372.0
Chloride as Cl (mg/L)	34.4
Sulphate as SO_4 (mg/L)	78.3
Barium as Ba (mg/L)	0.038
Iron as Fe (mg/L)	0.16
Manganese as Mn (mg/L)	0.41
Zinc as Zn (mg/L)	0.01
Metals in total (mg/L)	0.01

Monitoring Well ID	RC/40167
Metals (µg/L)	
Antimony	2.3
Barium	10.90
Chromium	0.3
Cobalt	2.0
Molybdenum	2.8
Zinc	1.4
Total Petroleum Hydrocarbons (µg/L)	
C15-C28	430.0
Total (C6-C36)	430.0
Miscellaneous Parameters	
TOC (mg O2/L)	7.2
Chloride (mg/L)	20.9
Phosphate (mg/L)	0.2
Sulphate (mg/L)	214.1
Total Ammoniacal Nitrogen (mg/L)	2.92
Total Nitrogen (mg/L)	3.03
Total Phosphorous (mg/L)	0.094
Faecal Coliform (cfu/100ml)	130.0
NEA Trade Effluent Parameters	
pH Value	6.3
COD (mg O2/L)	22.0
Total Dissolved Solids (mg/L)	481.0
Chloride as Cl (mg/L)	20.9
Sulphate as SO_4 (mg/L)	214.0
Barium as Ba (mg/L)	0.011
Iron as Fe (mg/L)	6.08
Boron as B (mg/L)	0.0073
Manganese as Mn (mg/L)	0.095
Zinc as Zn (mg/L)	0.0014
Metals in total (mg/L)	0.0014

Monitoring Well ID	RC/40171
Metals (µg/L)	
Barium	13.20
Chromium	0.2
Zinc	12.3
Total Petroleum Hydrocarbons (µg/L)	
C15-C28	174
Total (C6-C36)	174
Miscellaneous Parameters	
Chloride (mg/L)	2.0
Phosphate (mg/L)	0.17
Sulphate (mg/L)	4.1
Total Ammoniacal Nitrogen (mg/L)	0.03
Total Nitrogen (mg/L)	0.32
Total Phosphorous (mg/L)	0.11
Faecal Coliform (cfu/100ml)	2.0
NEA Trade Effluent Parameters	
pH Value	4.6
Total Dissolved Solids (mg/L)	16.0
Chloride as Cl (mg/L)	2.04
Sulphate as SO_4 (mg/L)	4.11
Barium as Ba (mg/L)	0.013
Iron as Fe (mg/L)	0.18
Manganese as Mn (mg/L)	0.019
Zinc as Zn (mg/L)	0.012
Metals in total (mg/L)	0.012

Monitoring Well ID	RC/40170
Metals (µg/L)	
Arsenic	2.4
Antimony	1.00
Barium	37.30
Chromium	1.2
Cobalt	2.2
Mercury	0.11
Molybdenum	3
Zinc	4.1
Total Petroleum Hydrocarbons (µg/L)	
C15-C28	174
Total (C6-C36)	174
Miscellaneous Parameters	
TOC (mg O2/L)	39.8
Fluoride as F (mg/L)	0.9
Chloride (mg/L)	1.6
Phosphate (mg/L)	0.38
Sulphate (mg/L)	19.0
Total Ammoniacal Nitrogen (mg/L)	8.8
Total Nitrogen (mg/L)	11
Total Phosphorous (mg/L)	0.13
Faecal Coliform (cfu/100ml)	48
NEA Trade Effluent Parameters	
pH Value	6.2
COD (mg O2/L)	93.0
Total Suspended Solids (mg/L)	56.3
Total Dissolved Solids (mg/L)	385.0
Chloride as Cl (mg/L)	1.57
Sulphate as SO_4 (mg/L)	19.00
Barium as Ba (mg/L)	0.037
Iron as Fe (mg/L)	6.16
Boron as B (mg/L)	0.0048
Manganese as Mn (mg/L)	0.860
Fluoride as F (mg/L)	0.870
Mercury as Hg (mg/L)	0.000
Zinc as Zn (mg/L)	0.0041
Metals in total (mg/L)	0.0042

Monitoring Well ID	RC/40169
Metals (µg/L)	
Arsenic	14.3
Antimony	1.90
Barium	100.50
Chromium	0.3
Copper	3.4
Mercury	0.07
Lead	2.2
Molybdenum	32.7
Zinc	7.6
Total Petroleum Hydrocarbons (µg/L)	
C15-C28	303
Total (C6-C36)	303
Miscellaneous Parameters	
TOC (mg O2/L)	10.1
Chloride (mg/L)	34.0
Phosphate (mg/L)	0.48
Sulphate (mg/L)	126.1
Total Ammoniacal Nitrogen (mg/L)	2.35
Total Nitrogen (mg/L)	2.94
Total Phosphorous (mg/L)	0.18
Faecal Coliform (cfu/100ml)	1,600
NEA Trade Effluent Parameters	
pH Value	7.5
Total Suspended Solids (mg/L)	40.0
Total Dissolved Solids (mg/L)	631.0
Chloride as Cl (mg/L)	34.00
Sulphate as SO_4 (mg/L)	126.00
Arsenic as As (mg/L)	0.014
Barium as Ba (mg/L)	0.100
Iron as Fe (mg/L)	0.01
Boron as B (mg/L)	0.0890
Manganese as Mn (mg/L)	0.140
Fluoride as F (mg/L)	0.490
Copper as Cu (mg/L)	0.0034
Zinc as Zn (mg/L)	0.0076
Metals in total (mg/L)	0.0110

Monitoring Well ID	RC/40166
Metals (µg/L)	
Barium	4.9
Miscellaneous Parameters	
Chloride (mg/L)	1.0
Sulphate (mg/L)	40.8
Total Nitrogen (mg/L)	0.11
Total Phosphorous (mg/L)	0.098
Faecal Coliform (cfu/100ml)	1,600
NEA Trade Effluent Parameters	
pH Value	5.8
Total Suspended Solids (mg/L)	14.0
Total Dissolved Solids (mg/L)	113.0
Chloride as Cl (mg/L)	1.00
Sulphate as SO_4 (mg/L)	40.8
Barium as Ba (mg/L)	0.0049
Iron as Fe (mg/L)	0.0056
Manganese as Mn (mg/L)	0.051

Legend

- Study Area
- Watercourses
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Report_ID

- 1W92

N

Rev.	Date	By	Description	Chk'd	App'd
A	SEP 2022	SAG	EIS (Turf City and Holland Plain)	NHT	JAG
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Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

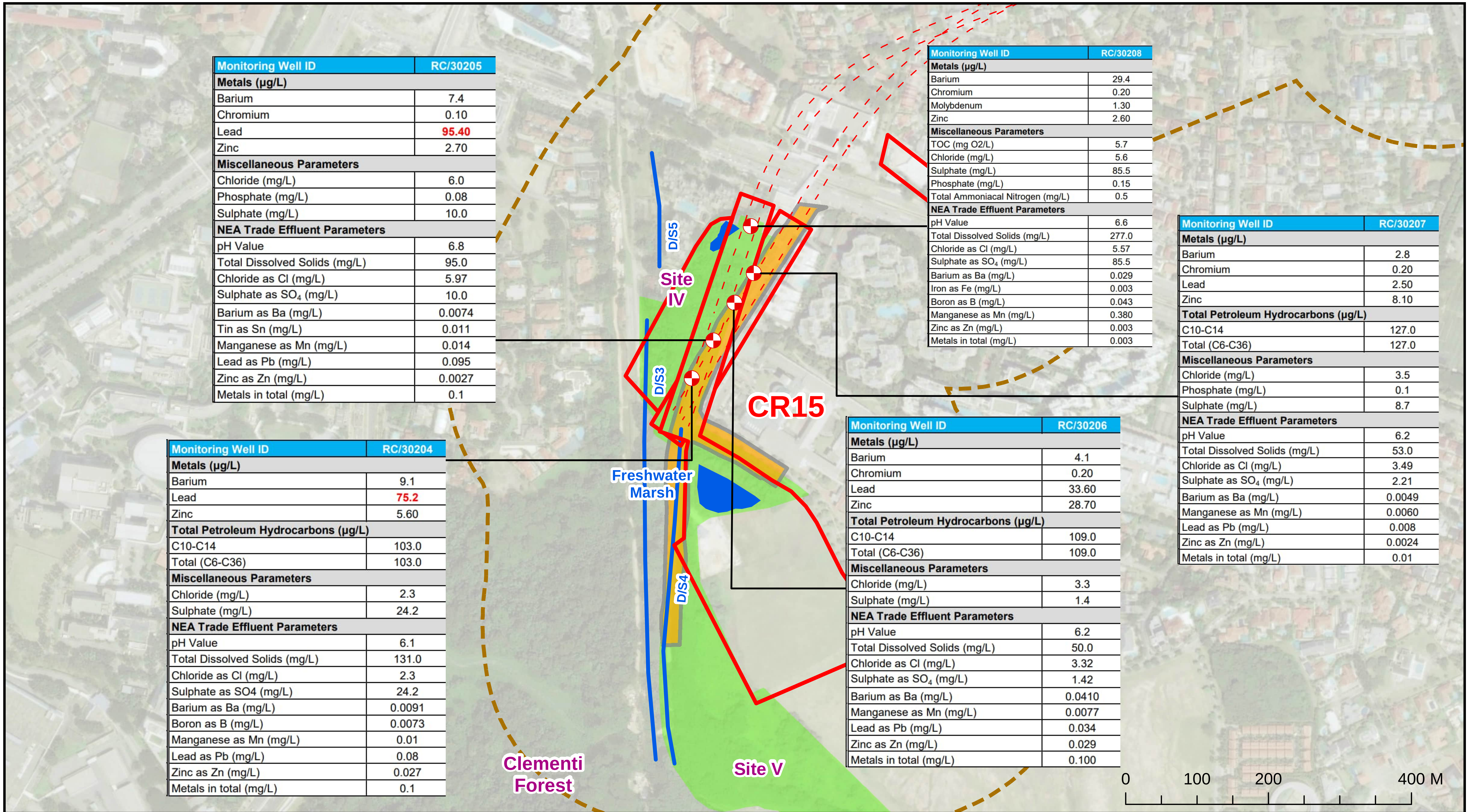
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

AVAILABLE GROUNDWATER ANALYTICAL RESULTS AT CR14 AND ITS VICINITY

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SAG	NHT	JAG	9 - 5	A	1 of 1
Drawn SAG		Date SEP 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map



Monitoring Well ID	RC/30205
Metals (µg/L)	
Barium	7.4
Chromium	0.10
Lead	95.40
Zinc	2.70
Miscellaneous Parameters	
Chloride (mg/L)	6.0
Phosphate (mg/L)	0.08
Sulphate (mg/L)	10.0
NEA Trade Effluent Parameters	
pH Value	6.8
Total Dissolved Solids (mg/L)	95.0
Chloride as Cl (mg/L)	5.97
Sulphate as SO_4 (mg/L)	10.0
Barium as Ba (mg/L)	0.0074
Tin as Sn (mg/L)	0.011
Manganese as Mn (mg/L)	0.014
Lead as Pb (mg/L)	0.095
Zinc as Zn (mg/L)	0.0027
Metals in total (mg/L)	0.1

Monitoring Well ID	RC/30208
Metals (µg/L)	
Barium	29.4
Chromium	0.20
Molybdenum	1.30
Zinc	2.60
Miscellaneous Parameters	
TOC (mg O2/L)	5.7
Chloride (mg/L)	5.6
Sulphate (mg/L)	85.5
Phosphate (mg/L)	0.15
Total Ammoniacal Nitrogen (mg/L)	0.5
NEA Trade Effluent Parameters	
pH Value	6.6
Total Dissolved Solids (mg/L)	277.0
Chloride as Cl (mg/L)	5.57
Sulphate as SO_4 (mg/L)	85.5
Barium as Ba (mg/L)	0.029
Iron as Fe (mg/L)	0.003
Boron as B (mg/L)	0.043
Manganese as Mn (mg/L)	0.380
Zinc as Zn (mg/L)	0.003
Metals in total (mg/L)	0.003

Monitoring Well ID	RC/30207
Metals (µg/L)	
Barium	2.8
Chromium	0.20
Lead	2.50
Zinc	8.10
Total Petroleum Hydrocarbons (µg/L)	
C10-C14	127.0
Total (C6-C36)	127.0
Miscellaneous Parameters	
Chloride (mg/L)	3.5
Phosphate (mg/L)	0.1
Sulphate (mg/L)	8.7
NEA Trade Effluent Parameters	
pH Value	6.2
Total Dissolved Solids (mg/L)	53.0
Chloride as Cl (mg/L)	3.49
Sulphate as SO_4 (mg/L)	2.21
Barium as Ba (mg/L)	0.0049
Manganese as Mn (mg/L)	0.0060
Lead as Pb (mg/L)	0.008
Zinc as Zn (mg/L)	0.0024
Metals in total (mg/L)	0.01

Monitoring Well ID	RC/30204
Metals (µg/L)	
Barium	9.1
Lead	75.2
Zinc	5.60
Total Petroleum Hydrocarbons (µg/L)	
C10-C14	103.0
Total (C6-C36)	103.0
Miscellaneous Parameters	
Chloride (mg/L)	2.3
Sulphate (mg/L)	24.2
NEA Trade Effluent Parameters	
pH Value	6.1
Total Dissolved Solids (mg/L)	131.0
Chloride as Cl (mg/L)	2.3
Sulphate as SO4 (mg/L)	24.2
Barium as Ba (mg/L)	0.0091
Boron as B (mg/L)	0.0073
Manganese as Mn (mg/L)	0.01
Lead as Pb (mg/L)	0.08
Zinc as Zn (mg/L)	0.027
Metals in total (mg/L)	0.1

Monitoring Well ID	RC/30206
Metals (µg/L)	
Barium	4.1
Chromium	0.20
Lead	33.60
Zinc	28.70
Total Petroleum Hydrocarbons (µg/L)	
C10-C14	109.0
Total (C6-C36)	109.0
Miscellaneous Parameters	
Chloride (mg/L)	3.3
Sulphate (mg/L)	1.4
NEA Trade Effluent Parameters	
pH Value	6.2
Total Dissolved Solids (mg/L)	50.0
Chloride as Cl (mg/L)	3.32
Sulphate as SO_4 (mg/L)	1.42
Barium as Ba (mg/L)	0.0410
Manganese as Mn (mg/L)	0.0077
Lead as Pb (mg/L)	0.034
Zinc as Zn (mg/L)	0.029
Metals in total (mg/L)	0.100

Legend

- Study Area
- Watercourses
- Proposed CRL Alignment (Base)
- Construction Worksite Footprint (Base)
- Planned Roadworks
- Biodiversity Study Area

Previous Studies

- 1W92

N

Rev.	Date	By	Description	Chk'd	App'd
A	SEP 2022	SAG	EIS (Turf City and Holland Plain)	NHT	JAG
-	AUG 2022	SAG	EIS (Turf City and Holland Plain)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

AVAILABLE GROUNDWATER ANALYTIC RESULTS AT CR15 AND ITS VICINITY

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
SAG	NHT	JAG	9 - 6	A	1 of 1
Drawn SAG		Date SEP 2022	CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

9.6 Potential Sources of Soil and Groundwater Impacts

Soil and groundwater can be potentially exposed to contaminants due to activities during the construction and operational phases of the Project.

9.6.1 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 lead to contamination of the soil and groundwater during the construction phase are listed in Table 9-3.

Table 9-3 Potential Sources of Soil and Groundwater Impacts (Construction Phase)

Activity	Potential Sources of Impacts	Potential Associated Impacts
Site Clearance, levelling and land grading works Construction of shaft, station boxes, facility buildings and other infrastructures	Increased runoff from hard standing surface resulting in decreased infiltration into the ground Disposal of wastewater generated from tunnelling activities Groundwater from dewatering from excavated areas	Decreased groundwater baseflow feeding into potential streams Potential groundwater drawdown due to dewatering process during tunnelling activities
Excavation of cut and cover areas Stockpiling of excavated soil from cut and cover areas and tunnel boring activities Improper management and disposal of excavated soils and/or groundwater during excavations and tunnel boring activities	Exposure of land and stockpiles from the various construction activities Contaminated excavated soils (if encountered), if not stored, handled, transported and disposed properly, can lead to direct or indirect contamination Wastewater generated from tunnelling activities	Soil erosion of exposed soil from excavation and stockpiles Potential for direct soil and/or groundwater contamination within the study area Potential pollution to the adjacent areas within the immediate vicinity of the project due to migration of soil and groundwater contamination, off-site Potential contamination to the surface watercourses located in the vicinity of the construction site (its impact will be assessed in Section 8)
Improper handling, transfer and storage of toxic chemical waste	• Discharge of toxic chemical waste due to spillage or leakage during storage, handling and transfer • Inappropriate or inadequate design parameters for storage containers	Potential for direct soil and/ or groundwater contamination within the Study Area Potential pollution to the adjacent areas within the immediate vicinity of the Project due to migration of soil and groundwater contamination, off-site
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.	• Discharge of chemical due to spillage or leakage during storage, handling, transfer and refuelling (oil, grease or other chemical substance release) • Inappropriate or inadequate design parameters for storage containers	

The proposed minimum controls or stand practices commonly implemented in Singapore are discussed in Section 9.7.

9.6.2 Operational Phase

It is anticipated that there will be limited sources of impacts to soil and groundwater during the operational phase as use of chemicals and generation of toxic chemical waste are expected to be of limited quantities. Hazardous waste generated during the operational phase are associated to maintenance works on the alignment, stations and facility buildings while non-hazardous waste generations are expected to be generated from the site office staff's general waste within the station.

The activities which could lead to contamination of the soil and groundwater during the operational phase are listed in Table 9-4.

Table 9-4 Potential Sources of Soil and Groundwater Impacts (Operational Phase)

Activity	Potential Sources of Impacts	Potential Associated Impacts
Maintenance works on the alignment and facility building	Small quantities of toxic chemical waste generated during maintenance works and operational phase (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e., thinner, paints, lubricants, etc.) Operation of the trains resulting in diesel oil leakage Improper handling of hazardous chemicals/ substances during operational phase	For maintenance activities within the alignment, toxic chemicals waste leakage could occur and seep into the wastewater drainage within the alignment and/or into the soil and groundwater For general maintenance for the stations and facility buildings, hazardous waste from equipment could potentially leak into drainage systems and/ or into the soil and groundwater Potential pollution within the Study Area where toxic chemicals and waste are stored

The proposed minimum controls or standard practices commonly implemented in Singapore are discussed in Section 9.7.

9.7 Minimum Control for Potential Impacts

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

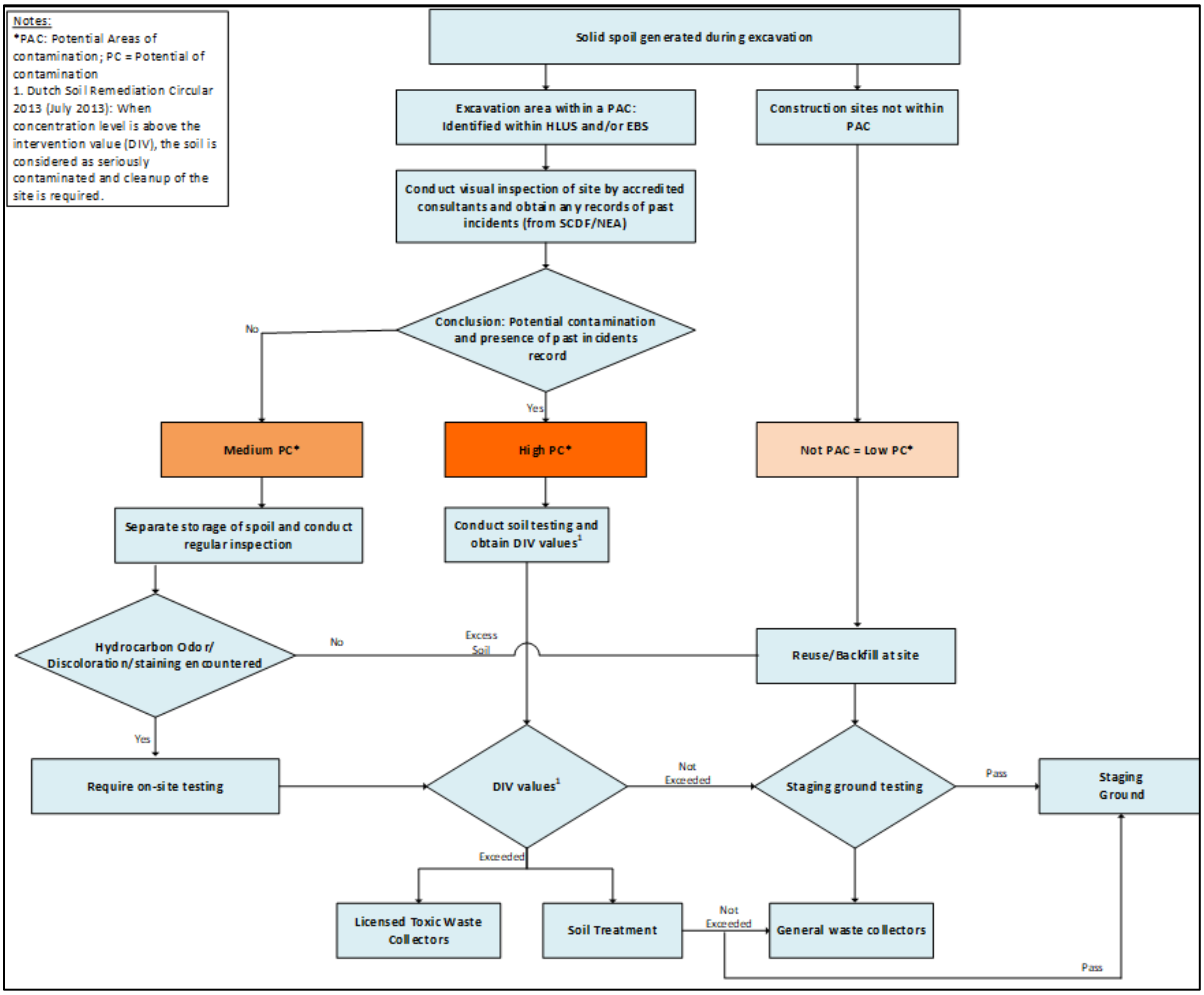
9.7.1 Construction Phase

Table 9-5 sets out the minimum controls that have been identified for the project during construction phase. Regular inspection and workers training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the site staff on site.

Table 9-5 Minimum Controls during Construction Phase (Soil and Groundwater)

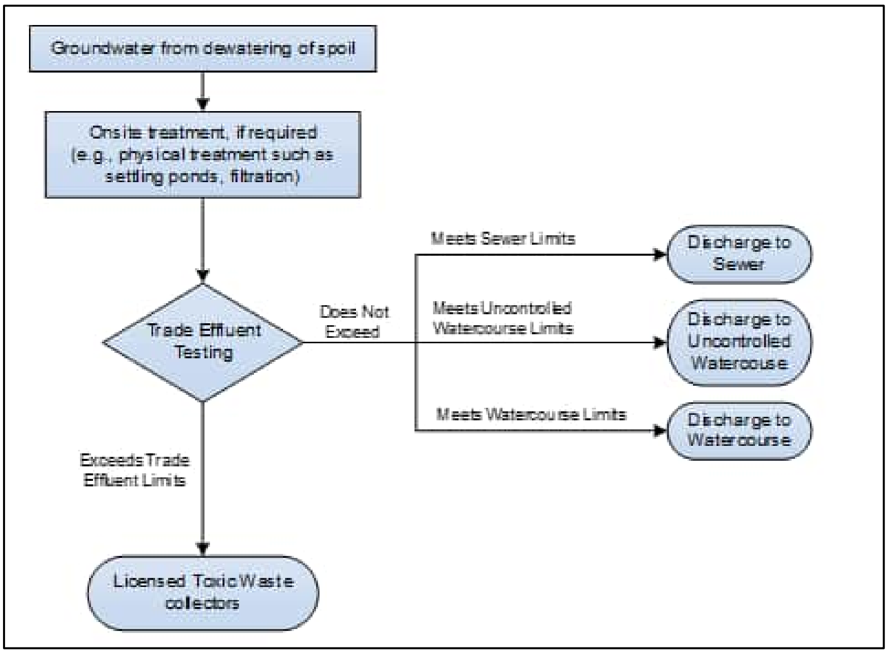
Potential Sources of Impacts	Minimum Controls
Decreased groundwater baseflow feeding into the streams	Install piezometers to monitor the changes in groundwater level in compliance with Building Control Regulations 2003 as part of its instrumentation and monitoring plan to be endorsed by the Qualified Professional (QP) Proper Earth Retaining Stabilising Structures (ERSS) should be selected and designed to limit groundwater settlement
Improper management and disposal of excavated soils and/or groundwater during excavations and tunnel boring activities	Identify all types of solid waste (e.g., tunnelling 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 9-7. This flow chart explains how to handle excavated soils, and identify potential areas of contamination as well as potential of contamination (POC) in excavated soils. If the POC 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. A site management plan should include plans of safe handling, transfer and storage of excavated soils following the procedure in Figure 9-7. Discharge of extracted groundwater shall be to an area approved for such disposal by the NEA and PUB and following the process set out in Figure 9-8. PUB should be consulted and approval should be obtained prior to any discharges into sewer and/ or controlled watercourse. Based on the results of the soil and groundwater baseline study, the detected concentrations of lead in some of the groundwater samples taken in the vicinity of CR15 exceed the DIV. Therefore, 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

Potential Sources of Impacts	Minimum Controls
	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 9-7.
Toxic Chemical Waste and Wastewater Generation during Construction Phase	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 tunnelling activities should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor. Contractor will need to seek approval from both relevant authorities (e.g., 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 of.
Improper Handling of Hazardous Chemicals/Substances during Construction Phase	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 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.



Note: 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.

Figure 9-7 Screening and Disposal of Excavated Soils



Note: DIVs for groundwater consider risks to human health and local ecosystems, whichever is more sensitive. When assessing risk to human health, a typical Dutch residential land use setting is considered which includes exposure via potable consumption of groundwater and consumption of home-grown produce which are not common exposure scenarios for Singapore.

Figure 9-8 Disposal of the Groundwater Generated Through Dewatering or Inflow into Excavations

9.7.2 Operational Phase

Table 9-6 sets out the minimum controls that have been identified for the project during operational phase.

Table 9-6 Minimum Controls during Operational Phase (Soil and Groundwater)

Potential Sources of Impacts	Minimum Controls
Small quantities of toxic chemical waste generated during maintenance works (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.)	Store all toxic chemical waste at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drum and potentially pollutive substances. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. Dispose all toxic waste chemicals to licensed TIW collectors for treatment
Improper handling and storage of hazardous chemicals/ substances during operational phase	Store all hazardous substances/chemicals at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical 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. 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. 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.

9.8 Prediction and Evaluation of Soil and Groundwater Impacts

9.8.1 Construction Phase

9.8.1.1 Decreased Groundwater Baseflow Feeding into the Streams

The streams identified within the Study Area receive water from the upstream surface runoff and rainfall, and potentially baseflow contribution from groundwater. The pre-construction activities (e.g., site clearance, utilities diversion) and main construction activities of shaft, station boxes, facility buildings and other infrastructures of this Project which include deep excavations and dewatering process, could lead to potential impact on groundwater condition of the catchment of the existing waterbodies. Based on the construction timeline (refer to Section 3.4), the construction phase is expected to last approximately for 10 years, and the Project is expected to be constructed phase by phase instead of the whole area together.

Based on the hydrological baseline study (refer to Section 8.5.1.1), at Turf City area, the watercourses studied consists of one (1) roadside concrete drain at upstream of a watercourse (D/S15), one (1) man-made earth drain (D/S8) and one (1) naturalised stream (D/S16) (refer to Figure 8-1). Within forested areas adjacent to Fairway Quarters (i.e., Site I and Site II), two (2) waterbodies have been identified to have high conservation value (i.e., D/S15 and D/S16) due to their importance in sustaining the life of a range of common/ rare faunal species residing in the area. No waterbodies of conservation value have been identified in the forested area within Racecourse Oval (i.e., Site III) (refer to Section 7.5.1). As detailed in Section 8.5.1.1, D/S15 and DS16 are located within Site I and are mostly fed by the surface water runoff from surrounding urban and vegetated areas. However, given the observed bank characteristics and the topography of the surrounding area, it is possible that their flow is also partly supported by groundwater baseflow. Therefore, the waterbodies D/S15 and D/S16 have been categorised as Priority 2 sensitive receptors. The review of proposed construction activities (refer to Section 3.2) shows that some activities, such as construction of shaft, station box, accompanying facilities and/ or infrastructure as well as tunnelling can cause decrease in groundwater levels (e.g., due to required soil dewatering). Furthermore, construction of a potential road under study could also cause decrease in groundwater levels due to change in land use (i.e., reduced percolation into the soil due to increase in impervious surfaces). Based on the inferred groundwater flow (i.e., generally westwards, towards Site III) the construction footprint of CR14 and surrounding structures was assessed to be located downgradient. Therefore, the impact on groundwater levels in the vicinity of D/S15 and D/S16 is expected to be limited, if any. Additionally, phase-by-phase construction and distance of the CR14 construction sites are expected to further reduce the impact on groundwater levels. With regards to construction of a potential road under study in the vicinity of Site I and Site II (and D/S16), it is expected that the groundwater level decrease will not be significant due to proposed road's relatively small area size compared to surrounding catchment areas. Therefore, the impact intensity was considered Low on groundwater baseflow reduction. Based on the sensitivity of receptors (i.e., Priority 2) and assessed impact intensity, the impact consequence was Very Low. Given that the occurrence of the decreased groundwater baseflow is probably during the dry season (i.e., Occasional), the impact significance of the decreased groundwater baseflow to the waterbodies in Turf City area (i.e., D/S15 and D/S16) is Minor and no further mitigation measures were required.

In the Holland Plain area, there are one (1) earth drain (D/S3), two (2) concrete drains (D/S4, D/S5), a few waterbodies (ponds at Site IV, Freshwater Marsh at Site V) (refer to Section 8.5.1.1). This Freshwater Marsh at Site V has been identified as an area of high conservation value because it is a unique and increasingly rare habitat in Singapore, with multiple ecological benefits – it supports a high diversity of fauna and also acts as an important carbon sink. Because this swampy marshland could be partly supported by groundwater inflow, it is categorised as Priority 2 sensitive receptor. The groundwater elevation data is not available for Site V. Although it was assessed that the inferred groundwater flow within site IV is towards northeast, this might not the case within Site V. Namely, based on the available topographic data, the elevation of Site IV decreases from the southwest to the northeast of the site, which is aligned with the inferred groundwater flow for this area (i.e. inferred groundwater flow is towards northeast, as detailed in the Section 9.5.3). However, elevation within Site V decreases from the north to the southwest, implying that the groundwater flow might be in the direction of this elevation decrease (i.e., towards southwest). This would mean that the proposed construction activities would occur upgradient of the groundwater, potentially decreasing groundwater levels. Given the proposed phase-by-phase construction, impact intensity on groundwater level within Site V has been assessed to be Medium. As the freshwater marsh has been categorised as Priority 2 receptor, impact consequence was assessed to be Low (as per Impact Consequence Matrix, as shown in Table 6-6). Hydrology baseline study has found that the swampy marshland within Site V is recharged mainly via runoff originating from immediate vicinity and precipitation directly over the Marsh area. However, given the location of construction footprint (i.e., marshland will be within the construction footprint) it is Likely that the construction activities will impact groundwater level and potentially have an impact on Freshwater Marsh. Therefore, the overall impact significance was assessed to be moderate. To better estimate the hydrogeological conditions underneath the Freshwater Marsh, it is recommended to carry out soil and groundwater investigations in their vicinity which will focus on soil characteristics (e.g. texture, soil type, etc.) and quality as well as groundwater quality and levels. This will help further understand the relationship and dependencies between the marsh habitat and soil and groundwater conditions.

9.8.1.2 Improper Management and Disposal of Excavated Soil and Groundwater

The construction method is expected to generate large amounts of spoil material. The quantity of solid waste stored on site (e.g. excavated soil, 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 9.7).

In the event that contaminated soils or groundwater are encountered during excavations implementation of the measures detailed in Figure 9-7 and Figure 9-8 will ensure that the contaminated soil and/or groundwater is properly managed and disposed.

The overall sensitivity of the soil and groundwater receptors in the Study Area (both at Turf City and Holland Plain area) is considered as Priority 3, as specified in Section 9.3. The available soil and groundwater quality data are limited, with boreholes and monitoring wells located within Site III and its vicinity, vicinity of Site II and Site IV (refer to Figure 9-3 to Figure 9-6). As detailed in Section 9.5, majority of the parameters analysed in collected samples did not exceed their respective DIVs.

Based on HLUS reports, the contamination severity level from the past/ current land uses in the vicinity of CR14 worksite was estimated to be low (refer to Table 9-2). Previous soil and groundwater study carried out in the same area [R-71] reported exceedance in only one (1) near-surface soil sample (i.e. for arsenic, at RC/40166), located west of Site III, within the future planned road works (under study) (refer to Figure 9-3), while none of the groundwater samples reported exceedances of DIVs. Further analysis of available data at this location shows that no detections of arsenic were reported in the groundwater sample collected in the corresponding monitoring well even though the observed groundwater level was relatively high (i.e., 0.58 m bgl). Furthermore, Tier 1 Risk Based Assessment [R-71], carried out for the conservative assumption of construction worker potentially being exposed to such pollution (i.e., exceedance of DIV for arsenic) via ingestion showed that reported concentrations do not represent critical concern (i.e. lower than US EPA risk-based screening level). Therefore, the impact intensity was assessed to be Low. As the soil and groundwater are considered Priority 3 receptors, impact consequence of improper management and disposal of excavated soil and groundwater was estimated to be Very Low. With the implementation of minimum controls, the likelihood of occurrence was expected to be Occasional during the construction phase. Based on the impact consequence and likelihood, and as per Impact Significance Matrix (Table 6-8), the overall impact significance was assessed to be Minor and no further mitigation measures were required. Based on the HLUS reports, the contamination severity level from past land uses within Site I and II is estimated to be low. Furthermore, available soil and groundwater data available at the vicinity of Site II (i.e., RC/40170 and RC/40171) did not report any exceedances of DIVs. Therefore, the impact intensity was assessed to be Low. As per Impact Consequence Matrix, impact consequence for Site I and II was assessed to be Very Low with Occasional likelihood of occurrence (given that the minimal controls have been successfully implemented). The overall impact significance is then Minor and no further mitigation measures were required.

The findings of HLUS reports showed that the contamination severity from the majority of past/ current land uses in the vicinity of CR15 worksite was low, with only contamination severity (if any) from Esso petrol station (Yarwood) located north of Dunearn Road assessed as High. However, previous soil and groundwater study [R-71] carried out at Holland Plain area (i.e., Site IV), has not reported any exceedances of soil DIVs. Exceedance was reported in two (2) groundwater samples (both for lead, at RC/30204 and RC/30205) (refer to Figure 9-6). Taking into consideration inferred groundwater flow and location of Esso petrol station (i.e., downgradient compared to monitoring wells RC/30294 and RC/30205) it is unlikely that these exceedances were caused by the petrol station activities. Furthermore, based on Tier 1 Risk Based Assessment [R-71], carried out for the conservative assumption of construction worker potentially being exposed to such potential pollution (i.e., exceedance of groundwater DIV for lead) during excavations via ingestion, no health risk was identified (i.e., concentrations lower than US EPA risk-based screening level). Therefore, the impact intensity was assessed to be Low. Because soil and groundwater within Study Area are categorised as Priority 3 receptors, impact consequence was assessed to be Very Low. With the implementation of minimum controls, the likelihood of occurrence was expected to be Occasional during the construction phase. Based on the impact consequence and likelihood, and as per Impact Significance Matrix (Table 6-8), the overall impact significance was assessed to be Minor and no further mitigation measures were required. As no data was available for Site V, impact intensity was considered to be Low based on the findings of HLUS reports [R-4, R-5]. With soil and groundwater being Priority 3 receptors, impact consequence was assessed to be Very Low with Occasional likelihood of occurrence (under assumption that minimum controls have been successfully implemented). Therefore, the overall impact significance was assessed to be Minor and no further mitigation measures were required.

9.8.1.3 Toxic Chemical Waste Generation

The quantity of toxic chemical waste stored on site is expected to be limited with the assumption that waste generated on-site will be periodically removed and disposed off-site by licensed Toxic Industrial Waste (TIW) contractors during the construction phase. Based on HLUS reports [R-4, R-5], the contamination severity level was expected to be low from most of the land uses within the Study Area (refer to Table 9-2), with exception of Esso Petrol Station (i.e., high severity of potential contamination). However, as the groundwater flow is inferred to be northeast, Esso petrol station is located downgradient from Site IV and therefore propagation of potential contamination (if any) is unlikely. Therefore, the overall impact intensity is considered Low (localised soil and groundwater impacts which is not likely to extend beyond the project site and possible to remediate), with the impact consequence of soil and/or groundwater contamination assessed to be Very Low.

Based upon implementation of the minimum controls and that the controls are approved by the relevant agency, where applicable, it is unlikely that discharge, spillage or leakage from toxic waste in a quantity that may adversely impact the environment will regularly occur during the construction phase. Mandatory worker training regarding environmental management and spill management and regular site inspections serve as preventative measures for such occurrences. On this basis, the likelihood of occurrence during construction phase is expected to be Occasional.

Overall, based upon an assessment of the likelihood and consequences, and considering the routine, standard industry practices implemented during the construction phase, the potential impact of toxic chemical waste spillage or leakage to soil and/or groundwater is assessed to be Minor. Therefore, no further mitigation measures were required.

9.8.1.4 Improper Handling of Hazardous Chemicals/Substances

Chemicals used during the construction phase will be stored at designated sheltered area provided 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. It is expected that the discharge, spillage or leakage of hazardous chemicals/ substances due to improper handling, if any, will not be in a quantity that will cause significant adverse effects on the surrounding environment and will be possible to remediate (i.e., Low impact intensity). Hence, the impact consequence of potential contamination (Low impact intensity) from chemical spillage is considered to be Very Low during the construction phase.

With the minimum controls being implemented, the likelihood of occurrence of a chemical spill leading to soil and/or groundwater contamination is assessed to be Occasional during construction phase. Therefore, the overall environmental impact of chemical spillage to soil and/or groundwater likely to occur during the construction phase is assessed to be Minor. Therefore, no further mitigation measures were required.

9.8.2 Operational Phase

9.8.2.1 Toxic Chemical Waste Generation during Maintenance Work

For the periodic maintenance work to be conducted along the alignment and facility buildings, it can be expected that toxic chemical waste might be generated in the form of used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e., thinner, paints, lubricants, etc. These toxic wastes are expected to be of limited quantities and disposed of periodically by licensed TIW contractors during the operational phase. The operation of the trains could also potentially result in oil leakage to the rail tracks and possibly ground surface which could potentially cause surface runoff pollution in the event of rain.

The impact intensity is considered Low (localised soil and groundwater impacts which is not likely to extend beyond the project site and possible to remediate), with the impact consequence of soil and/or groundwater contamination assessed to be Very Low.

Based upon implementation of the minimum controls and that the controls are approved by the relevant agency, where applicable, it is unlikely that discharge, spillage or leakage from toxic waste in a quantity that may adversely impact the environment and will only occur during the operational phase as often as maintenance is scheduled. Mandatory worker training regarding environmental management and spill management and regular site inspections serve as preventative measures for such occurrences. For example, in the event where spillage occurs during the maintenance of the alignment, toxic chemicals could possibly enter the drainage system of the alignment and cause pollution downstream with the potential to impact the soil and groundwater. It is imperative to have preventative measures from the source to prevent pollution downstream of the drainage process. On this basis, the likelihood of occurrence during operational phase is expected to be Occasional.

Overall, based upon an assessment of the likelihood and consequences, and considering the routine, standard industry practices implemented during the operational phase, the potential impact of toxic chemical waste spillage or leakage to soil and/or groundwater is assessed to be Minor. Therefore, no further mitigation measures were required.

9.8.2.2 Improper Handling of Hazardous Chemicals/Substances

Chemicals used during the operational phase will be stored at designated maintenance area provided 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 (maintenance team) competent in their use. Based on HLUS reports [R-4, R-5], the contamination severity level are low to most of the land uses within the Study Area (refer to Table 9-2), hence, the impact consequence of potential contamination (Low impact intensity) from chemical spillage is considered to be Very Low during the operational phase.

With the minimum controls being implemented, the likelihood of occurrence of a chemical spill leading to soil and/or groundwater contamination is assessed to be Occasional during operational phase. Therefore, the overall environmental impact of chemical spillage to soil and/or groundwater likely to occur during the construction phase is assessed to be Minor. Therefore, no further mitigation measures were required.

9.9 Recommended Mitigation Measures

9.9.1 Construction Phase

As detailed in Section 9.8, only impact on freshwater marshes from reduction of baseflow was assessed to be Moderate during construction phase (refer to the Section 9.9.1.1for proposed mitigation measure). Other impacts during construction phase were all assessed to be Minor and therefore no mitigation measures were proposed to further minimise the adverse impacts on the environment.

9.9.1.1 Compensation / Offset

Due to the site clearance activities, loss of vegetation is expected to have major impact on freshwater marsh and it is anticipated that this habitat will be completely lost. Due to the space constraints and land use plan it remains difficult to avoid this area. Therefore, due to the high likelihood of losing such ecologically valuable habitat, it is recommended to compensate the impact with marsh creation in the vicinity of current location (refer to Section 7). Prior to creation, it is recommended to carry out soil and groundwater investigations in the area where freshwater marsh is currently located as well as in the area where it is intended to be created. This is to assure that the new site will have same or very similar soil and groundwater conditions.

9.9.2 Operational Phase

In this section, no mitigation measures are proposed to further minimise the adverse impacts on the environment as there is no impact significance on sensitive receptors were assessed to be Moderate or Major.

9.10 Residual Impacts

Residual impact assessment has been undertaken assuming that the mitigation measures recommended in the previous section are implemented.

The newly created Freshwater Marsh is proposed to be located within the mitigated construction footprint. Therefore, it is expected that the overall impact significance of decreased groundwater baseflow feeding into marshland due to construction activities will still be Moderate. It is recommended to reassess soil and groundwater impacts on this newly created Freshwater Marsh, based on the additional soil and groundwater investigation study.

Other impacts were all assessed to be Minor and therefore no residual impact assessment has been undertaken.

9.11 Cumulative Impacts from Other Major Concurrent Development

9.11.1 Construction Phase

At Turf City Area, concurrent construction in the vicinity of CR14 worksite during construction phase include A1-W2 launch shaft worksite and temporary access road, located east of the CR14 Mitigated Scenario worksite. Based on inferred groundwater flow in the area, A1-W2 worksite is located upgradient from CR14 worksite and therefore might increase the impact on soil and groundwater. For this reason, proper mitigation measures should be proposed to deal with potential groundwater level decrease and excavated soil and groundwater to minimise adverse impacts.

At Holland Plain area, concurrent constructions in the vicinity of CR15 worksite during construction phase include CR16 worksite, road network to support Holland Plain developments, Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail. Construction activities within CR16 worksite may require activities which could potentially have adverse impacts on soil and groundwater. However, given the distance of the CR16 worksite from CR15 worksite and under assumption that appropriate minimal control measures will be successfully implemented, it is expected that impact on soil and groundwater at Site IV and V will not be significant. The proposed construction of road network is expected to change the current land use and therefore hydrological cycle (i.e., more impermeable surfaces leading to reduced percolation into the soil). However, under the assumption that minimum control measures will be implemented, it is expected that the impact on soil and groundwater will not be significant. Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail are expected to include mostly minor construction activities (e.g., cut and cover for trail levelling), hence these developments are unlikely to increase soil and groundwater impact.

9.11.2 Operational Phase

At Turf City area, A1-W2 facility building is planned to be operational concurrently with CR14. However, due its small footprint (compared to the overall catchment area), distance from CR14 vent shafts and entrances (east of Site I, Site II and Site III), the proposed future facility building is not expected to significantly increase impact on soil and groundwater.

In the Holland Plain area, the concurrent project in the vicinity of CR15 station include CR16 station, road network within Holland Plain developments, Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail. As these developments will occupy relatively small area and as it is expected that the groundwater levels will find new equilibrium upon completion of construction activities, the proposed developments are unlikely to increase the impact on soil and groundwater.

9.12 Summary of Key Findings

The potential impacts on soil and groundwater of historical and current/ potential land uses as well as activities associated with the construction and operational phases of the Project was discussed with reference to LTA's HLUS reports, previously carried out soil and/ or groundwater studies, construction waste information and other best available data.

The soil and groundwater within the Project site were identified as Priority 3 sensitive receptors, as they were not expected for direct sensitive uses (e.g., agricultural/ irrigation/ drinking water purposes) and not directly extracted for industrial uses, therefore not posing unacceptable risks. Waterbodies that support habitats and/ or species of high conservation significance and which are partly supported by groundwater were identified as Priority 2 sensitive receptors.

The potential sources of soil and groundwater impact during construction were expected to be mainly from pre-construction activities (e.g. site clearance, levelling and land grading works) and main construction activities of this Project such as tunnelling activities may cause decreased groundwater baseflow feeding into the streams, potential contamination from toxic chemical waste used or generated on site, as well as potential leakage from improper handling of hazardous chemical/ substances on site.

The potential sources of soil and groundwater impact during operational phase were expected to be mainly from maintenance of the alignment and station with potential contamination from toxic chemical waste used or generated, as well as potential leakage from improper handling of hazardous chemical/substances within the operational footprint of the Project. According to preliminary planning at the time of writing this Report, this Project is assumed to have maintenance works for each station and rails within the tunnels to be carried out once a week. These activities could lead to generation of small quantities of toxic chemical waste (e.g., used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.) as well as accidental leakages of hazardous chemicals/ substances due to improper handling/ management. Those may seep into the wastewater drainage systems and/ or into the soil and groundwater, potentially impacting their quality. Furthermore, there is a potential for contamination of soil and/ or groundwater due to accidental spills and leaks in the storage areas of maintenance chemicals.

Minimum control measures for soil and groundwater which are commonly implemented in Singapore have been included in this section. Regular inspection and workers training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the site staff on site. Hence, the significance from potential sources of soil and groundwater impacts during construction and operational phases such as improper management and disposal of excavated soil and groundwater, toxic chemical waste generation and improper handling of hazardous chemicals/substances was assessed to be Minor to the sensitive receptors and no further mitigation measures were required for CRL2 Project. With regards to groundwater baseflow reduction, only impact on freshwater marshes was assessed to be Moderate, while the impact on other identified waterbodies was assessed to be Minor. Upon implementation of proposed mitigation measure (i.e. creation of freshwater marsh habitat in the vicinity) it is expected that the impact will remain Moderate, due to its proximity to construction footprint.

Cumulative impacts from concurrent developments identified in the vicinity of the CR2005 Project during both construction and operational phases were assessed. It was concluded that the concurrent development of A1-W2 (i.e., launch shaft and temporary access road during construction phase and facility building during operational phase) might increase the impact during construction phase only. Therefore, appropriate mitigation measures should be proposed to minimise adverse impacts by the project developer to avoid accidental spillage of chemicals impacting the quality of soil and groundwater and to minimise groundwater drawdown in line with best practice measures. The impact from other concurrent developments might not increase soil and groundwater impact in their construction or operational phases given best management practices and minimum controls are in place. Due to the distance of CR16 worksite from Site IV and V, it is not expected that its construction and operational activities would have any additional impacts on soil and groundwater. Land use change due to road network to support Holland Plain developments could potentially decrease the seepage of water into the soil. However, given the relatively small area compared to the overall catchment area it is not expected that this development will increase soil and groundwater impact. Jurong Line Nature Trail and Clementi Forest Stream Nature trail are expected to include mostly minor construction activities and are unlikely to increase soil and groundwater impacts..

Table 9-7 Summary of Soil and Groundwater Impact Assessment

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I and Site II	Decreased Groundwater Baseflow Feeding into the Streams: Minor Improper Management and Disposal of Excavated Soils and Groundwater: Minor Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Minor (See Note 1)
Site III	Decreased Groundwater Baseflow Feeding into the Streams: Minor Improper Management and Disposal of Excavated Soils and Groundwater: Minor Toxic Chemical Waste Generation: Minor	Minor (See Note 1)

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
	Improper Handling of Hazardous Chemicals/Substances: Minor	
Site IV	Decreased Groundwater Baseflow Feeding into the Streams: Minor Improper Management and Disposal of Excavated Soils and Groundwater: Minor Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Minor (See Note 1)
Site V	Decreased Groundwater Baseflow Feeding into the Streams: Minor to Moderate Improper Management and Disposal of Excavated Soils and Groundwater: Minor Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Decreased Groundwater Baseflow Feeding into the Streams: Minor to Moderate Improper Management and Disposal of Excavated Soils and Groundwater: Minor (See Note 1) Toxic Chemical Waste Generation: Minor (See Note 1) Improper Handling of Hazardous Chemicals/Substances: Minor (See Note 1)
Operational Phase		
Site I and Site II	Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Minor (See Note 1)
Site III	Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Minor (See Note 1)
Site IV	Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Minor (See Note 1)
Site V	Toxic Chemical Waste Generation: Minor Improper Handling of Hazardous Chemicals/Substances: Minor	Minor (See Note 1)
Note: 1 – The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.		

10. Air Quality

10.1 Introduction

This section presents the air quality impact assessment for the construction and operational phases of the project. The key steps for conducting the air quality impact assessment are as follows:

- Review baseline monitoring data to evaluate the existing air quality in the Study Area;
- Identify and classify sensitivity of the area around the construction worksite or project footprint;
- 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; and
- Determine the overall significance of the residual air quality impacts after implementation of mitigation measures.

10.2 Methodology

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

10.2.1 Study Area

The Study Area for air quality impact assessment is recommended as 50 m from the construction worksite areas for impact during construction phase in accordance with UK IAQM guidance [R-47] and 250 m around the Project Footprint for operational phase. It should be noted that the operational footprint considered in air quality impact assessment also includes existing operational roads outside or nearby the Project Site, if any. As the proposed alignment of the future road for CR14 is still under study, it has been assumed that the future road will be along the alignment of the temporary construction access road (see Figure 3-1). During the scoping phase for this EIS, an initial screening of receptors in the Study Area was conducted in order to determine the areas which are sensitive to potential construction and operational impacts.

10.2.2 Baseline Air Quality Study

Baseline air quality monitoring includes primary data collection in the form of baseline ambient air quality monitoring in the Study Area. Of the criteria pollutants generally measured as part of ambient air monitoring, such as CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$, this baseline monitoring only focuses on dust levels i.e. PM_{10} and $PM_{2.5}$, since these are the major pollutants that are likely to have the largest 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 Study Area. Primary monitoring data includes monitoring equipment to be setup at the site for at least a week; while simultaneous data recorded are from nearest NEA's monitoring station from web resources. The observed site data and NEA's monitored data are compared to provide confidence in the collected data.

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 was established. With varying seasonal fluctuations, it is understandable that wind flow and direction will vary throughout the year, and hence short-term baselines will also fluctuate. However, a correlation, be it direct or indicative between the site baseline and NEA's central and western areas 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 Study Area were collected from publicly available sources.

10.2.2.1 Desktop Assessment

10.2.2.1.1 *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 quality 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.

10.2.2.1.1.1 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 2016 – 2020 have been presented and compared with Singapore Long Term Ambient Air Quality Targets in Section 10.5.1.1.1.1. Air pollution control in Singapore is governed by legislation listed in Section 4.

Figure 10-1 NEA Ambient Air Quality Monitoring Stations in Singapore [W-44]

10.2.2.1.1.2 Hourly Pollution Standards Index (PSI) and 24-hour PM_{10} and $PM_{2.5}$ Concentrations

PSI (Pollutant Standards Index) is an index to provide accurate and easily understandable information about daily levels of air quality. The concentration levels of particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and carbon monoxide (CO) monitored by air monitoring locations located in different parts of Singapore are used to determine the PSI. The PSI value gives an indication of the air quality as shown in Table 10-1. 24-hr $PM_{2.5}$ and PM_{10} PSI readings were available on data.gov.sg for the Western Region of Singapore during the primary data collection period, which was on 25 February – 3 March 2020 and 6 – 13 July 2022, and these are presented and discussed in Section 10.5.1.1.1.2.

Table 10-1 General Air Quality Descriptor Based on PSI value [W-39]

PSI Value	Air Quality Descriptor
0 – 50	Good
51 – 100	Moderate

PSI Value	Air Quality Descriptor
101 -200	Unhealthy
201 – 300	Very unhealthy
Above 300	Hazardous

10.2.2.1.1.3 Other Parameters (Rainfall, Temperature, Wind Speed)

Rainfall, temperature, and wind speed can significantly affect the distribution of pollutants. Clementi, Upper Thomson and Lower Peirce are the nearest monitoring stations to the Study Area, located approximately 660 m, 640 m and 540 m from the alignment respectively. Clementi monitoring station recorded rainfall, temperature and wind speed data. While Upper Thomson and Lower Peirce stations only recorded rainfall data. These are discussed in Section 10.5.1.1.1.3.

Figure 10-2 NEA Weather Monitoring Stations in Singapore [W-40]

10.2.2.1.2 *Secondary Air Quality Monitoring Data from Concurrent Study*

Air quality monitoring services were conducted by AECOM Singapore Pte Ltd with the assistance from ALS Technichem (S) Pte Ltd as part of the concurrent study in the vicinity of the Study Area []. A total of two (2) air monitoring locations were conducted as part of concurrent study for one (1) week to collect air quality samples for the following air quality parameters:

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

Air quality monitoring was conducted from 23 – 30 September 2021 and 1 – 8 December 2021. The air monitoring location for the concurrent study is presented in Table 10-2 and Figure 10-3. The results for concurrent study air quality monitoring are presented in Section 10.5.1.1.2.

TSI Environmental DustTrak Monitoring System was used for the purpose of PM_{10} and $PM_{2.5}$ monitoring. Concentrations of PM_{10} and $PM_{2.5}$ were 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 were determined by detecting how the particles scatter light.

Table 10-2 Air Quality Monitoring Location in Concurrent Study

Monitoring ID in the Concurrent Study	Monitoring Location	Photo of Monitoring Location
AQ2	Within 53 Fairways Drive in the vicinity of Site I and Site II	
AQ3	Within forested area located along Turf Club Road in the vicinity of Site III	

10.2.2.2 Primary Data Collection (Survey & Sampling)

Air quality monitoring services were provided by ALS Technichem (S) Pte. (ALS). A total of two (2) 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 of the proposed station box and facility buildings;
- Other ASRs away from the construction worksite areas / project footprint were eliminated as these receptors are assumed to be barricaded by the first row of buildings;
- ASRs with areas having ongoing construction were avoided;
- Exclude areas where CCNR EIA has already established some air baseline in the past;
- The closest ASR to the construction worksite areas / project footprint was selected; and
- ASRs where the owner denied permission during site walkover was excluded (e.g. past experience with terrace houses/ bungalows, embassies at Swiss valley area, heavy car park area at Grand Stand, etc).

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

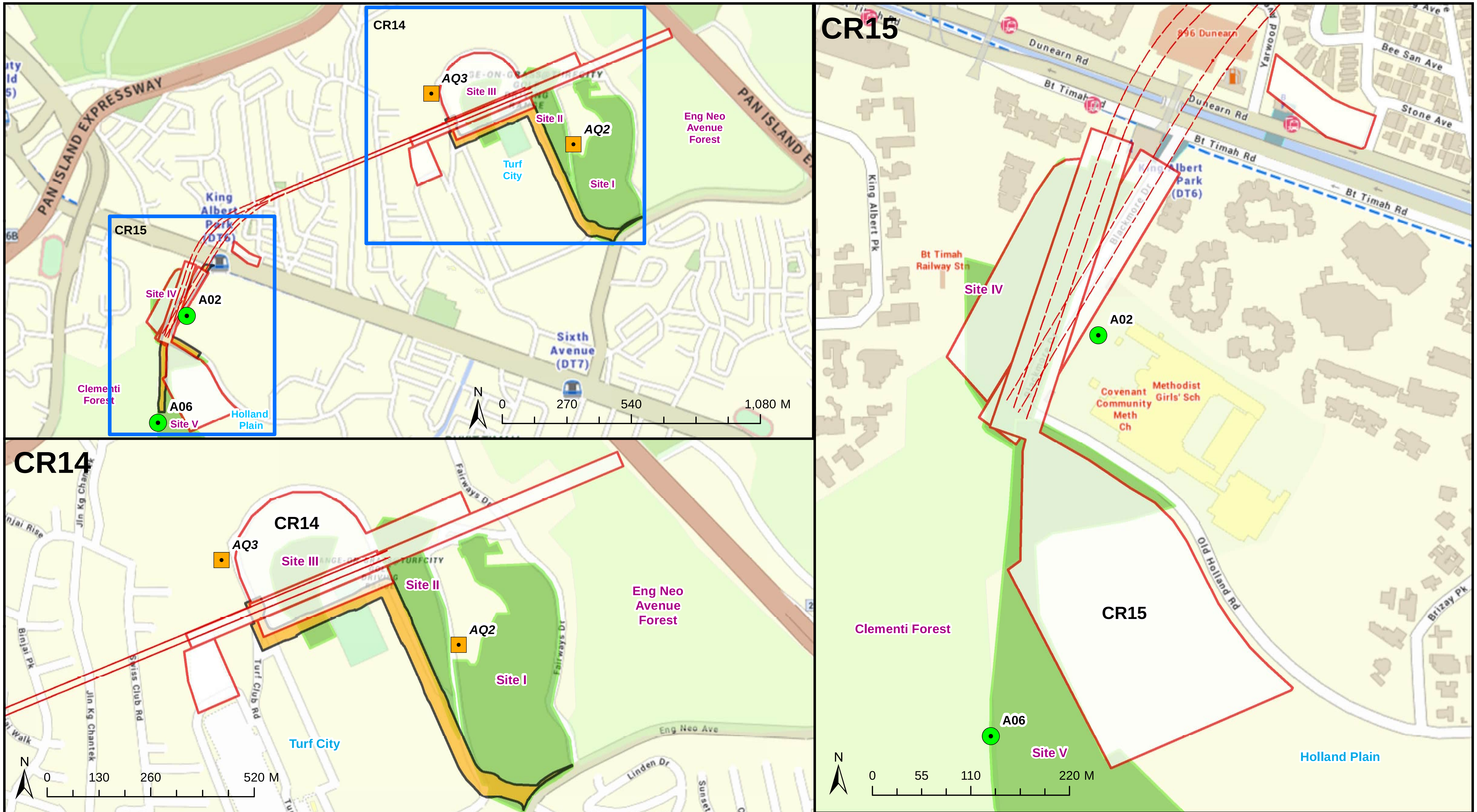
- Particulate matter smaller than 2.5 µm, $PM_{2.5}$; and
- Particulate matter smaller than 10 µm, PM_{10}.

Air quality monitoring will be conducted for 1 week within the Study Area in order to establish a baseline for existing air quality levels. Following the site survey conducted on 5-6 November 2019, 25 March 2020 and 17 June 2020, 2 (two) monitoring locations were identified to represent the site. This has been proposed and accepted in the inception report. 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 will be installed at 1.8 m from ground level in the breathing zone. Proposed air monitoring locations are provided in Table 10-3 and Figure 10-3.

TSI Environmental DustTrak Monitoring System will be used for the purpose of PM_{10} and $PM_{2.5}$ monitoring. Concentrations of PM_{10} 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 M.

Table 10-3 Baseline Air Quality Monitoring Locations

Monitoring Location	Receptor Type	Nearest Construction Worksite Area/ Project Footprint	Justification	Photo of Monitoring Location
A02: Methodist Girls' School	Educational Institution	• CR15 Worksite (Construction) • CR15 Station (Operation)	A02 is located north of Holland Woods and east of Site IV. The ambient air quality in the vicinity of A02 will be largely dominated by traffic along Bukit Timah Road and Dunearn Road. The air quality in this area will also be influenced by ongoing road works along Bukit Timah Road. Methodist Girls' School has been identified as representative monitoring location and this proposed monitoring location will capture the ambient air quality levels in the vicinity of the worksite / station, northern part of Holland Woods and Site IV.	
A06: In the vicinity of Site V	Ecologically Sensitive Receptor	• CR15 Worksite (Construction)	A06 is located in close proximity to Site V. The ambient air quality in the vicinity of A06 will be affected by localised activity within Holland Plain and rail corridor. This monitoring location has been chosen to represent the site in terms of existing ambient air quality in Site V.	



Legend

- Baseline Air Monitoring Location
- Air Quality Baseline - Secondary Data
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Planned Road Works
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

BASELINE AIR QUALITY MONITORING LOCATION

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-3	-	1 of 1
Drawn: ML		Date: JULY 2022	CAD File Name :NA		A3

Note: Source of basemap - OneMap

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 EIS.

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 Study Area. While conducting the assessment, a typical construction machinery was assumed to be used during the construction equipment and activities. For air quality impacts, only above-ground areas were assessed. 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 Study Area in the vicinity of above-ground construction footprint 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 was presented in 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 EIS 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 Study Area. NEA's PSI data available from the nearest monitoring station were also reviewed for the Study Area. In addition, baseline air quality data were collected for representative location near the construction footprint. The baseline air quality review and data measured was discussed in Section 10.5.

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 was defined in Table 6-5 in Section 6.4.2.1. 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 evaluated the overall consequence prior to the implementation of mitigation. The worksite 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 was explained in matrices shown in Table 10-4 to Table 10-7. Each activity for the worksite has been rated as being High, Medium, Low, or Imperceptible in terms of overall consequence based upon pre-mitigation measures.

Table 10-4 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 10-5 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 10-6 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 10-7 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 was 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 6-7. Impact Significance has been evaluated in accordance with the matrix presented below in Table 10-8. 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 10-8 Impact Significance Matrix for Air Quality

Likelihood \ Consequence	Imperceptible / Very Low	Low	Medium	High
Unlikely	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 were 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 EIS at the proposed construction footprint, the residual Impact Significance was evaluated using the matrix outlined in Table 10-8. 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 Study Area. While conducting the assessment, an increase in traffic volume in the vicinity of the Project during operational phase was 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 Study Area within 250 m around the Project Footprint was subsequently undertaken. A further discussion on Receptor Sensitivity was 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 EIS 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 Study Area. NEA's PSI data available from the nearest monitoring station were also reviewed for the Study Area. In addition, baseline air quality data were collected for representative location near the Project Footprint. The baseline air quality review and data measured was discussed in Section 10.5.

10.2.3.2.4 *Impact Intensity Definition*

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

10.2.3.2.5 *Classification of Overall Consequence*

The air quality impact assessment therefore evaluated the overall consequence prior to the implementation of mitigation. The worksite 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 but after incorporation of minimum controls.

10.2.3.2.6 *Establishing Impact Significance*

Impact Significance was 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 6-7. Impact Significance has been evaluated in accordance with the matrix presented in Table 10-8.

10.2.3.2.7 *Mitigation Measures Recommendations*

Mitigation measures were proposed for implementation when for Moderate or Major Impact Significance.

10.2.3.2.8 *Establishing Residual Impact Significance*

Following implementation of mitigation measures prescribed in the EIS at the proposed Project Footprint, the residual Impact Significance was evaluated using the matrix outlined in Table 10-8. 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 Impacts

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

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 10-9 listed potential sources of air quality impact during construction phase of the project.

Table 10-9 Potential Air Quality Impacts during the Construction Stage

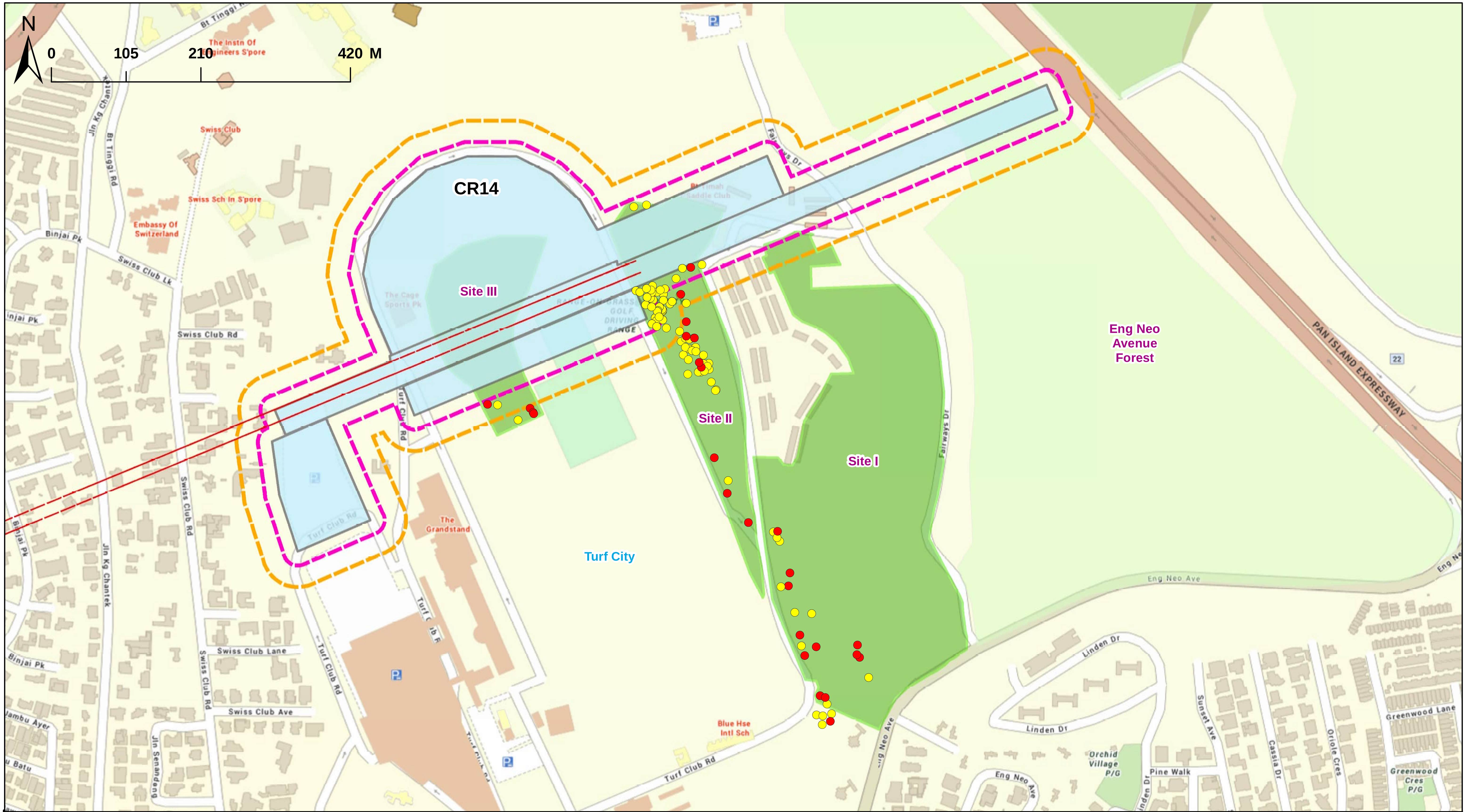
Potential Source of Impacts	Potential Associated Impacts
Dust emissions generated by earthworks processes, including land clearance, soil-stripping, ground levelling, excavation, stockpiling of spoil and landscaping at worksites CR14 and CR15.	Dust emissions could potentially result in adverse impacts 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, such as CR14 and CR15 stations (including entrances and vent shafts), and proposed new roads.	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 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.

Potential Source of Impacts	Potential Associated Impacts
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.

This area has been referred as earthworks footprint (refer to Figure 10-4 and Figure 10-5 for CR14 and CR15 respectively). 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. As per the information received from the CR2001 consultant and LTA In-House Design Team, it is assumed that the spoil amount will be >100,000 tonnes for CR14 and CR15 worksite areas. At any one time, it is also assumed that <5 heavy machineries will be moving within CR14 and CR15 earthworks footprint.

The worst-case emission source for construction has been assumed to comprise the station footprint (including entrances and vent shafts) and proposed new roads planned for development (alignment for CR14 road under study). This area has been referred as construction footprint (refer to Figure 10-6 and Figure 10-7 for CR14 and CR15 respectively). One (1) concrete batching plant is expected within CR14 and CR15 construction worksite areas. In line with the IAQM Guidance, the dust emission expected from the concrete batching plant is qualitatively assessed as part of the construction activity. As per the information received from the CR2001 consultant and LTA In-House Design Team, it is assumed that the concrete amount required will be 25,000 – 100,000 m^3 for CR14 and CR15. There is no demolition expected as part of this project construction phase hence, an assessment is not included in this section.

The trucks carrying spoil to and from the construction worksite area on access roads are also considered as a potential source of emission (referred to as trackout activity) as shown in Figure 10-8 and Figure 10-9 for CR14 and CR15 respectively. Based on the earthworks footprint for each construction worksite area, the number of outward trucks movement has been conservatively assumed to be >50 HDVs per day for CR14 and CR15 construction worksite areas. The road construction works are expected to be completed and paved where possible before the construction of other development commences. This is to ensure that the potential access roads are not significant dust generation sources. However, for a conservative trackout assessment, road material has been assumed to be Moderately Dusty and length of unpaved roads <100m. Impact prediction and evaluation were detailed in Section 10.7.1.



Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment (Base)
- Earthworks Footprint (Base)
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

CR14 BASE EMISSION SOURCES AND RECEPTORS (EARTHWORKS)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-4	-	1 of 1

Drawn: ML | Date: JULY 2022 | CAD File Name : NA | A3

Note: Source of basemap - OneMap

Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment (Base)
- Earthworks Footprint (Base)
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
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Project Title :

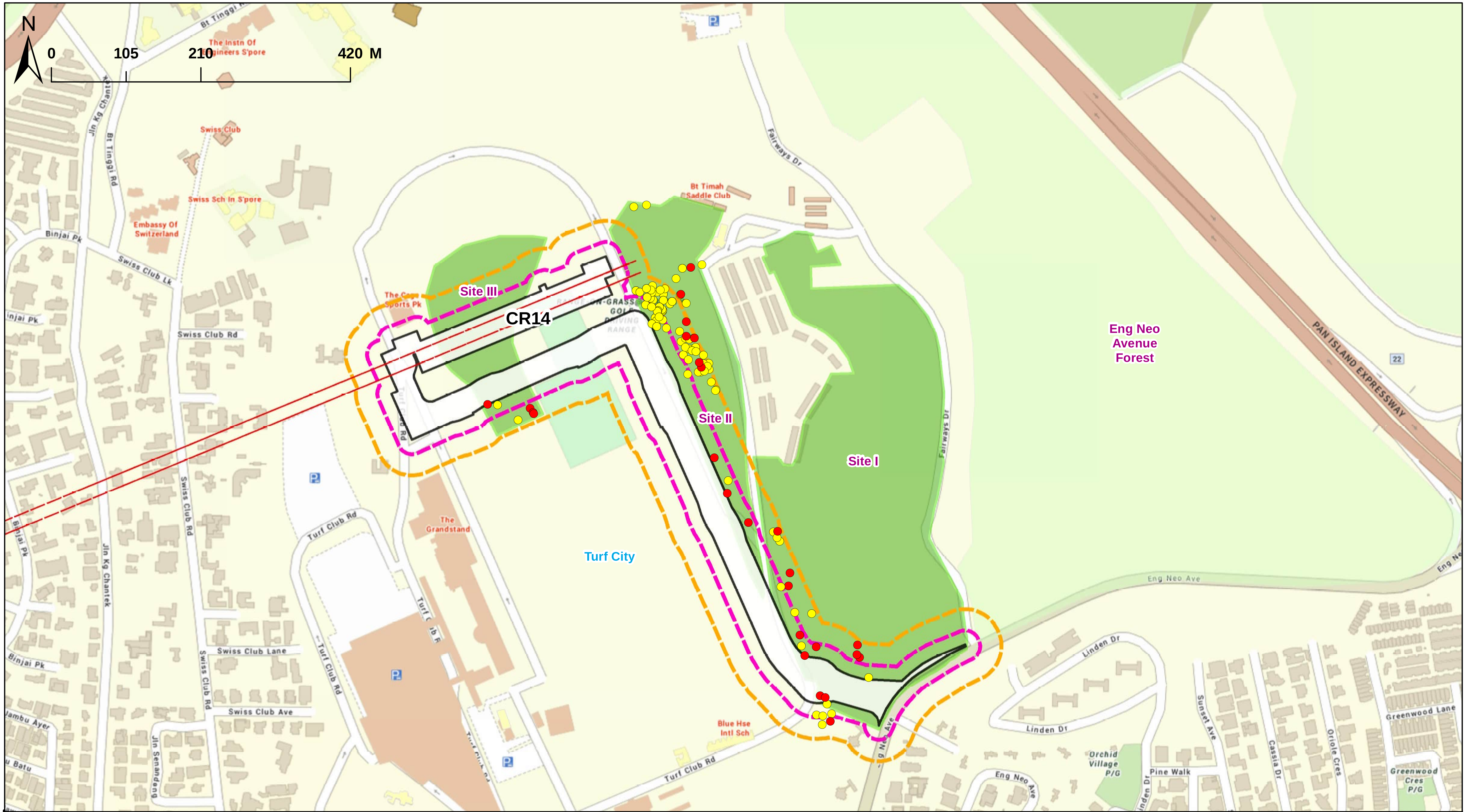
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

CR15 BASE EMISSION SOURCES AND RECEPTORS (EARTHWORKS)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-5	-	1 of 1
Drawn: ML	Date: JULY 2022		CAD File Name : NA		A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment (Base)
- Construction Footprint based on Tentative Future Road Alignment (Base)
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
A	SEPT 2022	HHL	EIS (Turf City and Holland Plain) Rev A	JAG/NHT	JAG
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
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Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

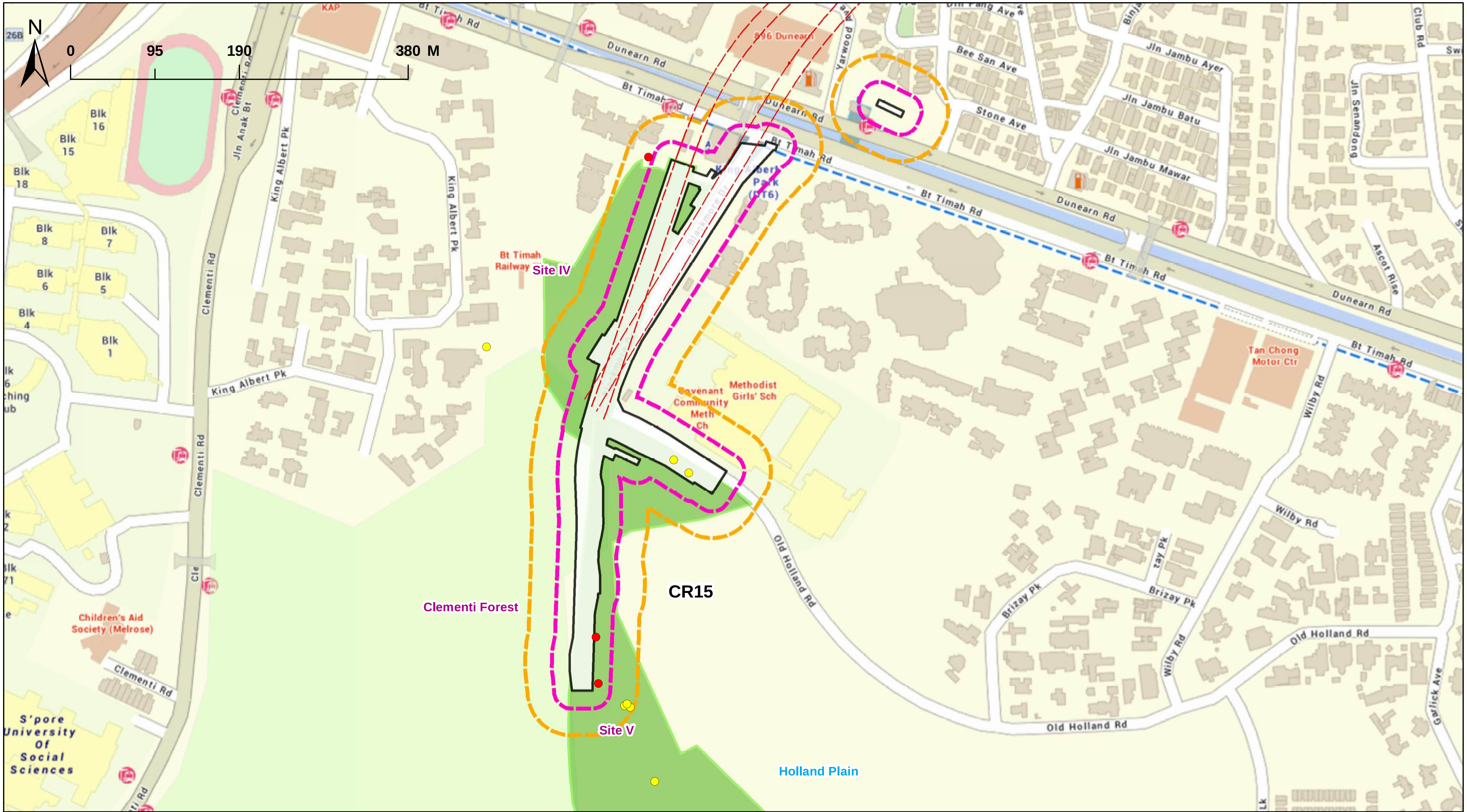
Figure Title :

CR14 BASE EMISSION SOURCES AND RECEPTORS (CONSTRUCTION)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-6	A	1 of 1

Drawn	Date	CAD File Name	
ML	SEPT 2022	NA	A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment (Base)
- Construction Footprint (Base)
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

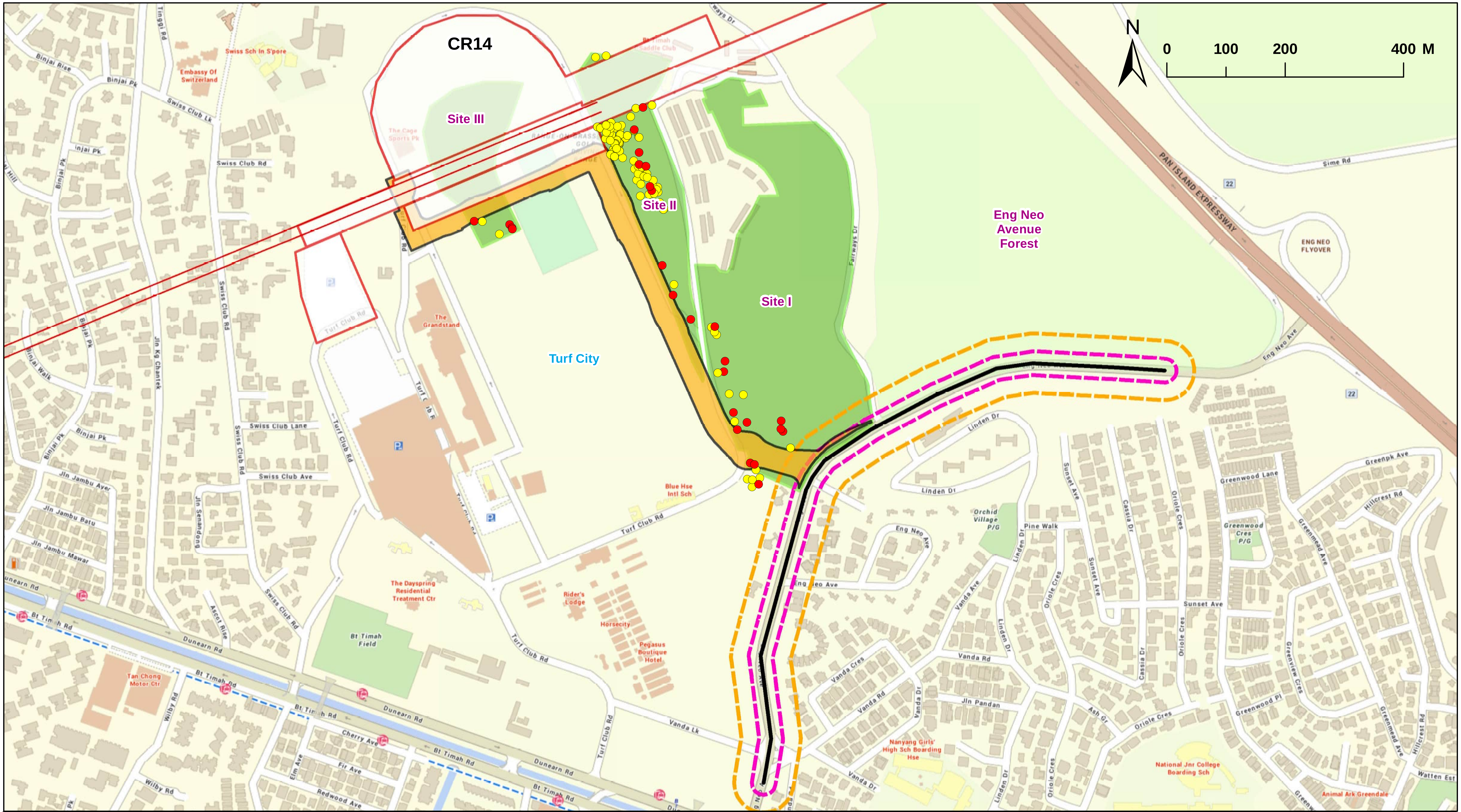
Figure Title :

CR15 BASE EMISSION SOURCES AND RECEPTORS (CONSTRUCTION)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-7	-	1 of 1

Drawn	Date	CAD File Name	
ML	JULY 2022	NA	A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Planned Road Works
- Potential Access Road
- 20m from Source
- 50m from Source
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

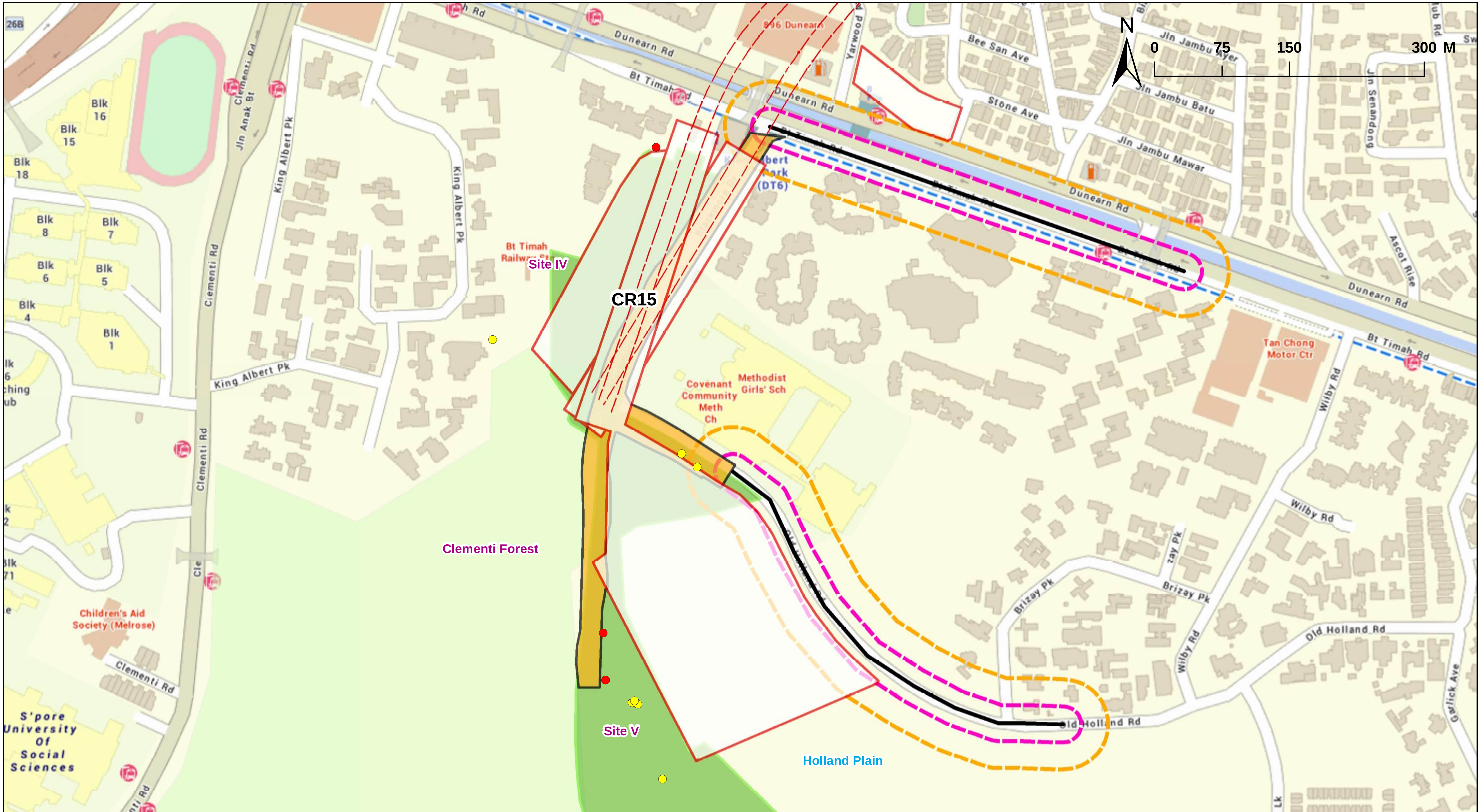
Figure Title :

CR14 BASE EMISSION SOURCES AND RECEPTORS (TRACKOUT)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-8	-	1 of 1

Drawn: ML
Date: JULY 2022
CAD File Name : NA
A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Planned Road Works
- Potential Access Road
- 20m from Source
- 50m from Source
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :
CR15 BASE EMISSION SOURCES AND RECEPTORS (TRACKOUT)

Designed	Checked	Approved	Drawn	Date
ML	JAG/NHT	JAG	ML	JULY 2022

Figure No. :	Rev.	Sheet
10-9	-	1 of 1

CAD File Name :NA A3

Note: Source of basemap - OneMap

10.3.2 Operational Phase

During operational phase, since the trains are powered by electricity, they do not emit air emissions as a direct impact to environment through the facility buildings. Hence, as presented in Table 10-10, potential air quality impact during operational phase of the Project would be vehicular emissions due to increased traffic in the vicinity of the Project.

The main air pollutants affecting vegetation and ecosystems are nitrogen oxides (Nox), sulphur dioxide (SO_2) and ammonia (NH_3) [R-50]. In the context of this project, the air pollutant of concern will be Nox which are produced from road traffic emission. SO_2 is not relevant for this project as low sulphur content fuel will be used. NH_3 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-50].

As per the NEA website, since 1 September 2017, all new petrol vehicles have had to meet the Euro 4 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 10-11.

Table 10-10 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 CR14 and CR15 stations 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 facility buildings.

Table 10-11 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 Sensitive Receptors

10.4.1 Construction Phase

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, a Study Area of 50 m was considered for ecological impacts during construction phase. Table 10-12 below summarises the sensitivity of each construction phase for earthworks, construction, and trackout for each construction worksite. All construction worksites are located within or in close proximity to ecologically sensitive receptors. Based on the distances of emission sources to the identified receptors (i.e. flora species of conservation significance or large specimens) presented in Figure 10-4 to Figure 10-9, the Sensitivity of the Area was determined to be Priority 1 to Priority 2. In line with the IAQM Guidance, Priority 1 refers to construction worksites with emission source located <20 m to the nearest ecologically sensitive receptors. Flora species of high value identified within the air quality Study Area are presented in Table 10-13.

Table 10-12 Receptor Sensitivity for Air Quality Impact Assessment – Construction Phase

Distance	Identified Receptors	Sensitivity of the Area
CR14 BASE SCENARIO CONSTRUCTION WORKSITES		
For Earthworks:		
Within 20m	Site II	Priority 1
Between 20m to 50m	Site II, Site III	
For Construction:		
Within 20m	Site I, Site II, Site III	Priority 1
Between 20m to 50m	Site I, Site II, Site III	
For Trackout:		
Within 20m	-	Priority 2
Between 20m to 50m	Site I	
CR15 BASE SCENARIO CONSTRUCTION WORKSITE		
For Earthworks:		
Within 20m	Site V	Priority 1
Between 20m to 50m	Site IV, Site V	
For Construction:		
Within 20m	Site V	Priority 1
Between 20m to 50m	Site IV, Site V	
For Trackout:		
Within 20m	-	Priority 2
Between 20m to 50m	Site V	

Table 10-13 Flora Species of High Value Identified within the Air Quality Study Area

Distance	Identified Species	Status	Number of Species Identified
CR14 Base Scenario Worksite			
Conservation Species			
Within 20m from Worksite	*Actinodaphne macrophylla*	Presumed Extinct	2
	Alsophila latebrosa	Vulnerable	10
	Amphineuron opulentum	Endangered	1
	Calophyllum tetrapterum	Vulnerable	1
	Cyclosorus polycarpus	Vulnerable	1
	Ficus aurata var. aurata	Vulnerable	5
	Ficus glandulifera	Critically Endangered	1
	Guioa pubescens	Vulnerable	3
	Litsea firma	Vulnerable	5
	Macaranga hullettii	Critically Endangered	1
	Oncosperma tigillarium	Vulnerable	2
	Piper pedicellosum	Critically Endangered	3
	Planchonella 398imbate	Vulnerable	15
	Sterculia parviflora	Critically Endangered	1
	Uncaria longiflora var. pteropoda	Critically Endangered	3
	Sterculia macrophylla	Critically Endangered	1
Between 20m to 50m from Worksite	*Actinodaphne macrophylla*	Presumed Extinct	3
	Alsophila latebrosa	Vulnerable	5
	Amphineuron opulentum	Endangered	1

Distance	Identified Species	Status	Number of Species Identified
	Angiopteris evecta	Vulnerable	1
	Aporosa benthamiana	Vulnerable	1
	Aporosa lucida var. lucida	Critically Endangered	2
	Artabotrys suaveolens	Endangered	3
	Baccaurea pyriformis	Presumed Extinct	2
	Bridelia stipularis	Vulnerable	1
	Calophyllum tetrapterum	Vulnerable	1
	Carallia brachiate	Endangered	1
	Connarus semidecandrus	Critically Endangered	4
	Ficus aurata var. aurata	Vulnerable	9
	Guioa pubescens	Vulnerable	3
	Horsfieldia polyspherula	Vulnerable	4
	Litsea firma	Vulnerable	15
	Macaranga hullettii	Critically Endangered	2
	Piper pedicellosum	Critically Endangered	4
	Planchonella 399imbate	Vulnerable	7
	Strophanthus caudatus	Endangered	1
	Xanthophyllum eurhynchum	Vulnerable	1
	Cyclosorus polycarpus	Vulnerable	1
Large Specimens			
Within 20m from Worksite	*Cyrtophyllum fragrans*	Common	1
	Ficus barteri	Cultivated Only	1
	Peltophorum pterocarpum	Critically Endangered	1
	Samanea saman	Casual	1
	Spathodea campanulate	Naturalised	1
	Syzygium grande	Common	1
	Thyrsostachys siamensis	Casual	2
	Falcataria moluccana	Naturalised	1
Between 20m to 50m from Worksite	*Cyrtophyllum fragrans*	Common	3
	Erythrophleum suaveolens	Cultivated Only	3
	Ficus benjamina	-	1
	Ficus macrocarpa	Common	4
	Ficus 399imbate399399	Common	1
	Pterocarpus indicus	Casual	2
	Falcataria moluccana	Naturalised	3
CR15 Base Scenario Worksite			
Conservation Species			
Within 20m from Worksite	*Guioa pubescens*	Vulnerable	1
	Litsea firma	Vulnerable	1
Between 20m to 50m from Worksite	Nepenthes ampullaria	Vulnerable	3
	Sterculia parviflora	Critically Endangered	1
	Ficus aurata var. aurata	Vulnerable	1
Large Specimens			
Within 20m from Worksite	*Mangifera foetida*	Vulnerable	1
Between 20m to 50m from Worksite	*Elaeis guineensis*	Cultivated Only	1
	Falcataria moluccana	Naturalised	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. Project footprint (i.e., station box (including vent shafts and entrances)) is located within or in the vicinity of ecologically sensitive receptors. Nearest sensitive receptors which might be impacted by the increased traffic are summarised in Table 10-14 below. As the project is located within or in the vicinity of ecologically sensitive receptors, the Sensitivity of the Area was determined to be Priority 1.

Table 10-14 Receptor Sensitivity for Air Quality Impact Assessment – Operational Phase

Project Footprint	Identified Receptors	Sensitivity of the Area
CR14	Site I, II, III, Eng Neo Avenue Forest	Priority 1
CR15	Site IV, V, Clementi Forest	Priority 1

10.5 Baseline Air Quality

10.5.1 Baseline Monitoring Results

10.5.1.1 Desktop Assessment

10.5.1.1.1 *Secondary Data Collection (Review of Background Data)*

10.5.1.1.1.1 NEA Long Term Ambient Air Quality

Table 10-15 provides the general NEA ambient air monitoring results for Singapore over the period 2016 – 2020 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 ($PM_{2.5}$), and sulphur dioxide (SO_2) have generally exceeded the Singapore Long Term Air Quality Targets over the period 2016 – 2020, except the year of 2020. Carbon monoxide (CO) and nitrogen dioxide (NO_2) were below the Singapore Ambient Air Quality Long Term Targets between 2016 – 2020. The elevated PM_{10}, and $PM_{2.5}$ 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. The ambient air quality level in 2020 is generally lower than the previous year due to potential lesser air pollutant emitted to the air during the COVID-19 pandemic.

Table 10-15 NEA Long Term Ambient Air Quality Monitoring [R-49]

Pollutants	Averaging Period	2016 results (µg/m^3)	2017 results (µg/m^3)	2018 results (µg/m^3)	2019 results (µg/m^3)	2020 results (µg/m^3)	Average results 2016 – 2020 (µg/m^3)	Singapore Ambient Air Quality Long Term Targets (µg/m^3)
PM_{10}	99th %ile of 24-Hour Averages	**61**	**57**	**59**	**90**	43	**53**	50
	Annual Mean	**26**	**25**	**29**	**30**	**25**	**26.3**	20
$PM_{2.5}$	99th %ile of 24-Hour Averages	**40**	**34**	**32**	**62**	24	**30**	25
	Annual Mean	**15**	**14**	**15**	**16**	**11**	**13.3**	10
CO	Maximum 1-Hour Average	2,700	2,300	2,500	2,300	1,600	2,280	30,000

Pollutants	Averaging Period	2016 results (µg/m³)	2017 results (µg/m³)	2018 results (µg/m³)	2019 results (µg/m³)	2020 results (µg/m³)	Average results 2016 – 2020 (µg/m³)	Singapore Ambient Air Quality Long Term Targets (µg/m³)
	Maximum 8-Hour Average	2,200	1,700	2,000	1,700	1,200	1,760	10,000
NO_2	Maximum 1-Hour Average	123	158	147	156	118	140.4	200
	Annual Mean	26	25	26	23	20	24	40
SO_2	24-Hour Average	**61**	**59**	**65**	**57**	30	**54.4**	50
O_3	8-Hour Average	**115**	**191**	**150**	**125**	**145**	**145.2**	100
Note: Values in **Bold** exceed the Singapore Ambient Air Quality Long Term Targets								

10.5.1.1.1.2 Hourly Pollution Standard Index (PSI) and 24-hour PM_{10} and $PM_{2.5}$ Concentrations Readings

According to NEA's website [W-41], PM_{10} and $PM_{2.5}$ data are subsumed into PSI. Hourly historical PSI, 24-hr PM_{10} and $PM_{2.5}$ readings available on data.gov.sg for Western Region of Singapore were collected during primary data collection period for comparison against primary baseline monitoring results as per the details presented in Table 10-16.

The hourly PSI, 24-hr PM_{10} and $PM_{2.5}$ concentration readings recorded over these days are summarised in Table 10-16 below. The PSI readings during the primary baseline monitoring period are considered Good to Moderate. Both 24-hr PM_{10} and $PM_{2.5}$ concentrations obtained from data.gov.sg were below the target throughout the monitoring period.

Figure 10-10 to Figure 10-11 below show the variation of hourly historical PSI readings in the Western Region of Singapore during the primary data collection period as per Table 10-16. Figure 10-12 to Figure 10-13 and Figure 10-14 to Figure 10-15 show the variation of PM_{10} and $PM_{2.5}$ concentrations recorded by the NEA during the primary baseline data collection period respectively.

Table 10-16 Summary of Publicly Available Hourly PSI, 24-hr PM10 and PM2.5 Concentrations

Purpose	Monitoring Date	Region of Singapore	Hourly PSI Readings	24-hr PM_{10} Concentration ($\mu g/m^3$)	24-hr $PM_{2.5}$ Concentration ($\mu g/m^3$)	Remarks
For comparison with A02: Methodist Girls' School	25 February – 3 March 2020	West	31 – 51	20 – 40	7 – 12	Good to Moderate PSI readings were observed during the primary baseline data collection period. Both NEA 24-hr PM_{10} and $PM_{2.5}$ concentrations readings of West Singapore were below the target throughout the monitoring period. This is in line with the primary baseline data which monitored compliance with the Singapore Ambient Air Quality Long Term Targets.
For comparison with A06: In the vicinity of Site V	6 – 13 July 2022	West	28 – 54	10 – 24	7 – 14	Good to Moderate PSI readings were observed during the primary baseline data collection period. Both NEA 24-hr PM_{10} and $PM_{2.5}$ concentrations readings of West Singapore were below the target throughout the monitoring period. This is in line with the primary baseline data which monitored compliance with the Singapore Ambient Air Quality Long Term Targets.

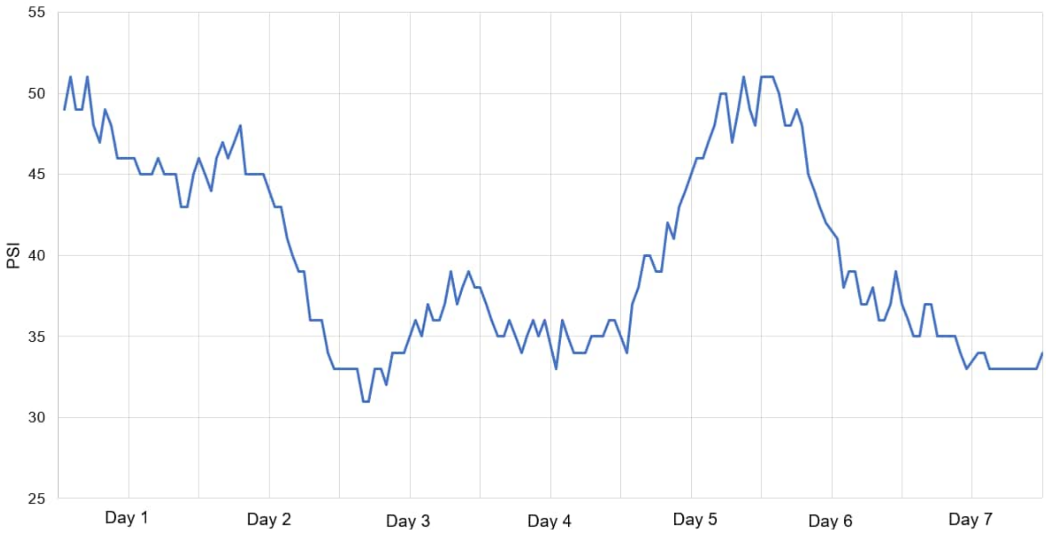


Figure 10-10 Hourly PSI Reading of Western Singapore for 25 February – 3 March 2020 [W-42]

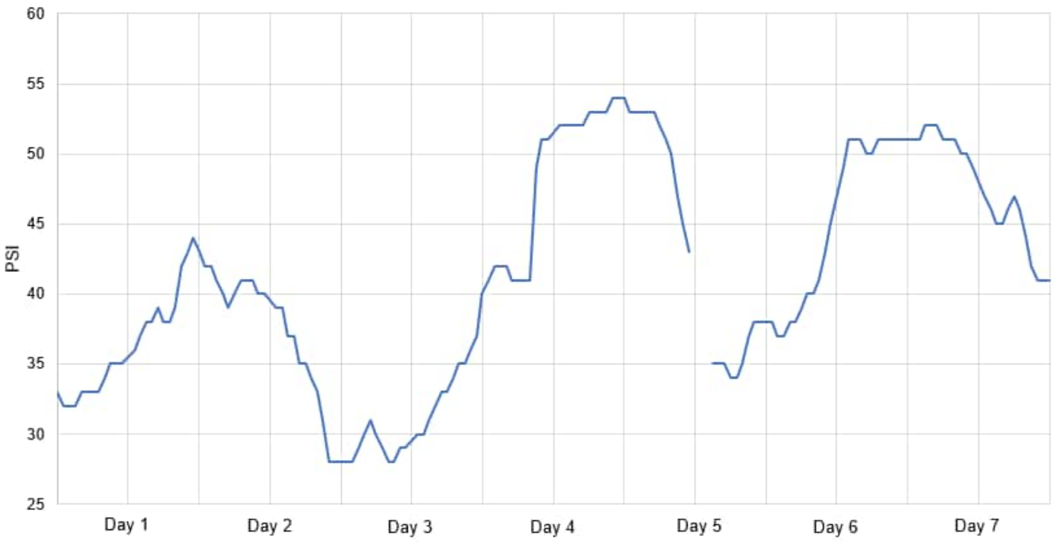


Figure 10-11 Hourly PSI Reading of Western Singapore for 6 – 13 July 2022 [W-42]

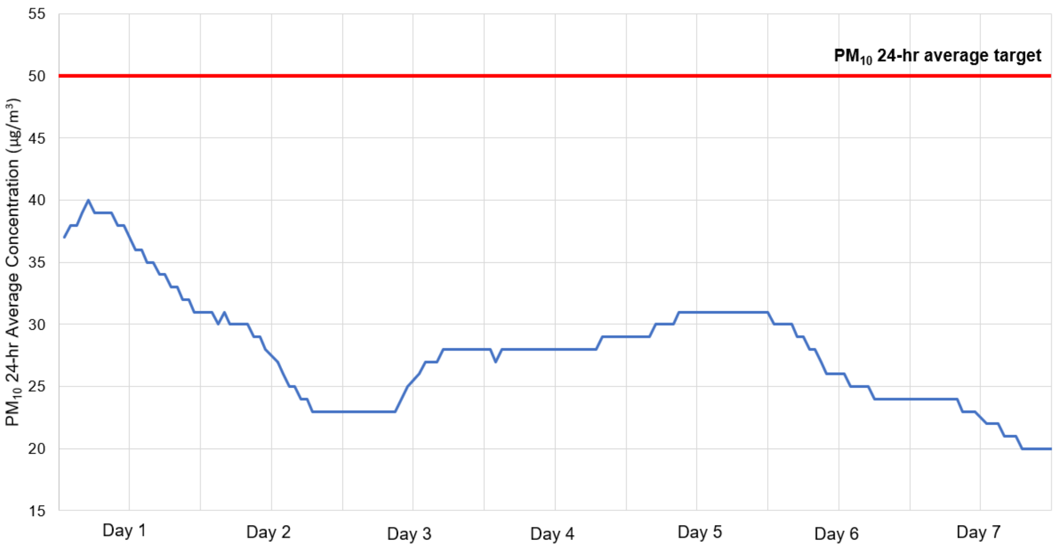


Figure 10-12 24-hr PM_{10} Concentrations of Western Singapore for 25 February – 3 March 2020 [W-42]

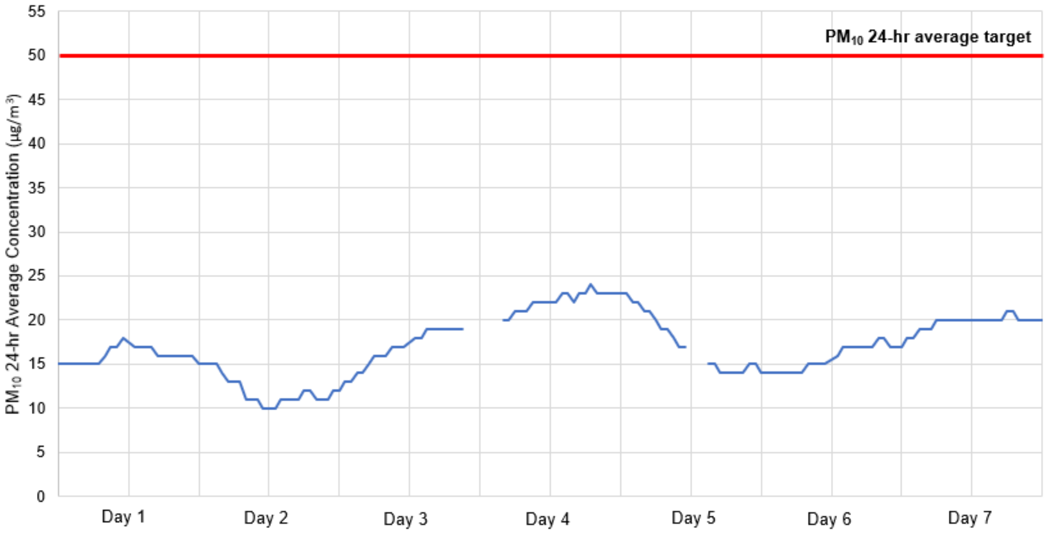


Figure 10-13 24-hr PM_{10} Concentrations of Western Singapore for 6 – 13 July 2022 [W-42]

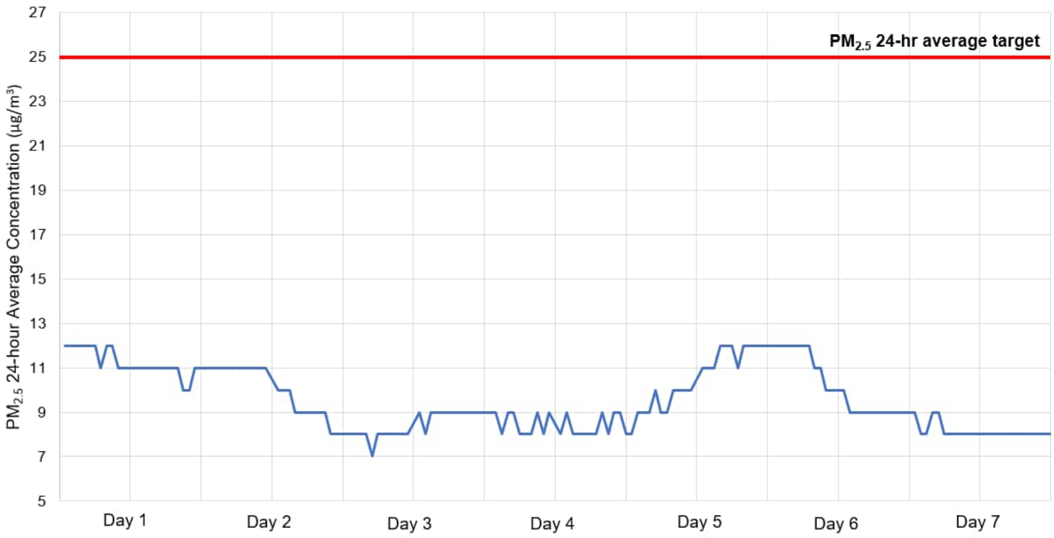


Figure 10-14 24-hr $PM_{2.5}$ Concentrations of Western Singapore for 25 February – 3 March 2020 [W-42]

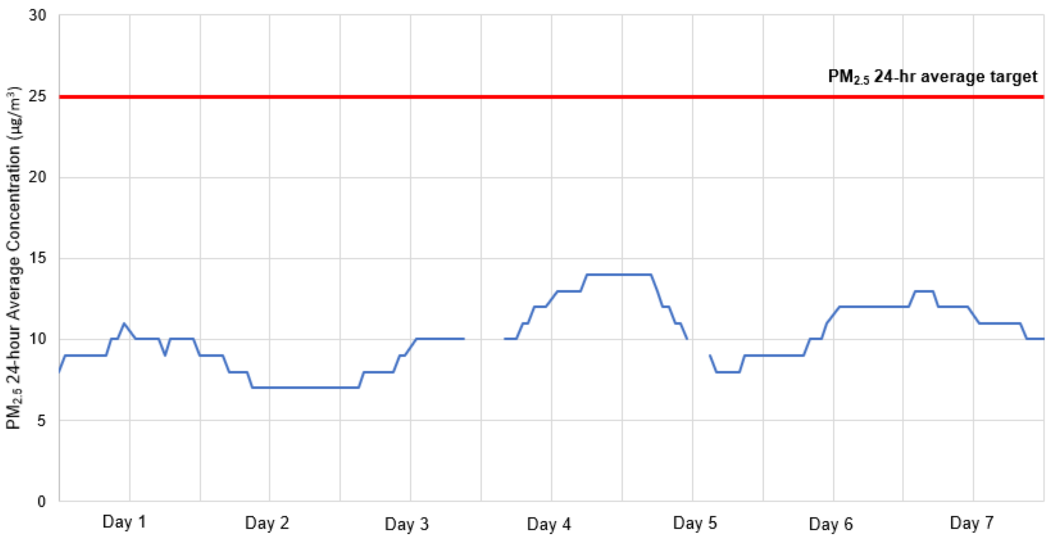


Figure 10-15 24-hr $PM_{2.5}$ Concentrations of Western Singapore for 6 – 13 July 2022 [W-42]

10.5.1.1.1.3 Other Parameters (Rainfall, Temperature, Wind Speed)

Figure 10-16, Figure 10-17, and Figure 10-18 below present the trend of daily total rainfall, mean temperature and mean wind speed observed at the nearest weather monitoring stations, from February 2015 to February 2020.

From Figure 10-16, an average of approximately 6.31 mm of daily rain was observed in the past 5 years over the 3 weather monitoring stations. This calculates to approximately 2,300 mm of rain annually. As discussed in Section 4.9.1, rainfall is higher over the northern and western parts of Singapore. This means the project is expected to receive relatively higher rainfall in the long term compared to the other parts of Singapore.

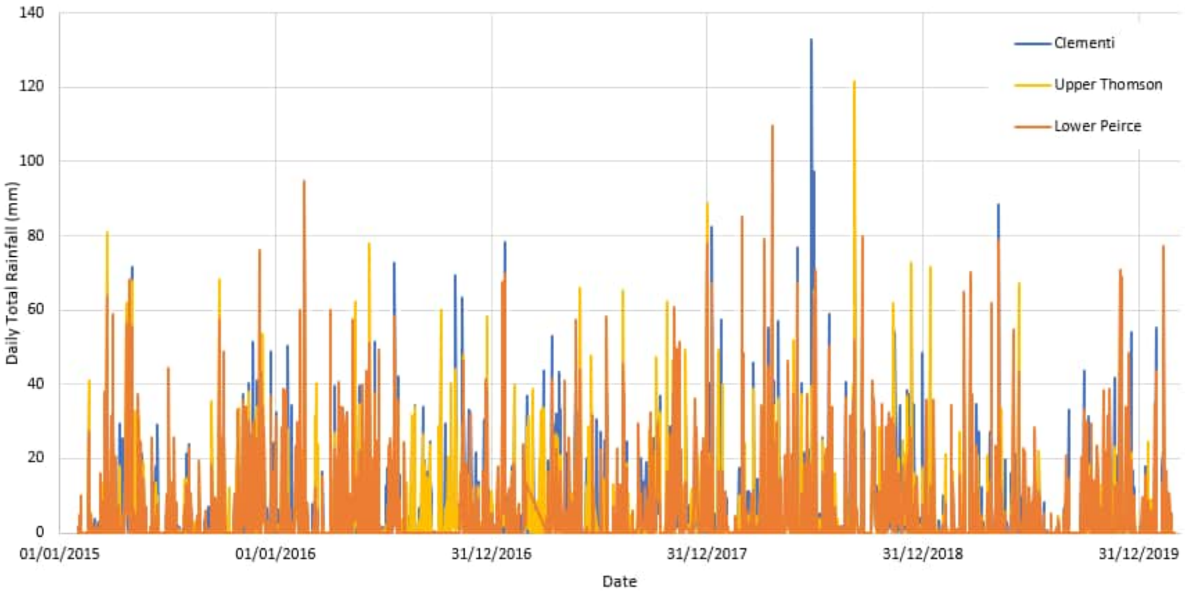


Figure 10-16 Daily Rainfall Monitored at Clementi, Upper Thomson and Lower Peirce Monitoring Stations [W-40]

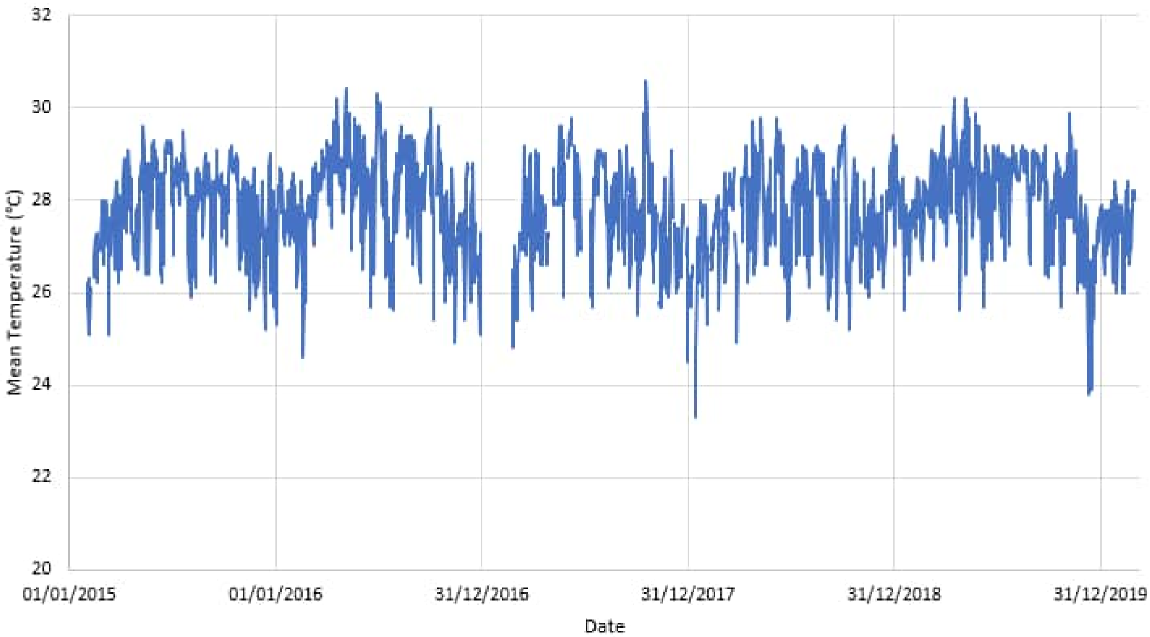


Figure 10-17 Mean Temperature Monitored at Clementi Monitoring Station [W-40]

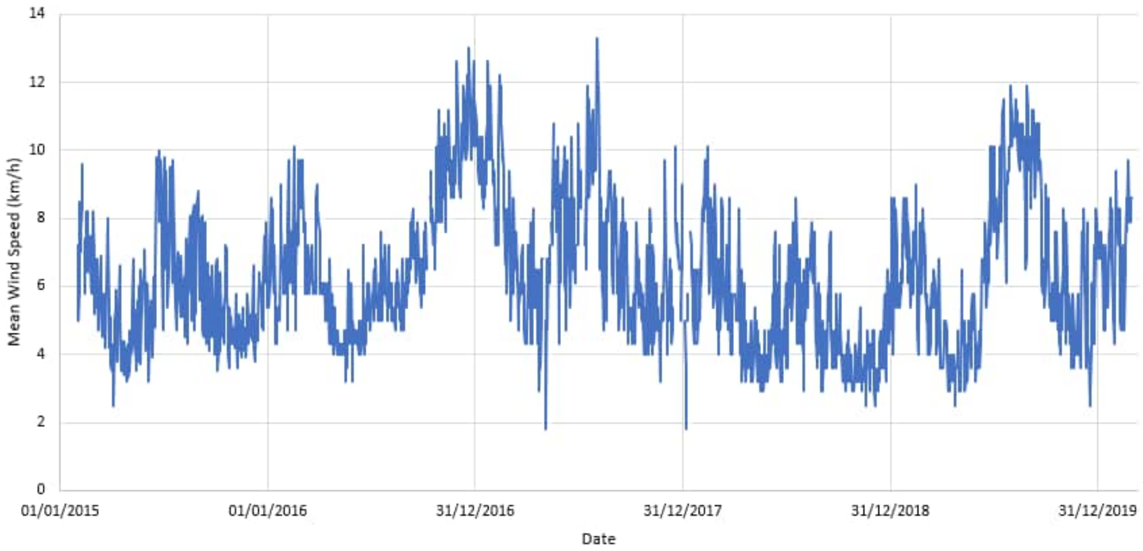


Figure 10-18 Mean Wind Speed Monitored at Clementi Monitoring Station [W-40]

10.5.1.1.2 *Secondary Air Quality Monitoring Data from Concurrent Study*

Seven (7) days of continuous ambient air quality monitoring was conducted to determine the pollutant concentrations from existing background pollutant sources. The monitoring results for each pollutant at all monitoring locations are summarised in Table 10-18 below and compared with the Singapore Ambient Air Quality Long Term Targets.

Table 10-17 Concurrent Study Air Quality Monitoring Results

Monitoring Location	Monitoring Date	Daily PM_{10} Concentration, µg/m³			Daily $PM_{2.5}$ Concentration, µg/m³		
		Min	Max	Average	Min	Max	Average
AQ2 – Within 53 Fairways Drive in the vicinity of Site I and Site II	23 – 30 September 2021	14.0	24.9	20.6	7.9	16.4	12.0
AQ3 – Within forested area located along Turf Club Road in the vicinity of Site III	1 – 8 December 2021	12.0	17.0	14.6	7.7	10.5	8.9
Singapore Ambient Air Quality Long Term Targets		*50*			*25*		

It can be observed from Table 10-18 that all pollutant concentrations are within the Singapore Ambient Air Quality Long Term Targets at the monitoring location. It should be noted that air quality monitoring was conducted during COVID-19 pandemic. Ambient air quality in this area might be higher during normal condition.

10.5.1.1.3 *Primary Data Collection (Survey & Sampling)*

Seven (7) days of continuous ambient air quality monitoring was conducted at the location mentioned above to determine the pollutant concentrations from existing background pollutant sources. The monitoring results for each pollutant at all monitoring locations are summarised in Table 10-18 below and compared with the Singapore Ambient Air Quality Long Term Targets.

Table 10-18 Baseline Air Quality Monitoring Results

Monitoring Location	Monitoring Date	Daily PM_{10} Concentration, µg/m^3			Daily $PM_{2.5}$ Concentration, µg/m^3		
		Average	Max	Min	Average	Max	Min
A02: Methodist Girls' School	25 February – 3 March 2020	14.3	18.3	11.6	10.7	13.6	9.0
A06: In the vicinity of Site V	6 – 13 July 2022	26.8	36.0	20.6	14.1	21.7	10.2
Singapore Ambient Air Quality Long Term Targets		***50***			***25***		
Note: * Monitoring at A04 was conducted during the first week of Singapore's Phase 2 reopening after the Circuit Breaker measures during COVID-19 pandemic. Ambient air quality in this area might be higher during normal condition.							

It can be observed from Table 10-18 that all pollutant concentrations are within the Singapore Ambient Air Quality Long Term Targets at all monitoring locations. The Contractor is recommended to conduct air quality monitoring of PM_{10} and $PM_{2.5}$ for 1 week prior to site clearance for the re-establishment of latest baseline conditions. It should be noted that air quality monitoring was conducted during COVID-19 pandemic. Ambient air quality in this area might be higher during normal condition.

10.6 Minimum Control for Potential Impacts

10.6.1 Construction Phase

This section proposes minimum controls or standard practices commonly implemented that have been assumed to be implemented for the purposes of impact assessment. The following control measures should be observed during the construction stage to reduce the dust levels:

- The construction footprint will be hoarded on all sides;
- No demolition of permanent structure is expected as part of the project; and
- Road construction or expansion will be completed first and paved where possible before the construction of other development commences.
- Implement a wheel washing system for local access roads in all construction sites (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.

10.6.2 Operational Phase

No minimum control has been assumed for the purpose of air quality impact assessment during operational phase. Refer to Section 10.7.2 for evaluation of air quality impacts 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.

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-77]. Dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants [P-78].

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 discussed in Section 10.5.1.1.1.3, the project is expected to receive relatively higher rainfall in the long term compared to the other parts of Singapore. 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 Study 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 10-19 to Table 10-21.

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

Table 10-19 Impacts of Dust Risk Assessment – Earthworks (Before Mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Site Area (m^2)	No. of Vehicles moving within the site	Total Material Moved (tonnes)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
CR14 Base Scenario	>10,000	<5	>100,000	High	Priority 1	High	Regular	Major
CR15 Base Scenario	>10,000	<5	>100,000	High	Priority 1	High	Regular	Major

Table 10-20 Impacts of Dust Risk Assessment – Construction (Before Mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Building Volume (m^3)	Construction Material	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
CR14 Base Scenario	25,000-100,000	Concrete	1	Medium	Priority 1	Medium	Regular	Moderate
CR15 Base Scenario	25,000-100,000	Concrete	1	Medium	Priority 1	Medium	Regular	Moderate

Table 10-21 Impacts of Dust Risk Assessment – Trackout (Before Mitigation)

Construction Worksite	Key Parameter			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
CR14 Base Scenario	>50	Moderately Dusty	<100	High	Priority 2	Medium	Regular	Moderate
CR15 Base Scenario	>50	Moderately Dusty	<100	High	Priority 2	Medium	Regular	Moderate

10.7.2 Operational Phase

During operational phase, since the trains are powered by electricity, they do not emit air emissions as a direct impact to environment through the facility buildings. As discussed in Section 10.3.2, emissions from vehicle exhaust due to increased traffic to the proposed project is expected. 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 hornwarts) are particularly vulnerable to direct exposure to the gases in this way [W-54]. 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 coexist with other biomes such as mosses. Numerous specimens of rain trees were recorded within the Study Area (refer to Section 7.3.1.2.3).

Indirectly, Nox can also deposit onto soil and, following transformation to nitrate, enrich the soil, leading to eutrophication. The effects of elevated Nox concentrations on vegetation can be broadly categorised as [R-51]:

- 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., CO_2 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-79]. 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-50].

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 55.56% 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 categories.

Table 10-22 Euro Emission Standard for Passenger Cars [W-55]

Tier	Approval Date	Emission standard for passenger cars, g/km				
		CO	HC	Nox	HC+Nox	PM
Compression Ignition (Diesel)						
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
Positive Ignition (Gasoline)						
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-55]

Category	Tier	Approval Date	Emission standard for commercial good vehicles, g/km				
			CO	HC	Nox	HC+Nox	PM
Compression Ignition (Diesel)							
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

Category	Tier	Approval Date	Emission standard for commercial good vehicles, g/km				
			CO	HC	Nox	HC+Nox	PM
	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
Positive Ignition (Gasoline)							
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
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

It should also be noted that currently there is a significant traffic volume along the PIE (CR14) and Bukit Timah and Dunearn Road (CR15). The proposed project has also planned the construction of future roads for maintenance access roads. In principle, an objective of introduction of trains is meant to replace the burden of traffic on roads, and in that sense introduction of CRL2 is likely to reduce overall traffic on roads at islandwide scale, however locally present traffic near CR14 and CR15 stations is likely to increase. 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. The buffer from the neighbouring high ecological sites which are not cleared (i.e., Eng Neo Avenue Forest, Site I, II, II, Clementi Forest, Site IV, V) will also help in terms of providing cleaner air from the impact from the vehicles. 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. Thus, as per Table 6-6, the Impact Consequence is calculated to be Very Low. Based on the impact significance matrix in Table 10-8, the Impact Significance is predicted to be Minor (refer to Table 10-24). No mitigation measures are required during operational phase.

Table 10-24 Impacts of Air Quality Impact Assessment – Operational Phase

Impact Intensity	Sensitivity of the Area	Overall Consequence	Likelihood	Impact Significance
Negligible	Priority 1	Very Low	Regular	**Minor**

10.8 Recommended Mitigation Measures

10.8.1 Construction Phase

10.8.1.1 Administrative Control

Based on the assessment in Section 10.7.1, the Impact Significance was determined to be Moderate to Major. In line with the general mitigation measures, the construction worksite areas for CR14 and CR15 have also been reduced. Refer to Figure 10-19 to Figure 10-20, Figure 10-21 to Figure 10-22, and Figure 10-23 to Figure 10-24 for earthworks, construction and trackout potential emission sources for both CR14 and CR15 Mitigated Scenario worksite area.

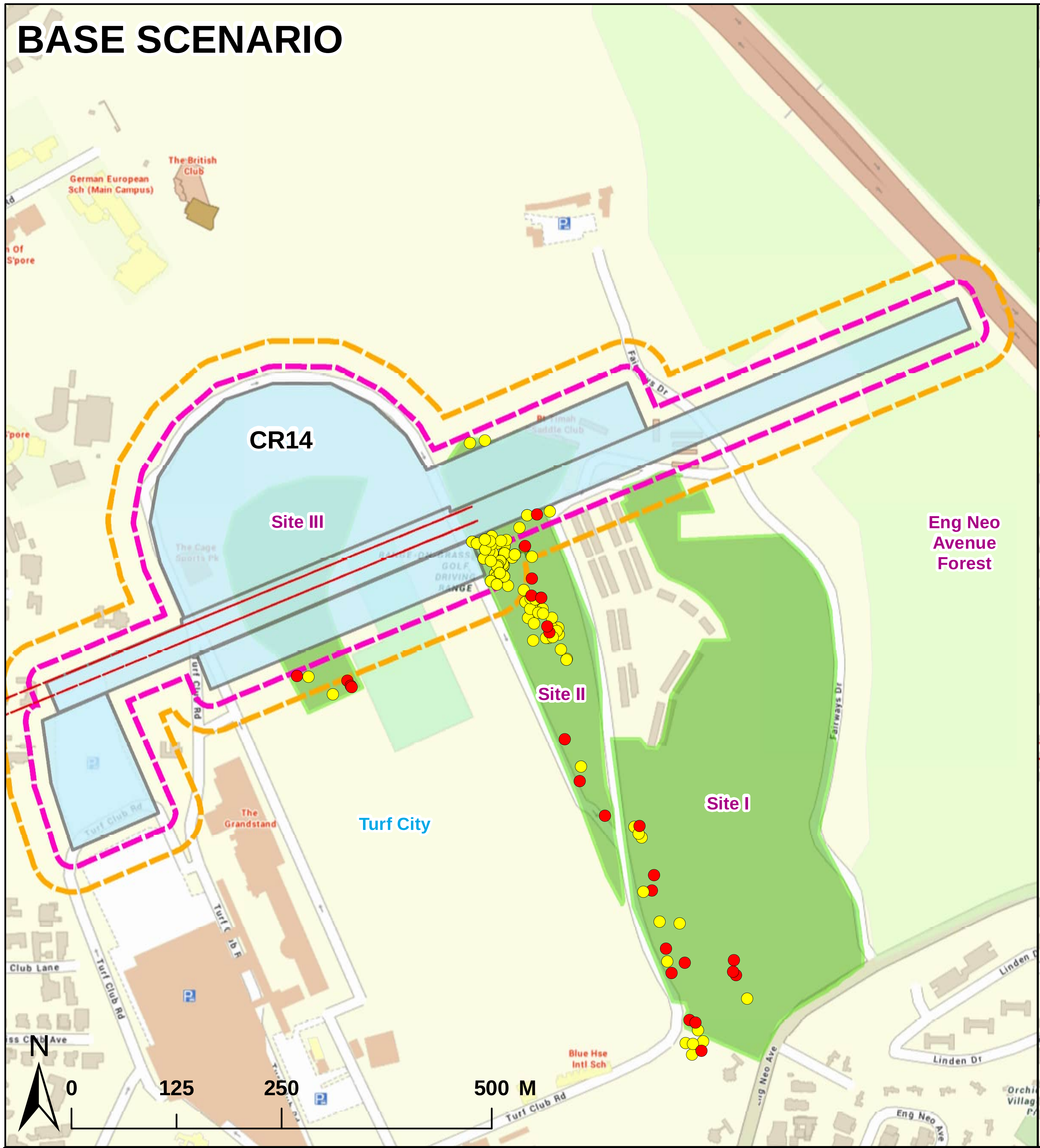
Table 10-25 below summarises the sensitivity of each construction phase for earthworks, construction, and trackout for each construction worksite comparing base and mitigated scenario. All construction worksites are located within or in close proximity to ecologically sensitive receptors. Based on the distances of emission sources to the identified receptors presented in Figure 10-19 to Figure 10-24, the Sensitivity of the Area was determined.

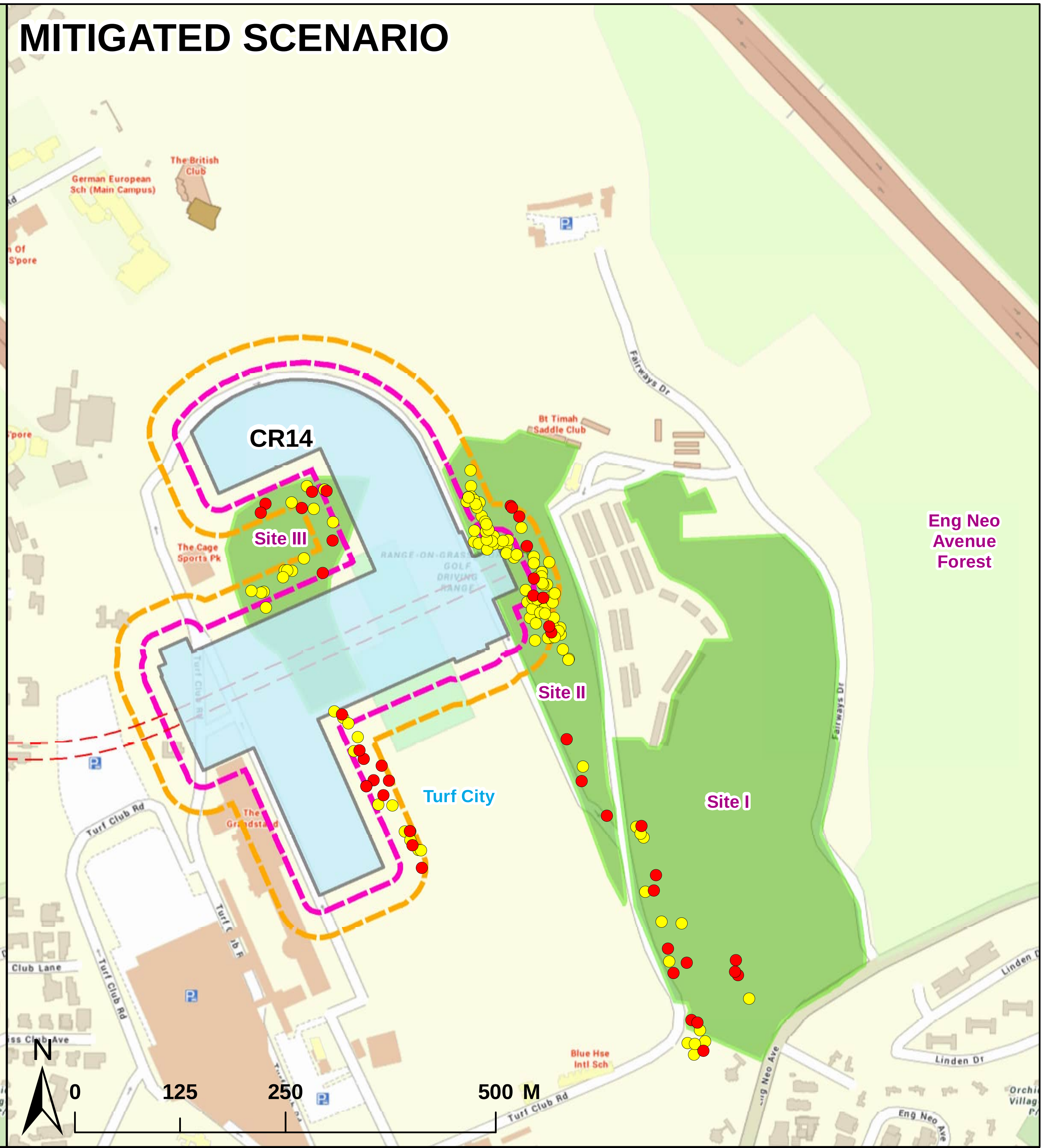
On top of the reduction of construction worksite area, the range of dust mitigation measures to be implemented at the construction sites are outlined in Table 10-26. Upon the implementation of mitigation measures, the Impact Significance was determined to be **Minor**. This will be detailed in Section 10.9.1.

Table 10-25 Receptor Sensitivity for Air Quality Impact Assessment – Construction Phase (Base and Mitigated Scenarios)

Distance	Base Scenario		Mitigated Scenario	
	Identified Receptors	Sensitivity of the Area	Identified Receptors	Sensitivity of the Area
CR14 CONSTRUCTION WORKSITES				
For Earthworks:				
Within 20m	Site II	Priority 1	Site II, Site III	Priority 1
Between 20m to 50m	Site II, Site III		Site II, Site III	
For Construction:				
Within 20m	Site I, Site II, Site III	Priority 1	Site I, Site II	Priority 1
Between 20m to 50m	Site I, Site II, Site III		Site I, Site II, Site III	
For Trackout:				
Within 20m	-	Priority 2	-	Priority 2
Between 20m to 50m	Site I		Site I	
CR15 CONSTRUCTION WORKSITE				
For Earthworks:				
Within 20m	Site V	Priority 1	Site IV, Site V	Priority 1
Between 20m to 50m	Site IV, Site V		Site V	
For Construction:				
Within 20m	Site V	Priority 1	Site IV, Site V	Priority 1

Distance	Base Scenario Identified Receptors	Base Scenario Sensitivity of the Area	Mitigated Scenario Identified Receptors	Mitigated Scenario Sensitivity of the Area
Between 20m to 50m	Site IV, Site V		Site IV, Site V	
For Trackout:				
Within 20m	-	Priority 2	-	Priority 2
Between 20m to 50m	Site V		Site V	





Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment
- Earthworks Footprint
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

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ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :

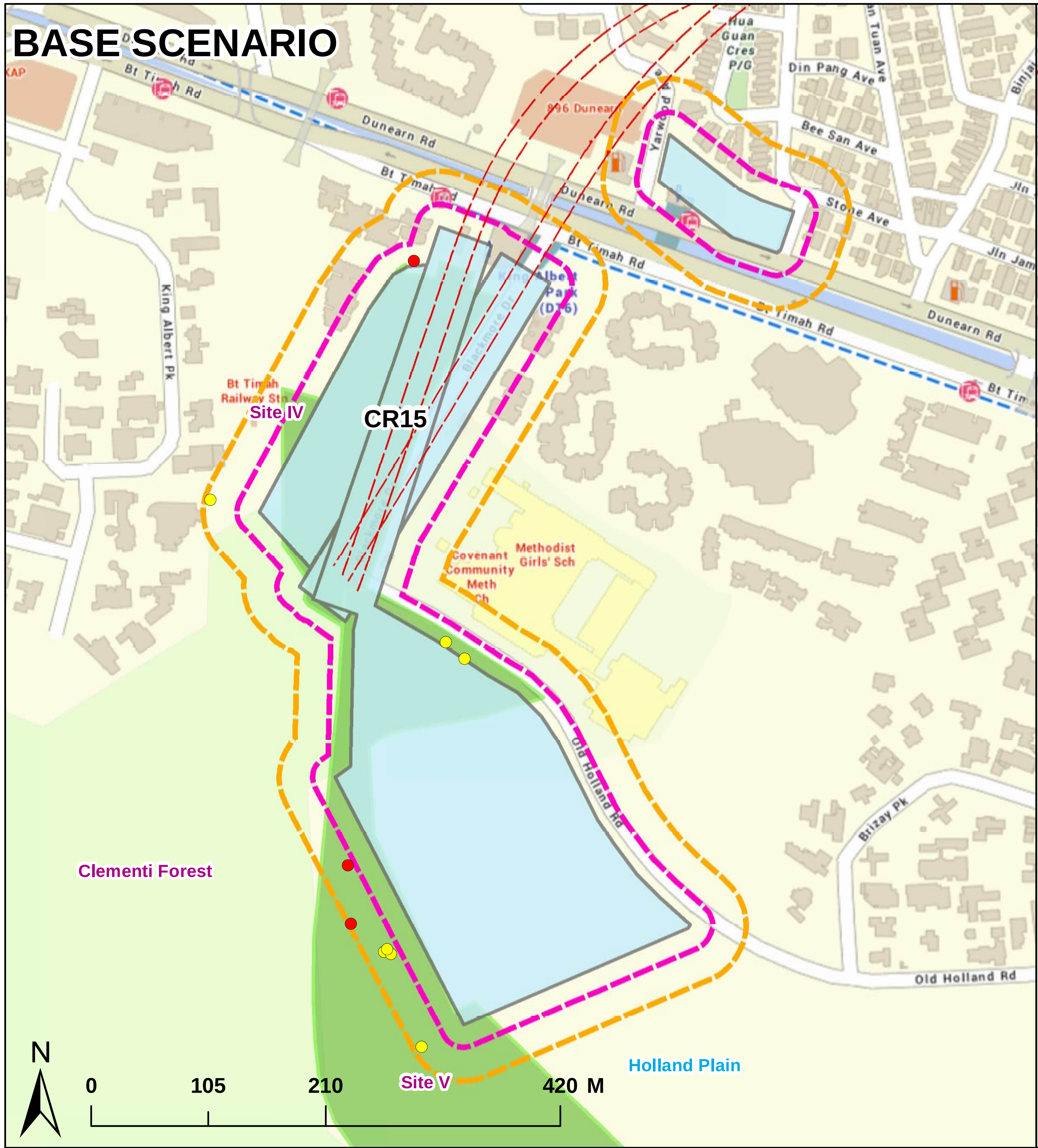
CR14 MITIGATED EMISSION SOURCES AND RECEPTORS (EARTHWORKS)

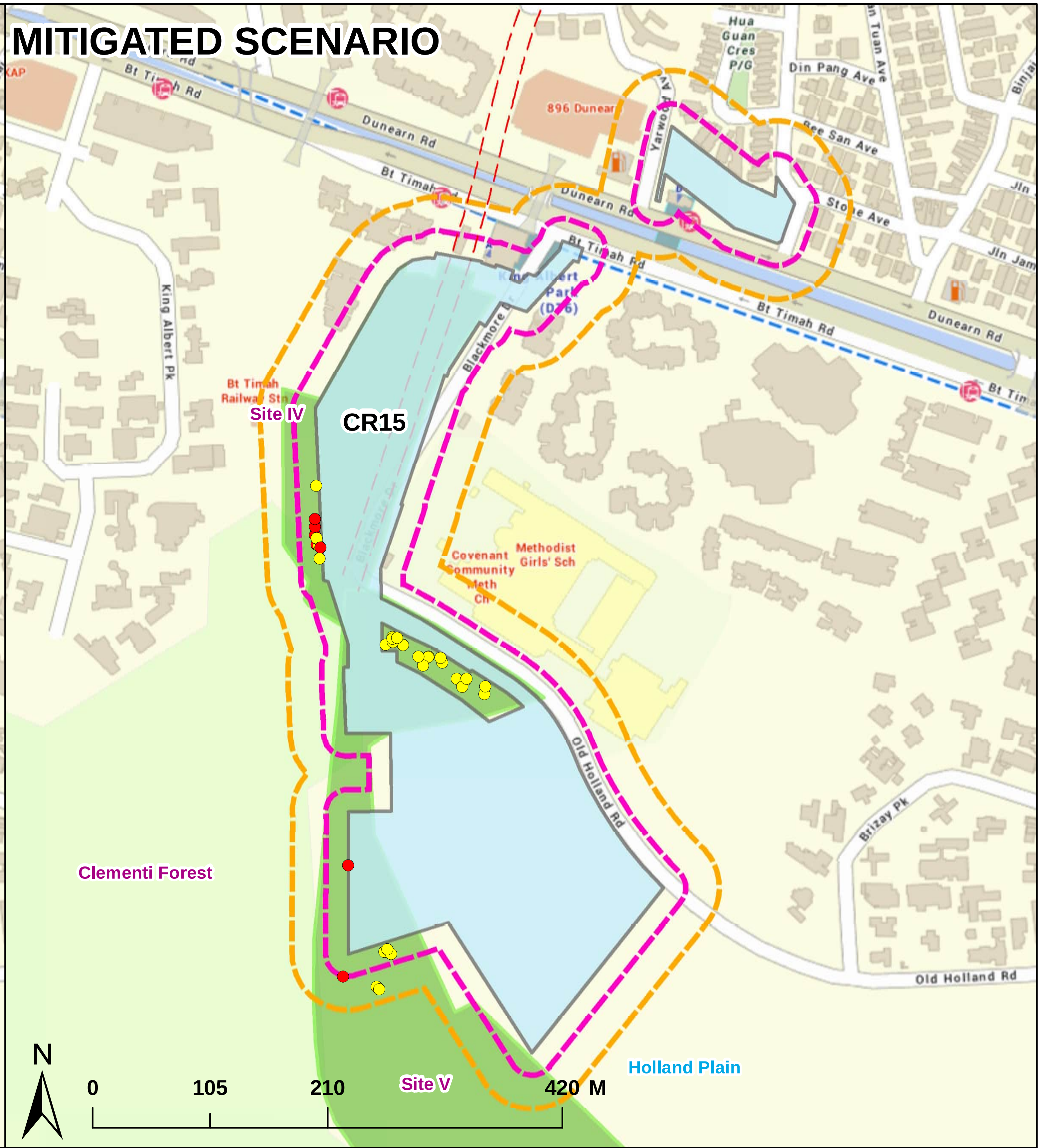
Designed	Checked	Approved	Drawn	Date
ML	JAG/NHT	JAG	ML	JULY 2022

Figure No.	Rev.	Sheet
10-19	-	1 of 1

CAD File Name : NA — A3

Note: Source of basemap - OneMap





Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment
- Earthworks Footprint
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

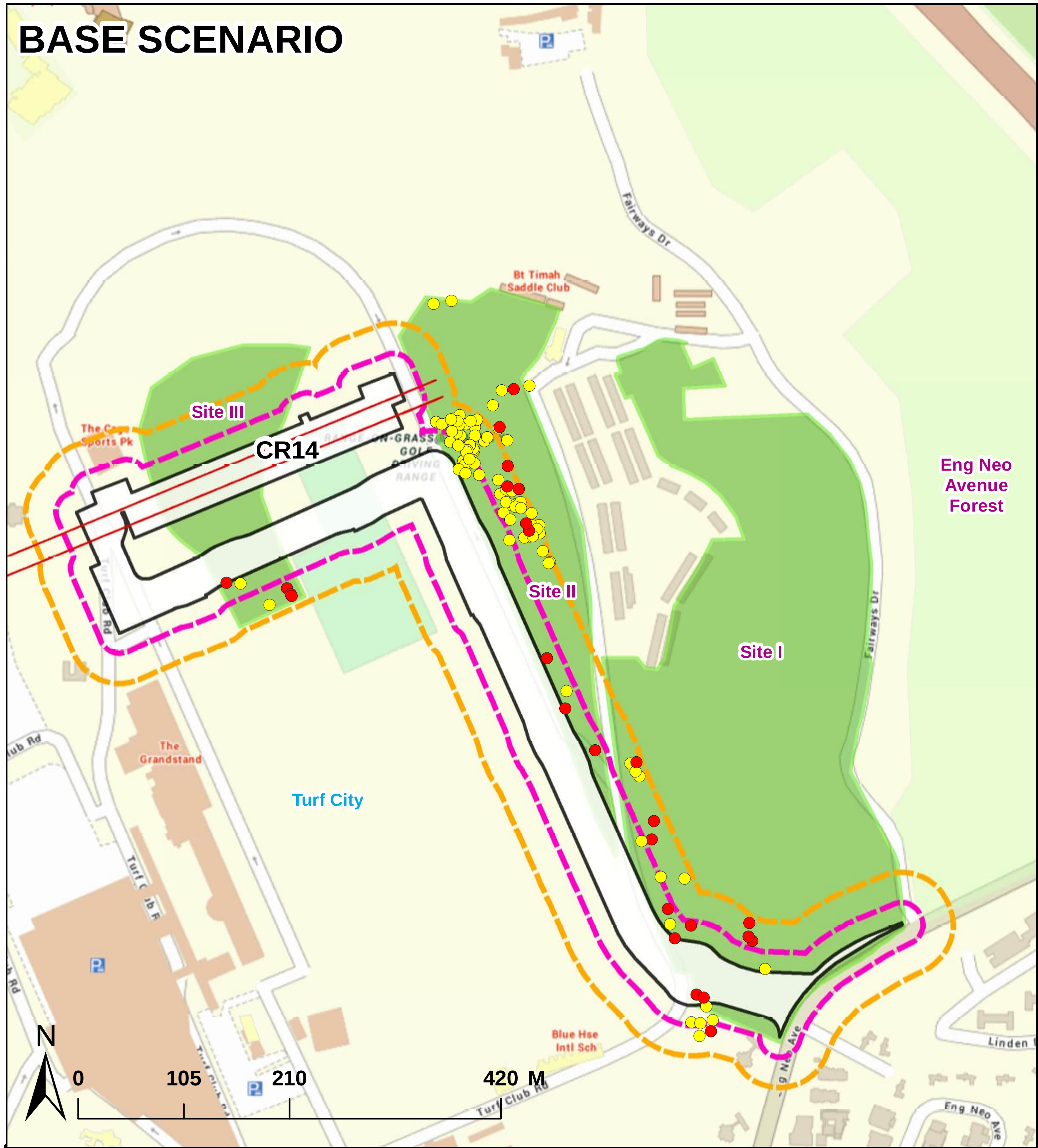
Figure Title :

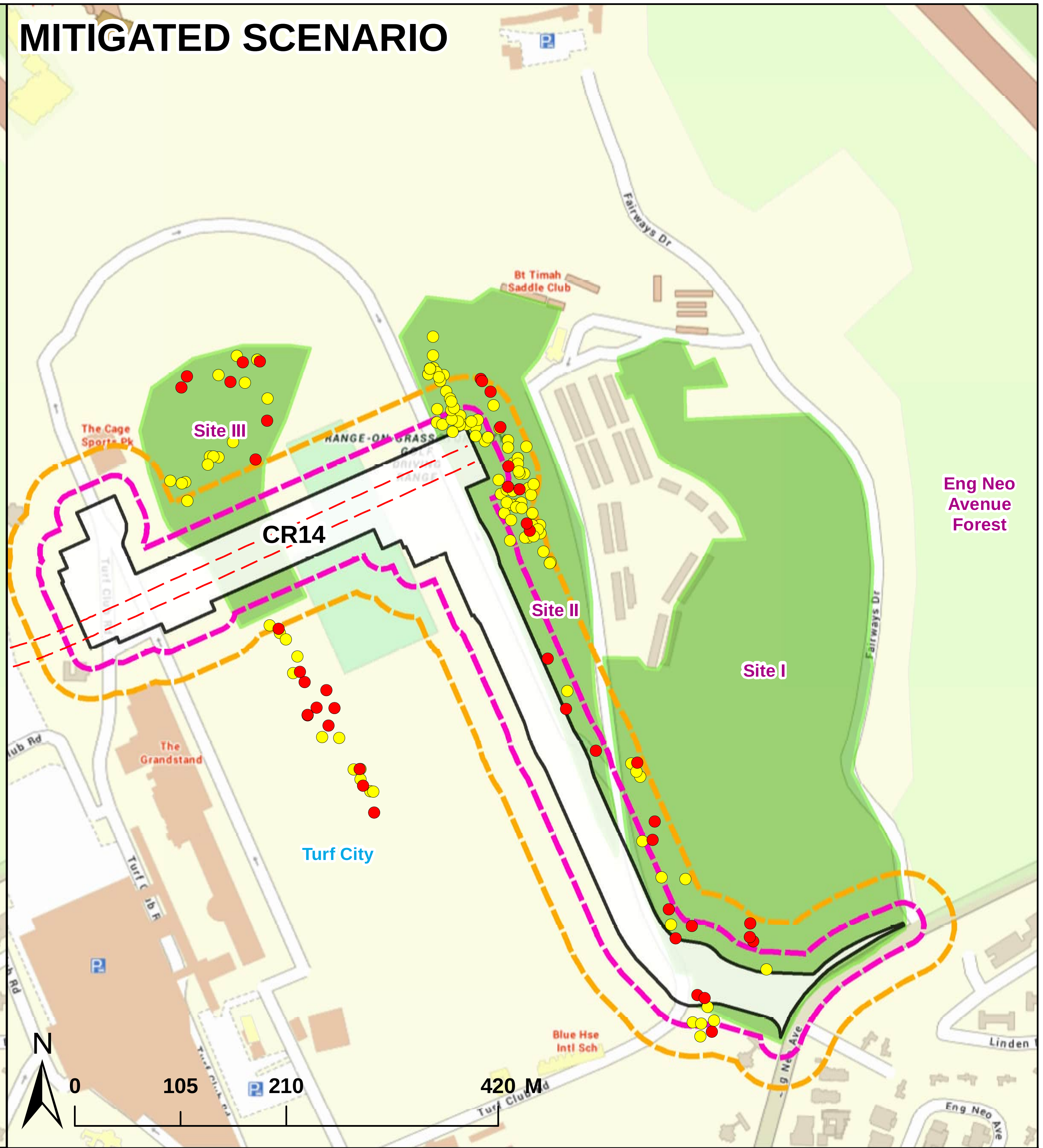
CR15 MITIGATED EMISSION SOURCES AND RECEPTORS (EARTHWORKS)

Designed	Checked	Approved	Figure No.	Rev.	Sheet
ML	JAG/NHT	JAG	10-20	-	1 of 1

Drawn	Date	CAD File Name	
ML	JULY 2022	NA	A3

Note: Source of basemap - OneMap





Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment
- Construction Footprint based on Tentative Future Road Alignment
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
A	SEPT 2022	HHL	EIS (Turf City and Holland Plain) Rev A	JAG/NHT	JAG
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :

CR14 MITIGATED EMISSION SOURCES AND RECEPTORS (CONSTRUCTION)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-21	A	1 of 1
	Drawn HHL	Date SEPT 2022	CAD File Name : NA		A3

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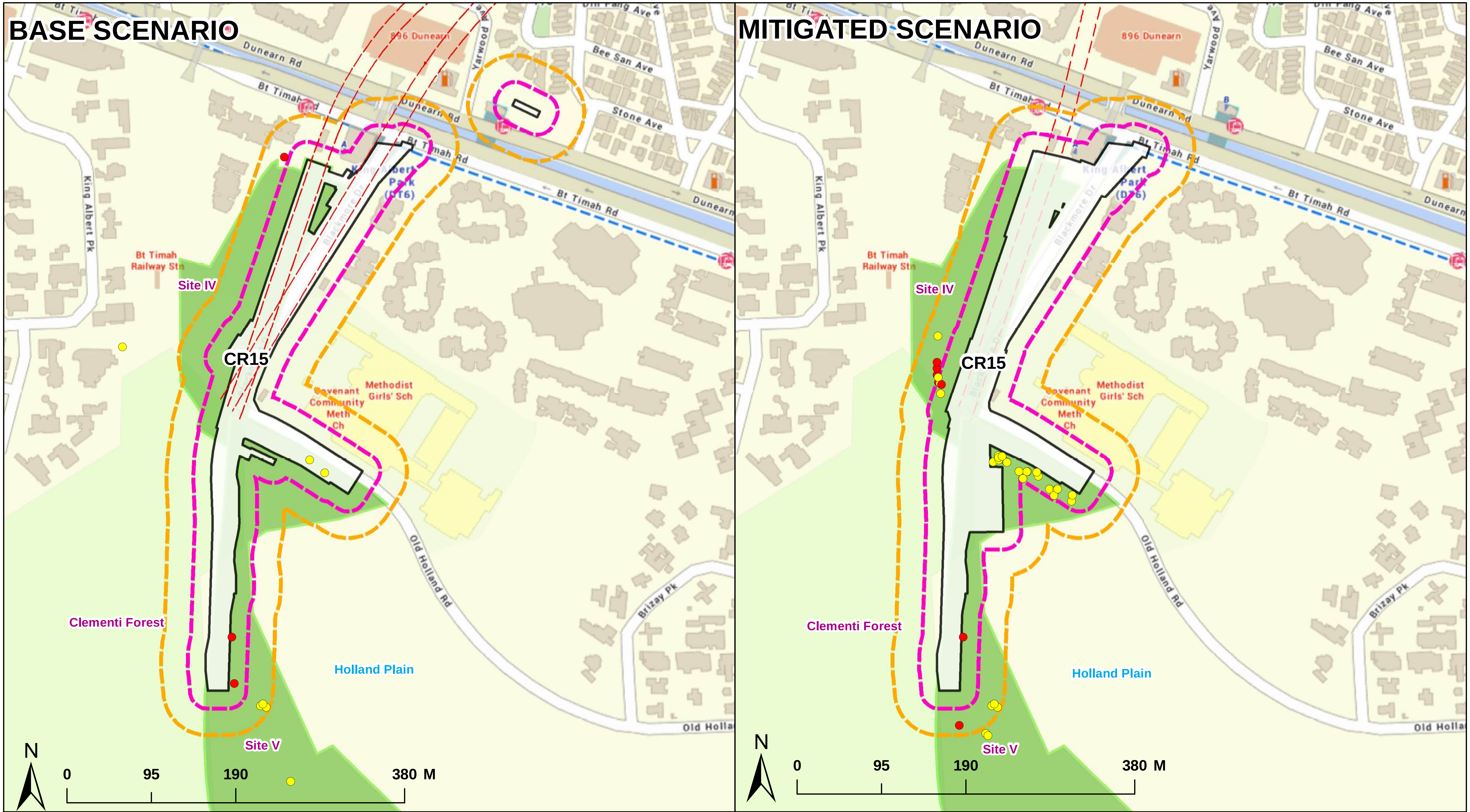

Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment
- Construction Footprint
- 20m from Sources
- 50m from Sources
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :

CR15 MITIGATED EMISSION SOURCES AND RECEPTORS (CONSTRUCTION)

Designed	Checked	Approved	Drawn	Date
ML	JAG/NHT	JAG	ML	JULY 2022

Figure No. : 10-22

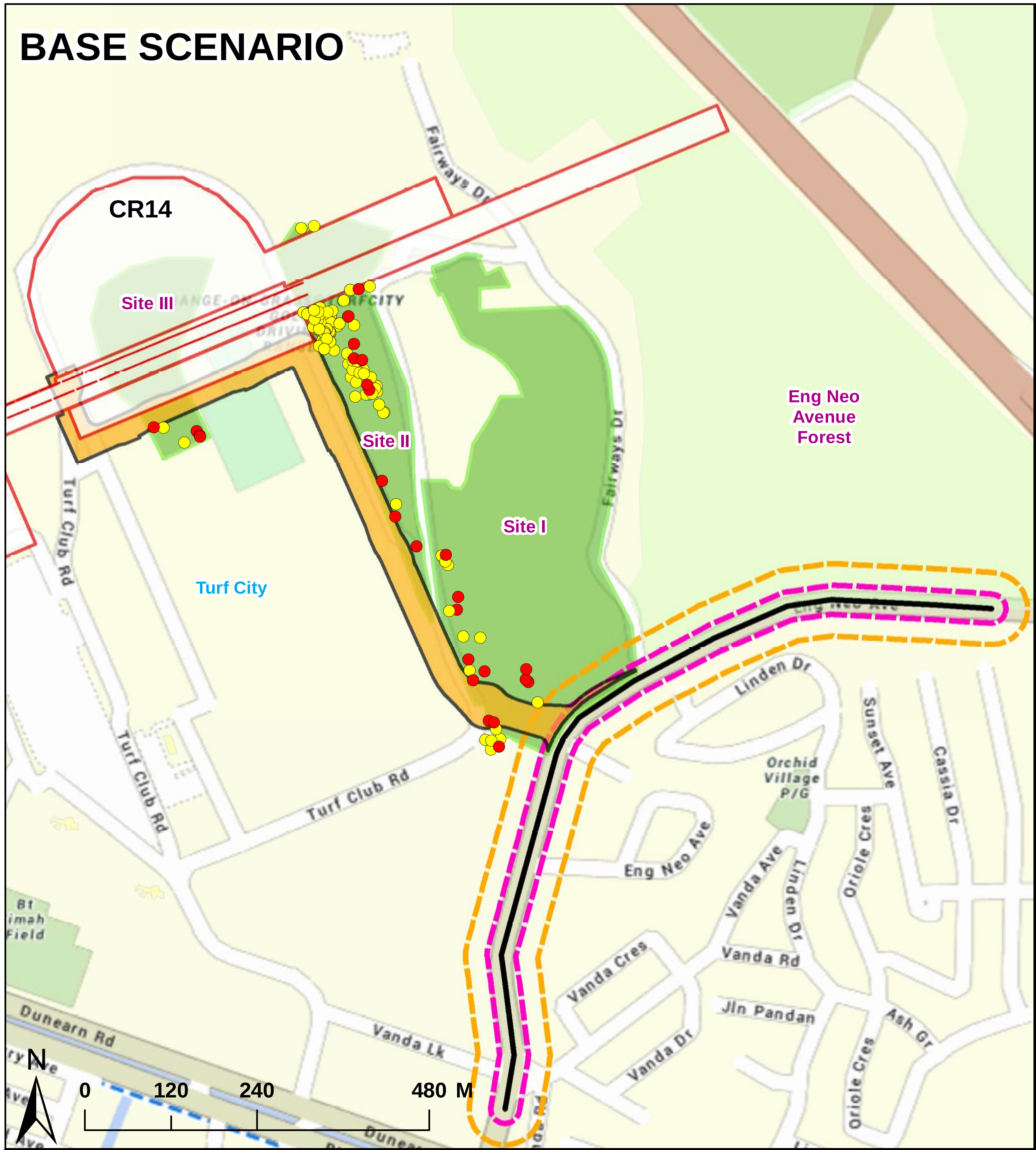
Rev. -

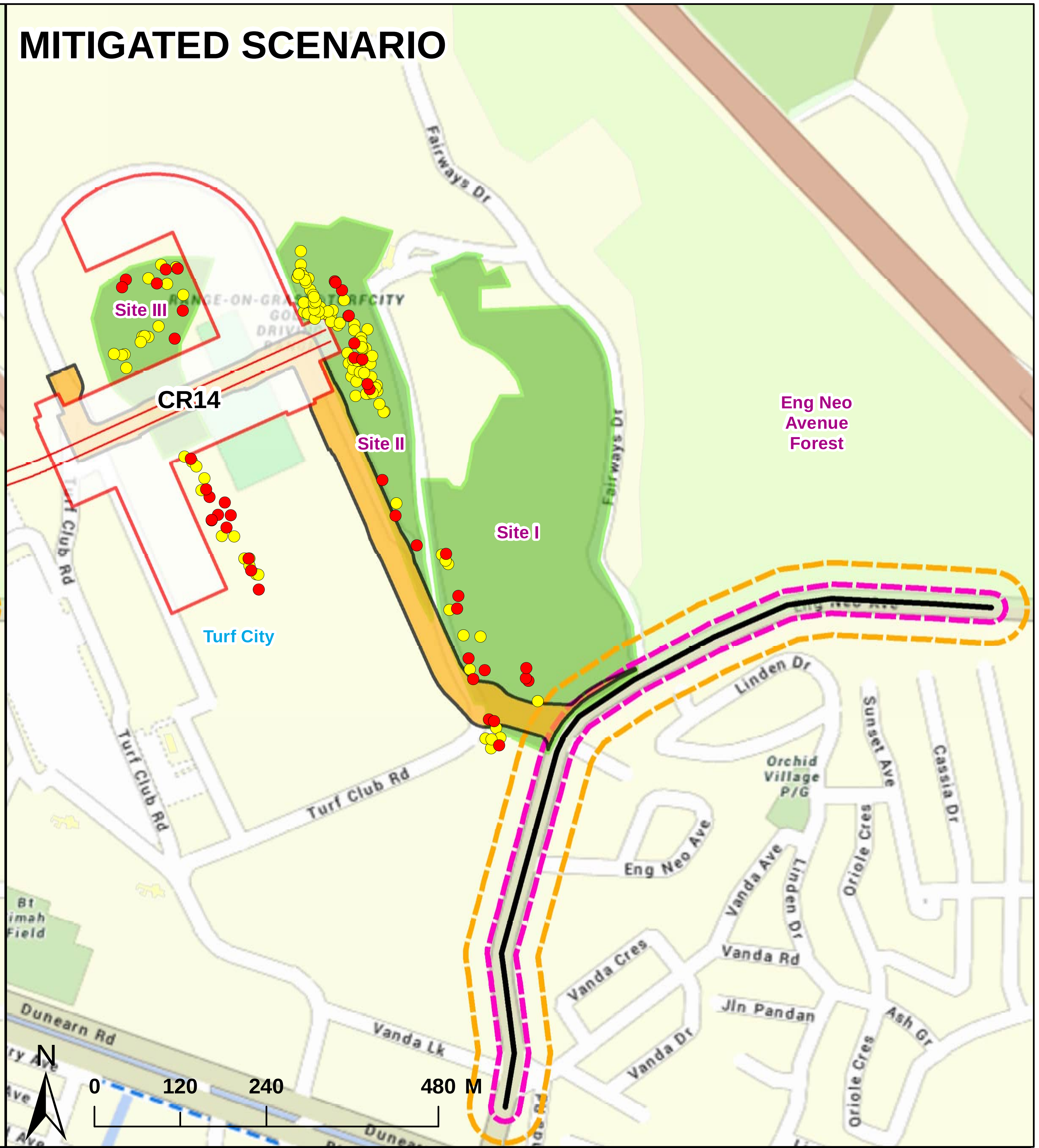
Sheet 1 of 1

CAD File Name : NA

A3

Note: Source of basemap - OneMap





Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment
- Construction Worksite Footprint
- Planned Road Works
- Potential Access Road
- 20m from Source
- 50m from Source
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

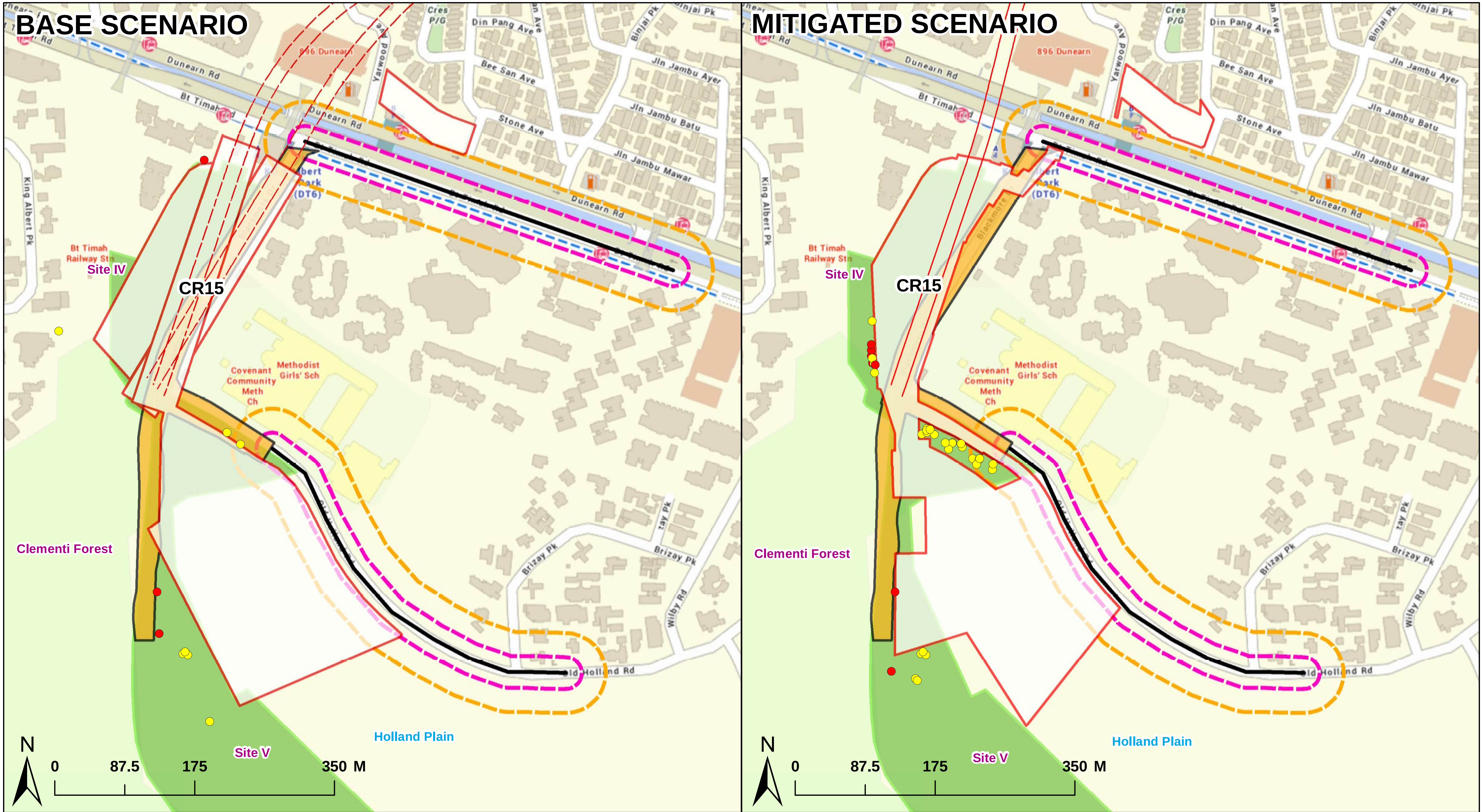
Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (TURF CITY AND HOLLAND PLAIN)

Figure Title :
CR14 MITIGATED EMISSION SOURCES AND RECEPTORS (TRACKOUT)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ML	JAG/NHT	JAG	10-23	-	1 of 1
	Drawn: ML	Date: JULY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Proposed CRL Alignment
- Construction Worksite Footprint
- Planned Road Works
- Potential Access Road
- 20m from Source
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- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	JULY 2022	ML	EIS (Turf City and Holland Plain)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(TURF CITY AND HOLLAND PLAIN)

Figure Title :
CR15 MITIGATED EMISSION SOURCES AND RECEPTORS (TRACKOUT)

Designed	Checked	Approved	Drawn	Date	Figure No.	Rev.	Sheet
ML	JAG/NHT	JAG	ML	JULY 2022	10-24	-	1 of 1

CAD File Name :NA A3

Note: Source of basemap - OneMap

Table 10-26 Air Quality Mitigation Measures (Construction Phase)

Mitigation Measures	CR14 Mitigated Scenario	CR15 Mitigated Scenario
GENERAL MITIGATION MEASURES TO BE IMPLEMENTED THROUGH OUT CONSTRUCTION PERIOD		
Communications		
Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	Mandatory	Mandatory
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.	Mandatory	Mandatory
Develop and implement an Air Pollution Control Plan (APCP) (see paragraph below for APCP details).	Mandatory	Mandatory
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.	Mandatory	Mandatory
Make the complaints log available to the local authority when asked.	Mandatory	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	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.	Recommended	Recommended
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 window sills within 100 m of site boundary. Cleaning should be provided if necessary.	Mandatory	Mandatory
Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan.	Mandatory	Mandatory
Increase the frequency of site inspections during prolonged dry or windy conditions.	Mandatory	Mandatory
Conduct monitoring for dust deposition at suitable locations (refer to Section 13.7 for details)	Mandatory	Mandatory
Preparing and maintaining the site		

Mitigation Measures	CR14 Mitigated Scenario	CR15 Mitigated Scenario
Plan site layout so that machinery and dust causing activities are located away from receptors, where possible.	Mandatory	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	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	Mandatory
Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust).	Mandatory	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	Mandatory
Operating vehicle/machinery and sustainable travel		
Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore.	Mandatory	Mandatory
Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs will be erected at site entrance to inform all visitors.	Mandatory	Mandatory
Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment.	Mandatory	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 within worksite, as well as local access roads leading to the site.	Mandatory	Mandatory
Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	Mandatory	Mandatory
Construction Operations		
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	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	Mandatory
Use enclosed chutes and conveyors and covered skips wherever possible.	Mandatory	Mandatory

Mitigation Measures	CR14 Mitigated Scenario	CR15 Mitigated Scenario
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	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	Mandatory
Waste Management		
Avoid burning of waste or other materials.	Mandatory	Mandatory
MITIGATION MEASURES FOR EARTHWORKS		
Re-vegetate earthworks and exposed areas/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	Mandatory
Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Mandatory	Mandatory
Only remove the cover in small areas during work and not all at once.	Mandatory	Mandatory
MITIGATION MEASURES FOR CONSTRUCTION		
Avoid scabbling (roughening of concrete surfaces) if possible.	Recommended	Recommended
Sand and aggregates will be delivered in a dampened stage and will be re-wetted before being dumped into storage bunker.	Recommended	Recommended
Drop heights at transfer points will be minimised to lessen dust generation	Recommended	Recommended
Special covered area will be provided for loading and unloading process	Recommended	Recommended
Water sprays or sprinklers will be employed at conveyor transfer points	Recommended	Recommended
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	Mandatory

Mitigation Measures	CR14 Mitigated Scenario	CR15 Mitigated Scenario
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.	Recommended	Recommended
For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	Recommended	Recommended
Vent will be provided with efficient fixed filter bags to comply with the dust emissions criteria.	Mandatory	Mandatory
Silos will not be filled up with cement more than 90% of its loading capacity, to avoid overfilling,	Recommended	Recommended
Silos will be equipped with overfill protection: audible high level sensor alarm and automatic shut-down switch, which could be activated to close when a problem is detected.	Mandatory	Mandatory
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.	Mandatory	Mandatory
Avoid dry sweeping of large areas.	Mandatory	Mandatory
Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Mandatory	Mandatory
Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	Mandatory	Mandatory
Record all inspections of haul routes and any subsequent action in a site log book.	Mandatory	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	Mandatory
Site access gates to be located at least 10 m from receptors where possible.	Mandatory	Mandatory

The APCP will 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 will 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 will 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 log book which is used to record information on incidents such as dust episodes, the sources identified, and the action taken and its efficacy. Any complaints will also be recorded within the log book along with the subsequent mitigation implemented and time to close out the complaint. The log book 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 13.4.3; and
- The air pollution control plan will 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.

10.8.2 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.

10.9 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 worksite area. The worksite option with smaller footprint (i.e., Mitigated Scenario) is preferred. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors.

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 10-27 to Table 10-29 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 10-27 Impacts of Dust Risk Assessment – Earthworks (After Mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Site Area (m^2)	No. of Vehicles moving within the site	Total Material Moved (tonnes)	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
CR14 Mitigated Scenario	>10,000	<5	>100,000	High	Priority 1	High	Rare	**Minor**
CR15 Mitigated Scenario	>10,000	<5	>100,000	High	Priority 1	High	Rare	**Minor**

Table 10-28 Impacts of Dust Risk Assessment – Construction (After Mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Building Volume (m^3)	Construction Material	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area	Overall Consequence / Dust Risk	Likelihood	Impact Significance
CR14 Mitigated Scenario	25,000-100,000	Concrete	1	Medium	Priority 1	Medium	Rare	**Minor**
CR15 Mitigated Scenario	25,000-100,000	Concrete	1	Medium	Priority 1	Medium	Rare	**Minor**

Table 10-29 Impacts of Dust Risk Assessment – Trackout (After Mitigation)

Construction Worksite	Key Parameter			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
CR14 Mitigated Scenario	>50	Moderately Dusty	<100	High	Priority 2	Medium	Rare	**Minor**
CR15 Mitigated Scenario	>50	Moderately Dusty	<100	High	Priority 2	Medium	Rare	**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 from Other Major Concurrent Development

It is known that construction activities are planned to occur in the vicinity of the Project as highlighted in Section 3.4.1. Hence, cumulative impacts from other relevant major concurrent development in the vicinity of the Project have been assessed and considered.

10.10.1 Construction Phase

Cumulative impacts for each of the construction worksite are presented in following sections.

10.10.1.1 CR14 Worksite

A1-W2 launch shaft worksite is located near Bukit Timah Saddle Club on the eastern side of CR14 Mitigated Scenario worksite. The impact significance before mitigation for CR14 ranges from Moderate to Major. Due to the presence of the A1-W2 construction site, the construction footprint in this area is expected to be larger. More vehicles moving within the site and more spoil to be moved as part of the excavation stage are also expected. However, upon proper implementation of mitigation measures, with this concurrent construction activity, the overall Impact Significance is not expected to significantly increase from the Project.

10.10.1.2 CR15 Worksite

Concurrent construction in the vicinity of CR15 worksite includes CR16 worksite, road network to support Holland Plain developments, Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail. The impact significance before mitigation for CR15 ranges from Moderate to Major. Due to the presence of the abovementioned concurrent projects, the construction footprint in this area is expected to be larger. More vehicles moving within the site and more spoil to be moved as part of the excavation stage are also expected. However, upon proper implementation of mitigation measures, with these concurrent construction activities, the overall Impact Significance is not expected to significantly increase from the project.

10.10.2 Operational Phase

Cumulative impacts during operational phase are presented in following sections.

10.10.2.1 CR14 Station

During operational phase, A1-W2 facility building is not planned. Hence, there is no cumulative impact during operational phase for CR14 station.

10.10.2.2 CR15 Station

Concurrent projects in the vicinity of CR15 station includes CR16 station, road network within Holland Plain developments, Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail. The impact significance before mitigation for CR15 station during operational phase is expected to be Negligible. Due to the presence of the abovementioned concurrent projects, the overall Impact Significance is not expected to significantly increase from the project.

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 Project site. Potential impacts to the neighbouring sensitive receptors during construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the earthworks, construction and trackout activities. During operational phase, fugitive emission from vehicle exhaust due to increased traffic in the vicinity of the Project is expected. Dust generated can have adverse effects upon vegetation by restricting photosynthesis, respiration and transpiration. Furthermore, gaseous pollutants can lead to phytotoxic by penetrating into the plants. The overall effect can be a decline in plant productivity.

In order to assess the current baseline air quality in the Study Area, baseline air quality data was collected at three (3) representative monitoring locations between 25 February – 3 March 2020 and 6 – 13 July 2022, and secondary data sourced from concurrent study carried out by AECOM in the vicinity for another two (2) locations. All pollutant concentrations (PM_{10} and $PM_{2.5}$) were found to be within the Singapore Ambient Air Quality Long Term Targets.

Air quality impact assessment for construction phase was undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. Pursuant to which, a 50 m Study Area was considered for earthworks, construction and trackout activities due to ecologically sensitive receptors in the vicinity of the worksites. Upon evaluation of impacts during construction phase, the results of the assessment show that unmitigated impacts were assessed as Moderate to Major across all construction worksites analysed (see Section 10.7.1 for assessment details). This is mainly because of the large extent of the construction worksite located very close to or within the areas with flora, fauna and habitat with high ecological value. This report, therefore, recommends mitigation measures that can be implemented by the Contractor as administrative or management measures, sourcing from best practice measures internationally, which are detailed Section 10.8.1, Section 13.9.1 and Section 13.13.

When these mitigation measures are applied successfully, the significance of impacts is anticipated to be reduced to **Minor** (see Section 10.9.1 for details). The key control and mitigation measures include but not limited to development 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. In addition, the worksite option with smaller footprint (i.e. Mitigated Scenario) is preferred. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors.

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

Cumulative impacts from other major concurrent development in the vicinity of each construction worksite are presented and detailed in Section 10.10. Due to the presence of these concurrent construction sites, the overall construction footprint is expected to be larger. Nevertheless, with all these concurrent construction activities, the overall Impact Significance is not expected to significantly increase from the Project.

Table 10-30 Summary of Impact Assessment for Air Quality

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I and Site II	Moderate to Major	**Minor**
Site III	Moderate to Major	**Minor**
Site IV	Moderate to Major	**Minor**
Site V	Moderate to Major	**Minor**
Operational Phase		
Site I and Site II	Minor	**Minor** (See Note 1)
Site III	Minor	**Minor** (See Note 1)
Site IV	Minor	**Minor** (See Note 1)
Site V	Minor	**Minor** (See Note 1)

Note:

1. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.