Land Transport Authority

Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line

SITE INVESTIGATION ENVIRONMENTAL IMPACT ASSESSMENT REPORT – *VOLUME IV, ALIGNMENT OPTION 2*

01 February 2016

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ERM

Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line

Site Investigation EIA – *Volume IV*, *Alignment Option 2*

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Client	Project No
Land Transport Authority Singapore	0256660

Project Summary

The Land Transport Authority have commissioned ERM to undertake environmental impact assessment studies relating of the construction and operation of the Cross Island Line (CRL) at or in close proximity to the Central Catchment Nature Reserve (CCNR), in Singapore. The phased studies are:

- *Phase 1a*: Environmental Baseline
- *Phase 1b*: EIA of the Site Investigation (SI) Works
- *Phase 2*: EIA of the construction and operation of the CRL for the two route options.

This document presents ***Volume IV*** of the Site Investigation EIA (*Phase 1b*) for the Project. Information and the assessment presented is based on secondary data available at the time of writing and environmental baseline data collected during the field surveys between October 2014 and November 2015.

Date
01 February 2016

Approved by

Alastair Scott
Managing Partner, ERM (S) Pte Ltd

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005	Site Investigation Environmental Impact Assessment Report – Vol IV	WT	RF	AS	01.02.16
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7 MANAGEMENT AND MONITORING

1 INTRODUCTION

This Volume of the SI EIA report presents the IA and EMMP for the proposed SI of Alignment Option 2 which skirts around the CCNR. The objective of the IA is to:

- To identify, quantify and assess potential impacts and determine the significance of impacts on sensitive receivers and potential affected uses;
- To propose mitigation measures to minimize significant impacts during SI works;
- To identify, predict and evaluate the residual environmental impacts (after practicable mitigation) and the cumulative effects expected to arise during SI works in relation to the sensitive receivers and potential affected uses; and
- To identify, assess and specify methods, measures and standards to be included during the SI works, ie develop an EMMP.

The remainder of this volume (IV) is structured as follows:

- *Chapter 2* details the proposed SI works that will be undertaken for Alignment Option 2 to inform the engineering feasibility of the CRL development;
- *Chapter 3* presents the IA of SI activities on the water environment receptors and resources within the Study Area;
- *Chapter 4* presents the IA of noise and vibration generated during the works on human receptors;
- *Chapter 5* presents the IA on emissions from the SI works on air quality;
- *Chapter 6* presents the IA on ecology and biodiversity from the SI activities; and
- Chapter 7 outlines the EMMP for Alignment Option 2 SI works.

2 ALIGNMENT OPTION 2 – SITE INVESTIGATION DESCRIPTION

2.1 INTRODUCTION

This chapter of the IA report describes the proposed site investigation (SI) associated with the engineering feasibility of Alignment Option 2 that skirts the CCNR from 400 m west of the PIE to Upper Thomson road to the east as illustrated on *Figure 2.1.* The SI will involve intrusive ground investigation[1] using A-frame drilling rig and geotechnical sampling.

The remainder of this chapter is structures as follows:

- *Section 2.2* details the preliminary investigation and utility clearance; and
- *Section 2.3* details the intrusive ground investigation works.

2.2 PRELIMINARY INVESTIGATIONS – GEOLOGICAL MAPPING & SITE RECONNAISSANCE

Common to most SI works completed by the LTA in Singapore, a preliminary desk study and site reconnaissance will be undertaken. These will enable essential information to be collected for geological mapping and determining the health, safety and environmental considerations for the ground investigation.

The desk study will include review of geological, hydrogeological and hydrology information; archaeology; land uses; and historical survey records. The site reconnaissance will be undertaken over a period of approximately two days, to confirm that the current status of the site is consistent with the findings of the desk study. The site reconnaissance will involve 2 persons tracing the alignment and proposed intrusive ground investigation locations illustrated on *Figure 2.1*, to record information such as: geological / geomorphological / landscape features and natural processes; drainage features; access constraints; and the presence of buildings and underground service mains (eg electricity cables or gas pipes). Due consideration will also be given to ecological barriers, ie trees, in delineating the final borehole locations so that no vegetation clearance will be required for the SI works along Alignment Option 2. This will be particularly the case within the isolated forest areas of the Island Golf Course and along the verge of Lornie Road and the PIE. The preliminary investigation phase will therefore enable finalization of the borehole locations.

2.3 INTRUSIVE GROUND INVESTIGATION

The intrusive investigation proposed for Alignment Option 2 will involve soil borings using an A-frame rotary drilling rig. The indicative locations of the proposed boreholes (illustrated on *Figure 2.1),* have been selected taking the following into account: aim to stagger the alignment of the tunnels for option 2; and comply with LTA's standard 25 m spacing for geotechnical boreholes in Singapore. Borehole locations also take into account areas where LTA have existing information from previous infrastructure projects. The locations will be refined further following completion of the site reconnaissance and desk study, however, for the purpose of this EIA, the locations outlined in *Figure 2.1* have been assumed.

[1] Intrusive ground investigation refers to the physical breaking of ground surface and excavation of soil through the use of equipment such as drilling rigs and excavators etc.

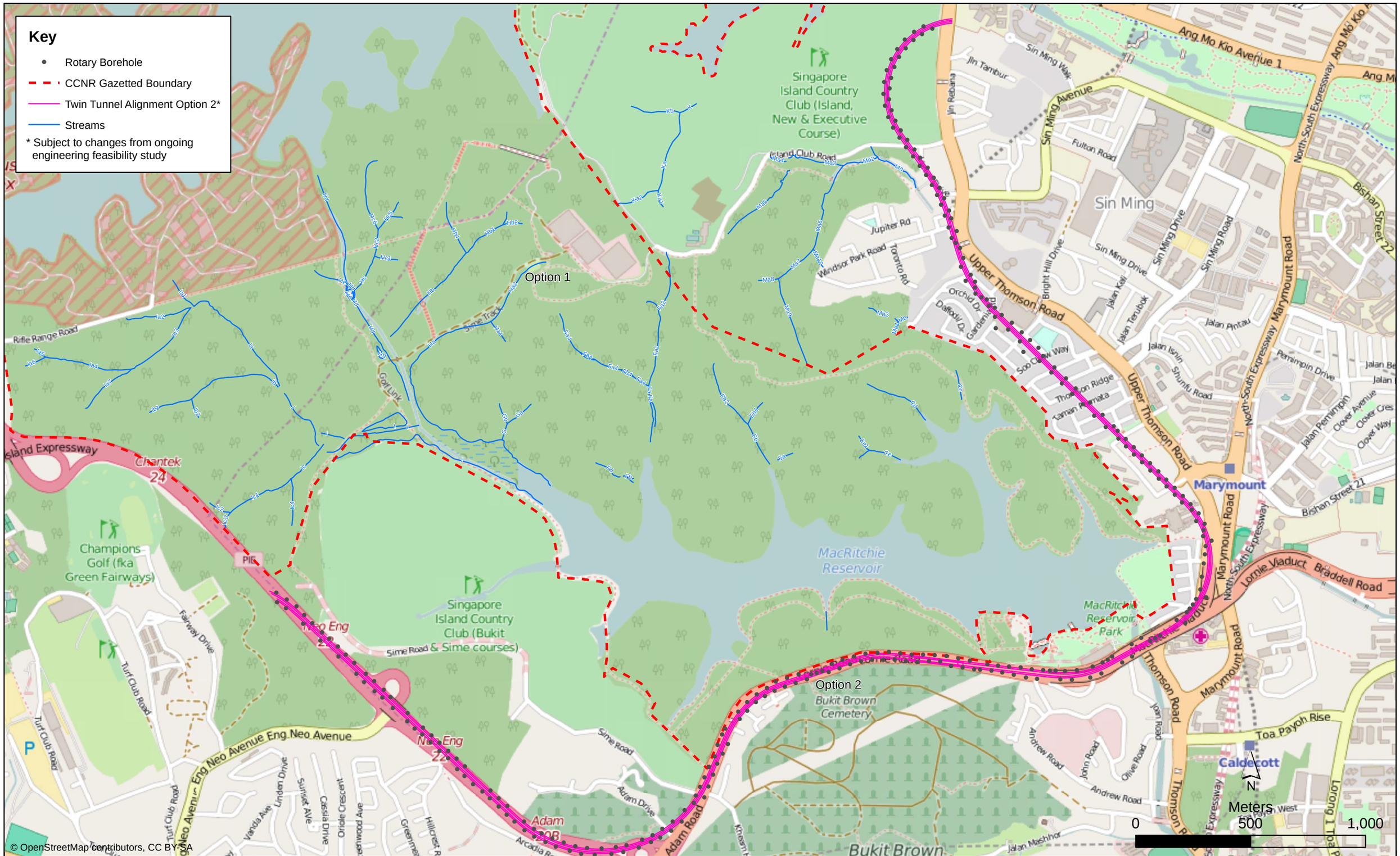

Figure 2.1 SI Locations – Alignment Option 2

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Date: 26/11/2015

Environmental Resources Management

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2.3.1 Rotary Boreholes

Up to 250 rotary boreholes as illustrated on *Figure 2.1* will be drilled along the alignment using a standard A-frame drilling rig. The specification of the A-frame drilling rig is provided in *Table 2.2*.

Mobilization

Prior to mobilization, all drilling and mobilization equipment will have a comprehensive maintenance inspection and be decontaminated. Typical equipment that will need to be mobilized to each borehole location includes:

- Drilling rig;
- Drip tray for machine engine and water pump;
- Drill rods sufficient to reach provisional depth of 70 m (assuming 24 x 3 m rods);
- Borehole casing, potentially full depth of borehole (assuming 24 x 3 m sections of casing);
- Standard Penetration Test (SPT) hammer (1), metal tubes for undisturbed samples in superficial materials (assumed 5 per hole), core barrel for rock coring (1), core boxes for rock core recovery (assume 30 m coring requires 6 core boxes);
- Small diesel fuel canister for emergency purposes (stored within lockable steel container with secondary containment);
- Lockable steel container, water and pump;
- Water storage and wastewater collection tanks.

A-frame rigs and the associated equipment will be transported to each location on a lorry crane. The borehole locations will be selected to ensure no access constraints to mobilizing and offloading/loading the rig and associated equipment.

Table 2.2: A-Frame Drilling Rig Specifications

Item	Standard A-Frame Drilling Rig
	
Mobilisation Speed	Up to 1.5 km /hr
Footprint of crawler / Vehicle height during mobilization	2.8 m long x 1.5 m wide / 2.4 m high
Extended mast height	7 m
Weight	2 tonne
Worksite footprint during operation	2 m x 11 m or similar Maximum worksite required for: rig, drilling rods; hydraulic fluid/fuel storage; water bowser; waste water bowser; pumps; mud tub; 2/3 operators; loading/unloading area for refilling water bowsers and removal of wastewater.
Fuel type	Diesel
Motor Size	10 - 15 kW
Drilling Type	Rotary
Rate of drilling	15 m/day for SPT borings; 5-7m/day for rock coring. (depends on ground conditions encountered)
Manpower Required	7-8 for mobilization/demobilization & set up 3-4 for operation
Maintenance	Monthly maintenance required – will be undertaken on site with drip trays.
Other	• Pumps, generator and drill rods and casing, fuel and drip tray for motor, SPT hammer, metal tubes for undisturbed samples, core barrel and boxes would be positioned on the lorry crane so no secondary vehicle required. • Freshwater for drilling would be from mains supply (in agreement with PUB) or in areas away from mains supply (eg around Sime Road parallel to the PIE) a secondary vehicle may be used to transport fresh water to each worksite. • Wastewater would be temporarily stored in tote tanks and removed daily by a licensed third party waste contractor or in some areas a PUB permit to discharge to the mains drainage system may be obtained (note, this would require additional settlement tank and analysis to demonstrate compliance with the PUB discharge permit requirements.

Set up

The borehole worksite will initially be cleared of utilities and demarcated for safety purposes. Utility clearance will be undertaken using cable avoidance detection equipment and excavation of a trial hole to up to 3 m depth using a hand auger. Should utilities be encountered, another trial hole will be excavated within 3 m of the original location. Temporary access routes will be set up around each worksite (if required) to maintain public access. No vegetation clearance is envisaged as being required for each worksite set-up.

Operation and Sampling

The trial holes will be used to create starter pits at each drilling location. Starter pits will be approximately 3 m depth and 1 m wide and used to contain drilling fluids during borehole installation. The spoil removed from each starter pit will be temporarily stockpiled (and covered) at the worksite and used as infill following completion of each borehole. Surplus waste spoil will be bagged and removed by third party licensed waste contractor.

The vertical alignment of the tunnel and the rock head level are currently uncertain, therefore provisional borehole drill depths of 70 m to 100 m are proposed. Drill casing up to 100 mm diameter will be used to drill through the geology (the minimum diameter used will be 54 mm). This provisional depth will be reviewed and refined as necessary following the preliminary investigations.

Standard penetration tests (SPT), undisturbed (UD) and disturbed sample collection, packer tests (PKT) and permeability tests will be undertaken to determine geotechnical properties of the underlying geology. As a minimum, the drilling contractor will undertake the drilling works accordance with:

- British Standard (BS) 5930:1999, Code of Practice for Site Investigation;
- BS 1377:1990, Methods of Testing Soils for Civil Engineering Purposes; and
- International Society for Rock Mechanics (ISRM), Rock Characterization Testing and Monitoring.

In order to complete the permeability tests, selected borehole excavations will have a 20 mm water standpipe installed. Monitoring will be undertaken by one technician over a period of approximately two weeks following completion of the borehole. Rather than remobilizing the rig in order to decommission and remove the monitoring well, monitoring wells will be infilled with grout.

2.3.2 Ancillary Facilities

Power Supply

A small generator will be required at each worksite to provide power for the water pumps and A-frame rig operations.

Fuel and Storage

All drilling will require diesel fuel. During operations, refueling of rigs will be required. A small fuel canister will be stored onsite within a locked cabinet with secondary containment for refueling purposes. The fuel will be refilled periodically offset and brought to site manually by workers or on a ancillary vehicle.

Water Supply

Water will be added to the borehole to provide lubrication, cooling of the drill bit and to aid in the removal of drill cuttings. The volume of water required will be dependent upon the geology encountered and drill method. For the purpose of this EIA, it is assumed that an average of 1,000 liters

of freshwater will be required daily during installation of each borehole. A tote tank will be positioned at each worksite. Daily re-supply of water will be undertaken by bowser and small vehicle and/or water will be taken from the mains supply in accordance with PUB requirements and permitting.

Waste Management

Solid waste associated with the works will include general waste from workers and a small amount of waste associated with the drilling operations (eg oil cans, grout bags, offcuts of monitoring well piping, rags *etc*). Liquid waste will include of drilling fluids, oil (from maintenance change over) and sanitary wastes.

Drilling fluids will pumped from the starter pits to a wastewater collection tote tank and removed from the worksite daily or as required. A small vehicle will be required for removal of the wastewater tote tank and other liquid wastes. The wastewater will be removed to a licensed third party disposal facility.

Sanitary facilities for all workers will consist of portable lavatories positioned in nearby accessible locations or the drilling contractors will utilize public sanitary facilities, depending on the worksite location.

Prior to commencement of the SI, a waste management plan will be put in place and training provided to all workers on the waste management procedures for the SI. The waste management plan will include the following:

- Waste hierarchy and classification;
- Daily inspection of waste management, such as the wastewater collection system (eg from starter pit), bagged waste, wastewater collection tote tank for leaks and damage;
- Bagging and daily removal of all solid waste from each worksite;
- Mobilization and demobilization procedures for the waste collection vehicle;
- Logging of waste generation and removal from each worksite;
- Sanitary facility location, maintenance and waste removal procedures;
- Inspection procedures to ensure waste management implementation;
- Disposal protocols and documentation requirements by licensed third party contractors; and
- Complaints procedure.

2.3.3 Intrusive Ground Investigation Resources and Schedule

The drilling of boreholes will be scheduled during daylight hours. The equipment, personnel and indicative duration of the surveys are summarized in *Table 2.3*. Based on previous LTA geotechnical works, up to four (4) drilling rigs may be mobilized for the SI programme for Alignment Option 2.

Table 2.3: Intrusive Ground Investigation Resources and Schedule

Ground Investigation	Equipment	Number Personnel Required	Duration
Rotary Boreholes : A-Frame Rig	▪ Drilling rig. ▪ Drip tray for motor. ▪ Drill rods sufficient to reach provisional depth of 70 m (assuming 24 x 3 m rods). ▪ Borehole casing, potentially full depth of borehole (assuming 24 x 3 m sections of casing). ▪ Standard Penetration Test (SPT) hammer (1). ▪ Metal tubes for undisturbed samples in superficial materials (assumed 5 per hole). ▪ Core barrel for rock coring (1), core boxes for rock core recovery (assume 30 m coring requires 6 core boxes). ▪ Lockable steel container. ▪ Water and pump. ▪ Water storage and wastewater collection tote tanks. ▪ Topographic survey equipment.	Up to 5	Up to 18 days per borehole (includes mobilization, operation of and demobilization of drilling rig but excludes permeability test and monitoring well decommissioning)

3 WATER ENVIRONMENT

3.1 INTRODUCTION

This chapter presents an assessment of the potential impacts of the SI works on surface water and groundwater.

The chapter is structured as follows:

- *Section 3.2* defines the scope of the assessment;
- *Section 3.3* describes the key baseline conditions at the Project site;
- *Section 3.4* provides an overview of the impact assessment approach; and
- *Section 3.5* provides an assessment of the potential impacts.

3.2 SCOPE OF THE ASSESSMENT

The scoping exercise identified several SI activities associated with Alignment Option 2 that may have significant interactions with the water environment in the Study Area. Taking these into consideration, along with the SI presented in *Chapter 2*, the assessment presented herein considers potential impacts on surface water and groundwater quality arising from site run-off.

This assessment has not considered impacts to the water environment due to generation of sanitary waste as sanitary waste associated with the Project will be managed by the use of existing sanitary facilities or temporary sanitary facilities operated by licensed third parties at the Study Area. Similarly all boreholes will be temporary and backfilled with grout after the SI works. Impacts to groundwater due to unsealed boreholes have been screened out.

Where the quality of surface water and groundwater is affected by the SI, this may have secondary impacts to their users, in particular ecology and biodiversity in the vegetated areas to the south /south west of Alignment Option 2 (*Figure 2.1*). While this chapter focuses on the impacts to the water environment, the resulting impacts of these on ecology and biodiversity are addressed in *Chapter 6*.

3.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

Key elements of the environmental baseline pertinent to the water environment in the Study Area include:

- Given Singapore's equatorial monsoon tropical climate, rainfall is prevalent throughout the year with an average of 2,348 mm/yr. Rainfall is typically highest during the northeast monsoon season, especially in December;
- Total rainfall received within the Study Area in 2013 was more than 2,900 mm, 10% to 30% above the national average;

- There are two concrete-lined canals within the Study Area. One canal which is connected to MacRitchie Reservoir. The other, is connected to stream Ma, which is part of the central watershed within the Marina Reservoir catchment area;
- A stormwater drainage channel runs parallel either side of the PIE and is likely in continuity with the stormwater drainage channel which runs parallel to Lornie Road;
- The results of surface water sampling within the Study Area showed water quality and concentrations below the *EPM (Trade Effluent) Regulations, 2008* for all parameters;
- Groundwater is not abstracted for use in Singapore;
- Groundwater underlying the Study Area is anticipated to be encountered within approximately 6 m bgs;
- There is likely to be a high degree of variability of groundwater flow rates in the shallow soils above bedrock and within the weathered bedrock related to the variability in hydraulic conductivity of these units in the area; and
- The hydraulic conductivity of competent bedrock is likely to be low in competent bedrock. Substantially higher groundwater flow rates are anticipated in areas of faulted or fractured bedrock.

3.4 ASSESSMENT METHODOLOGY

For assessment of the water environment, the sensitivity and magnitude criteria outlined in *Tables 3.1 and 3.2* have been used. Once the sensitivity and magnitude were established, the standard matrix based approach outlined in *Volume I, Chapter 4* was used to determine the impact significance.

Table 3.1: Sensitivity or Value Assessment Criteria for Water Resources

Value Criteria	Contributing Criteria	
	The extent to which the water resource plays an ecosystem or amenity role in terms of supporting flora and fauna. This includes its role as a migration route or in supporting a lifecycle stage.	The extent to which the water resource provides a use (drinking water, washing and other domestic or industrial uses) to the local communities and businesses, or is important in terms of national resource protection objectives, targets and legislation.
Low	The surface water resource does not support diverse aquatic habitat or populations, or supports aquatic habitat or population that is of low quality. The groundwater water resource supports aquatic habitat or populations, but the habitat/population is common/non-diverse/ in-significant.	The surface water resource has little or no role in terms of provisioning or services[1] for the local community. The groundwater resource is not currently abstracted and used in the vicinity of the Project, but is of sufficient quality and yield to be used for that purpose in the future (and there is a reasonable potential for future use).
Medium	The surface water resource supports diverse populations of flora and/ or fauna. The groundwater resource supports diverse or susceptible populations of flora and / or fauna.	The surface water resource has local importance in terms of provisioning services but there is ample capacity and/ or adequate opportunity for alternative sources of comparable quality. The groundwater resource is an important water supply, and is currently used, but there is capacity and / or adequate opportunity for alternative sources of comparable quality.
High	The surface water or groundwater resource supports economically important or biologically unique aquatic species of provides essential habitat for such species. The groundwater resource supports economically important or biologically unique species or provides essential habitat / nutrients to sustain such species.	The surface water or groundwater resource is wholly relied upon locally, with no suitable technically or economically feasible alternatives, or is important at a regional or transboundary watershed level for provisioning services or contribution to groundwater dependent ecosystems (eg transboundary rivers).

[1] Provisioning services are the material/energy products of ecosystems such as food and water.

Table 3.2: Criteria for Impact Magnitude

Magnitude Criteria	Definitions
Negligible	• Water quality impacts are likely to be well within ambient levels or allowable criteria. • Discharges are expected to be well within statutory limits. • Potential short-term localised effects on water quality but likely to be highly transitory (eg lasting a matter of hours) and well within natural fluctuations.
Small	• Water quality impacts are likely to be within ambient levels or allowable criteria. • Discharges are expected to be within statutory limits. • Potential short-term localised effects on water quality but which are likely to return to equilibrium conditions within a short timeframe (eg hours or days at most).
Medium	• Water quality impacts are likely to result in occasional exceedances of ambient levels or allowable criteria. • Occasional breach(es) of statutory discharge limits (limited periods) expected. • Potential localised effects on water quality which are likely to be fairly long lasting (eg weeks or months) and/or give rise to indirect ecological and/or socio- economic impacts.
Large	• Water quality impacts are likely to routinely exceed ambient criteria levels or allowable criteria over large areas. • Repeated breaches of statutory discharge limits (over extended periods) expected. • Potentially severe effects on water quality which are likely to be long-lasting (eg months or more) or permanent and/or give rise to indirect ecological and/or socio-economic impacts.

3.5 ASSESSMENT OF IMPACTS

3.5.1 Impacts to Water Quality During Rotary Rig Operation

As one of the 'Four National Taps' strategy in Singapore, the two concreted canals collect surface run-off from the surrounding areas and feed into the Marina Reservoir which is one of the main potable supplies in Singapore. However, these two canals are only a minor part of the central watershed, and the water within these canals does not support aquatic habitat or population. The drainage channel which runs parallel to the PIE was observed to be dry during the site walkovers but channels runoff from the PIE possible ultimately to the Marina Reservoir (although the exact outfall from this channel is unknown). Similar to the concrete cannels, this drainage channel does not appear to support aquatic habitats. Given the surface water resource from these canals (and possibly the drain parallel to the PIE) have local importance in terms of feeding into the Marina Reservoir, the sensitivity of surface water resource within the AOI of the borehole operations proposed along Alignment Option 2 is evaluated as *Medium*. Groundwater abstraction and utilization is prohibited in Singapore by the *Sewerage and Drainage Act, 2001* and it is assumed that groundwater does not support aquatic habitat or population considering the urban setting of the AOI. As a result, the sensitivity of groundwater is therefore considered to be *Low*.

The quality of water within the concreted canals and drainage channel parallel to the PIE could be impacted by spillage and leakage of hazardous fluid or run-off of wastewater generated during borehole excavation. The starter pits excavated at the onset of each borehole rig operation will be used to contain wastewater (or drilling slurry) consisting of water and soils generated as a result of water used during drilling. The volume of wastewater generated during the drilling operations will vary depending on the geology encountered, however, it is estimated to be a minimum of 1,000 liters daily. During operations the wastewater will be pumped from the starter pit into a tote tank for temporary storage, prior to removal by a waste contractor. Hazardous fluid such as diesel and lubricants will be used for

motor and pump operation and general maintenance during operation, however the volume of hazardous fluid stored on site will be small (eg assuming < 60 liters of diesel for refueling of rigs and < 1 liter of hydraulic lubricant for maintenance) and stored in a dedicated locked hazardous material storage box. Drip trays will also be positioned beneath the rig engine and pump motors to contain any leaks which may occur during operation of the rig itself. Wastewater generation and impact of run-off to ground and surface water quality during drilling will be managed by implementation of the following embedded controls:

- All drilling works will be conducted in accordance with the *Environmental Protection and Management Act, 2008, Environmental Protection and Management (Trade Effluent) Regulations, 2008* and LTA's *General Specifications, Appendix A, Safety, Health and Environment (for Rail Projects) December 2014 Edition*. These include various controls to protect impact to ground water and surface water courses, such as prohibiting hazardous material release; provision of spill kits on site; limitations on suspended solids; measures controlling sanitary waste release; and best management practices;

- Wastewater generated during operation of the drilling rig will be contained within a starter pit that has capacity to hold approximately 3 m^3 of water. The wastewater collected within will be pumped to an enclosed wastewater holding tank (or tote tank) and removed on a regular basis for disposal to a licensed third party waste management facility. The starter pits will be barricaded at all time and covered by wooden planks when not in use;

- As required by LTA's *General Specifications, Appendix A, Safety, Health and Environment (for Rail Projects) December 2014 Edition,* an Earth Control Measures Plan will be in place in the instance that clearance is required in the green area next to Sime Track to limit the potential for surface erosion and sediment runoff to surface water courses. This will be ascertained following completion of the site reconnaissance and selection of the final borehole locations; and

- A Waste Management Plan that includes considerations listed in *Section 2.3.2* will be implemented.

Three proposed borehole worksites will be located in close proximity to the concreted canals as illustrated on *Figure 2.1*. These worksites will be located at a distance approximately 5 m from the nearest surface water receptor. Worksite locations along the PIE will be within 2 meters of the drainage channel in this area as illustrated on the photo insert. The assumed 1,000 liters of wastewater which will be generated at each worksite will be transferred and stored within a tote tank and removed daily by a licensed third party. There will therefore be no discharge of wastewater (drilling slurry) direct to surface water drains/canal from the borehole drilling works. The lockable cabinet will double up as secondary containment to the small quantity of diesel fuel/lubricants (< 60 liters) that will be stored at each worksite for maintenance of equipment. Furthermore, drip trays will contain any leaks from the rig engine and/or pump motor. As the duration of operations is short and the quality of water within the canals and drainage channel is not likely to be affected by the run-off generated from the drilling rig during normal operations, the magnitude of impact to the quality of water resources within the AOI is assessed to be *Negligible* and overall significance of impact *Negligible*.

Source: ERM, 2015. PIE Verge and Drainage Channel / Borehole Worksite Location West of Sime Road

Table 3.3: Impact Assessment Summary

Criterion	Rating	Comment
Impacts to Water Quality During Rotary Rig Operation		
Nature	Negative	Change to surface water and groundwater qualities due to sediment loading, contaminated run-off and/ or generation of wastewater.
Type	Indirect	Any wastewater and sediment run-off would need to flow overland or via surface soils before reaching water courses.
Duration	Temporary	Drilling operation will take approximately two weeks at each borehole location.
Extent	Local	Sediments from wastewater would quickly dilute. Hazardous liquid (<60 liters) sufficiently small volumes and will be within locked secondary containment. Any spillage likely to be localized only.
Scale	-	Slight change of water quality in the canals affected.
Frequency	Intermittent	Wastewater will be generated every day during the drilling operations and rainfall events are regular in the Study Area.
Magnitude	Negligible	Wastewater that will be generated at each worksite is 1,000 liters per day. However wastewater will be removed by a licensed third party. It is assuming that only 60 liters of hazardous fluid will be stored on-site. The hazardous fluid will be stored in fuel canister locked in a dedicated cabinet. Secondary containment and spill kits will be provided to control accidental spillage and leakage.
Receptor Sensitivity	Medium to Low	The canals and drainage channel are a minor part of the central watershed that feeds into Marina Reservoir and the water within these canals does not support aquatic habitat or population. Groundwater is not abstracted for use and does not support aquatic habitat or population in urban area.
Significance	Negligible	Negligible adverse impact to surface water and groundwater quality due to sediment loading, contaminated run off and/or generation of wastewater during the rotary rig operation.

Although the impact is assessed as *Negligible*, the following precautionary measures are recommended for inclusion in the drilling operations to further minimize the impact:

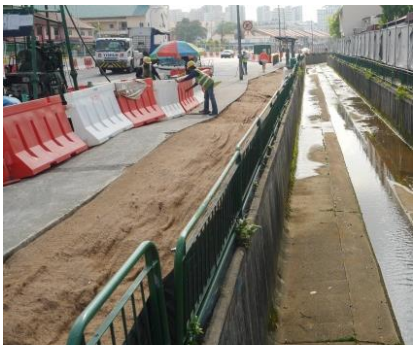
- Halt borehole operations during rainfall; and
- Replace starter pits with a Fluid Containment Tank (FCT) for drilling all boreholes to contain drilling slurry and minimize potential for overflow.

3.5.2 Cumulative Impacts

The sensitivities of surface water features and groundwater within the AOI of Alignment Option 2 have been evaluated in *Section 3.5.1*, and are deemed as *Medium* and *Low,* respectively.

The SI works scheduled to begin in 2016 Q1 will coincide with the construction activities of Upper Thomson MRT station and Thomson Line tunnels which are located in close proximity to one of the concrete lined canals identified in the Project AOI, ie the canal to the east of Windsor Park Road running along Upper Thomson Road. During the Project baseline an ECB was observed as part of the Thomson

Line development works. It is further understood that the works are being undertaken in accordance with an environmental management plan developed in line with LTA guidelines and Singapore regulatory requirements. Given that the potential impact from SI works in proximity to the said canal would be negligible and the environmental management measures reportedly in place for the Thomson MRT developments, the magnitude of a cumulative impact due to release to surface water is also considered to be *Negligible*.



ECB positioned between the surface waterbody and Thomson Line construction activities (ERM, 12.11.2015)

Construction activities of the new park connector around the CCNR may also be carried out at the same time with the SI work. The incremental impact from this development to nearby ground and surface water receptors are not considered to be significant as the construction activities will be relatively small scale involving minimal wastewater generation or usage of hazardous liquids that could impact ground. It is further assumed that the park connector development will be undertaken in accordance with regulatory requirements, permits and best management practices to limit potential impacts to the water environment. Considering the above, cumulative impact to the water environment from committed developments and the SI works are assessed to be of *Negligible* magnitude. Combined with the sensitivities, the overall impact significance is considered *Negligible*.

Table 3.4: Impact Assessment Summary

Criterion	Rating	Comment
Impacts to Water Quality Due to Cumulative Impacts		
Nature	Negative	Contamination of surface water features and groundwater common between the SI works and the new park connector such as the two concreted canals.
Type	Indirect	Indirect impacts as discussed in Tables 4.4.
Duration	Temporary	Temporary when SI works occur at the same time as the construction of the new park connector.
Extent	Local	The impacts will limit to the two canals and groundwater in the area common to the SI works and the construction site of the new park connector.
Scale	-	Slight change of water quality.
Frequency	Frequent	Daily when the SI works and construction of the new park connector overlap.
Magnitude	Negligible	The scale of construction for the new park connector and the SI works will be small and involve negligible wastewater generation and hazardous material that could impact the water environment to a large scale. Further both works will be undertaken in line with local regulatory requirements.
Receptor Sensitivity	Medium to Low	The two canals are minor part of the central watershed that feeds into Marina Reservoir and the water within these canals does not support aquatic habitat or population. Groundwater is not abstracted for use and does not support aquatic habitat or population in urban area.
Significance	Negligible	Negligible adverse impacts as a result of the cumulative impacts arise during the overlap period between the SI and construction activities of the new park connector.

4 NOISE AND VIBRATION

4.1 INTRODUCTION

This chapter presents an assessment of the potential impacts at receptors within the Project Study Area due to ambient noise, ground-borne noise and vibration levels generated during SI works.

The chapter is structured as follows:

- *Section 4.2* defines the scope of the assessment;
- *Section 4.3* describes the key baseline conditions at the Project site;
- *Section 4.4* presents an overview of the impact assessment approach;
- *Section 4.5* provides an assessment of the potential noise impacts;
- *Section 4.6* provides an assessment of the potential impacts from vibration ; and
- *Section 4.7* presents an assessment of cumulative impacts.

4.2 SCOPE OF THE ASSESSMENT

The scoping exercise has identified potentially significant ambient noise and vibration impacts associated with the simultaneous operation of four A-frame standard drill rig(s) along Alignment Option 2. It is also noted that SPT testing at each borehole will generate metal-on-metal noise and vibration during operation of the automatic drop hammer. As SPT tests will be carried out at every 2 m interval of soil, it is estimated that up to 17 tests will be required for each borehole. Each SPT test will involve dropping the rig hammer from a height of approximately 760 mm for up to 100 times over a 15 to 30 minute period. Due to the number of tests required for each borehole, noise impacts due to SPT testing were also assessed.

Vehicular movement (ie, positioning of the rig at each worksite and transportation of ancillary equipment) were also considered during scoping with regard to their potential interactions with the ambient noise environment. Given that the noise generated from these activities will be short-term in duration, and may be masked by baseline noise levels due to heavy traffic on nearby arterial roads within the Study Area, assessment of impacts associated with noise emitted during these activities were scoped out of this assessment.

In addition, cumulative vibration impacts due to the undertaking of SI works at the same time as committed developments within the Study Area were not deemed to be significant. It is anticipated that vibration generated from SI works would be localized to within meters of the A-frame rigs, and would be unlikely to contribute significantly to vibration levels from committed developments such as the North South Expressway tunnel construction, and North South Cable Transmission Tunnel (Contract NS3) construction. Therefore, cumulative vibration impacts have been scoped out of this assessment.

Where the ambient noise and vibration levels generated from the SI works are significantly higher than the baseline and/or relevant limits, this may have impacts on both human and ecological receptors.

This chapter focuses on the direct and indirect impacts on human receptors. The resulting impacts on noise and vibration on ecological receptors and ecosystems are addressed in *Chapter 6*.

4.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

This subsection summarizes the key baseline information pertinent to the assessment of impacts associated with noise and vibration from the SI activities. Detailed discussion regarding the noise and vibration baseline is provided in *Chapter 5 within Volume II of this EIA*.

4.3.1 Ambient Noise

General trends observed from long-term, short-term and supplementation short-term noise measurements undertaken at selected locations (*Volume II, Chapter 5*) during the baseline surveys (ie 24 November to 26 December 2014, Round 1, representative of the tail end of the inter-monsoon/ start of the Northeast monsoon; and 16 January to 09 February 2014, Round 2, representative of the Northeast monsoon) include:

- **NL201:** The predominant source of noise at this location comprise of vehicles passing along Upper Thomson Road. Other intermittent sources of noise include wind-blown vegetation. Hourly measurements indicate that noise levels typically range between 70 and 80 dB(A) and remain fairly constant from 6 am to midnight, on weekdays and weekends. Slight peaks in noise levels were observed to occur between 8 am and 9 am and from 6 pm to 7 pm. In general, noise levels measured in Round 1 of monitoring were lower than those in Round 2, which may be attributed to the lower volume of heavy vehicular traffic during Round 1 (55% and 59% lower during the respective peak and non-peak hours);

- **NL202:** The predominant source of noise at this location comprise of vehicles passing along both Thomson Road and Upper Thomson Road. Deceleration and acceleration of buses at nearby bus stops was a notable source of vehicular noise at this location. In general, noise levels measured during Round 1 of monitoring were higher than those in Round 2. This may be attributable to the higher volume of light and heavy vehicles during Round 1 (up to 3 times the volume of heavy vehicles during the peak periods, as compared to the second round). Measurements indicate that noise levels are typically high during the day (up to 70 dB(A)) due to traffic, and drop by approximately 9 dB(A) during the night-time off-peak hours. A distinct drop in noise levels can be observed from 8 pm to 4 am on weekdays and from midnight to 4 am on weekends; and

- **NL203:** The predominant source of noise at this location is the passing of vehicles along Lornie Road. Noise levels are generally high and fairly constant throughout the day and evening, ie between 77 to 82 dB(A). Noise levels start to drop from 8 pm on weekdays, and from midnight on weekends, reaching a low of 71 – 73 dB(A) at 4 am. Noise levels start increasing steadily from 4 am till the morning peak hour of 7 am.

In general, noise levels measured at representative monitoring locations within the Study Area were observed to be generally high and to fluctuate over the course of the day, in proportion to traffic volume, ie during peak and non-peak hours.

4.3.2 Vibration

Vibration measurements were taken at two locations along the Alignment Option 2 in March 2015. Measurements were taken over a 24 hour period at each location using an Instantel ground vibration monitor. Monitoring locations were selected to obtain representative baseline values at potential vibration sensitive receptors identified within the Study Area (see *Table 5.2* and *Figure 5.2*, *Volume II Chapter 5*). General trends observed from measurements undertaken at these locations include:

- **VL201, grass verge along Venus Drive:** Horizontal PPV ranged between 0.635 and 0.762 mm/s, while vertical PPV was recorded at 0.762 mm/s. Vibration sources observed include vehicles along Venus Drive, as well as joggers or trekkers using the adjacent pathway; and

- **VL202, grass verge along Lornie Road:** Horizontal PPV ranged between 0.508 and 0.635 mm/s, while vertical PPV was recorded at 0.889 mm/s. Vibration sources observed include heavy vehicular traffic along Lornie Road, as well as pedestrians using the adjacent pathway.

4.4 ASSESSMENT METHODOLOGY

4.4.1 Assessment Criteria

The evaluation of impact significance for noise and vibration impacts involves an assessment of the magnitude of the noise and vibration levels generated, against the relevant limits. These limits have been established through empirical studies and implicitly take into account the sensitivity of receptors to noise and vibration.

Noise

The *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations* stipulate permissible noise limits for worksites located within 150 m from existing residential premises. The applicable noise limits are summarized in *Volume I, Annex 1.0, Table A1.5* of this report. The regulations also allow for the application of correction factors to determine applicable permissible noise limits for worksites located in areas with high baseline noise levels.

Baseline daytime noise levels within the Study Area are observed to be relatively high due to constant vehicular traffic along the major roadways. The baseline measurements are summarized in *Table 4.1*, along with the relevant correction factor applied and the corrected permissible noise limits.

Table 4.1: Baseline Noise Levels & Corrected Permissible Noise Limits

Monitoring Point	Representative Receptor Category	Baseline Noise Level (dB(A))(Note 1)	Correction Factor (dB(A))	Corrected Daytime Permissible Limits (dB(A)) (Note 2)	
				$L_{Aeq,12hr}$	$L_{Aeq,5min}$
NL201	Residences along Upper Thomson Road	74.3 – 75.5	3	**79**	90
NL202	Residences near Upper Thomson and Thomson Road junction	65.5 – 69.1	1	**76**	90
	Mt Alvernia Hospital		1	**67**	**76**
NL203	Residences along Lornie Road	79.1 – 80.7	1	**82**	90
NL206	Residences ~100 m from Upper Thomson Road	56.7 – 61.0 (Note 3)	0	75	90
NL208 & NL209	St Theresa's Home	60.9 – 63.7 (Note 3)	3	**64**	75
NL211	Residences along Adam & Sime Road	51.4 – 56.0 (Note 3)	0	75	90

Notes

(1) $L_{Aeq,12hr}$ measurements unless indicated otherwise. In order to remain conservative, the lower bound value will be used to determine the applicable permissible noise limit.

(2) Values in bold have been corrected, ie the correction factor has been applied to the higher of either the permissible noise limit or the baseline measurement.

(3) Supplementary short-term measurements ($L_{Aeq,5min}$).

The criteria for assessment of the magnitude of noise impact due to SI works are presented in *Table 4.2*. As outlined in the *Fundamentals of Acoustics* published by the WHO[1], an increase in sound pressure levels of 3 dB represents a doubling of sound power and is just perceptible to the human ear, while a difference of 5 dB is clearly noticeable *(Hansen CH, nd)*. Based on this, it is assumed that noise levels up to 5 dB above the standards will be clearly noticeable exceedances to receptors and are classified as having *Moderate* significance, while any levels more than 10 dB(A) above the standards can cause impacts of *Major* significance to receptors.

Table 4.2: Impact Magnitude Criteria for Ambient Noise Impacts

Impact Magnitude	Definitions
Negligible	• Predicted noise levels are less than 3 dB(A) above the applicable permissible limits in *Table 4.1*.
Small	• Predicted noise levels are 3 to less than 5 dB(A) above the applicable permissible limits in *Table 4.1*.
Medium	• Predicted noise levels are between 5 and 10 dB(A) above the applicable permissible limits in *Table 4.1*.
Large	• Predicted noise levels are more than 10 dB(A) above the applicable permissible limits in *Table 4.1*.

[1] Hansen CH (nd) **Fundamentals of Acoustics.** Retrieved from http://www.who.int/occupational_health/publications/noise1.pdf

As the relevant limits take into account the sensitivity of the receptor, separate receptor sensitivity criteria are not applicable and therefore are not presented herein.

The other significance factor that is taken into account while determining the impact magnitude and significance in this assessment is the duration of impact. For example, impact to a receptor due to a construction activity with *Medium* impact magnitude based on *Table 4.*2 over a short term operating period, may be downgraded from *Moderate* to *Minor* significance on the basis of its short duration. For the purposes of this study, the durations of impact exposure (short, medium and long term) are defined in *Table 4.3.*

Table 4.3: Duration of Impact Exposure

Duration	Operating Period
Short term exposure	< 1 month
Medium term exposure	1 to 6 months
Long term exposure	> 6 months

Based on the above, the impact significance criteria for the SI works are therefore defined as shown in *Table 4.4*.

Table 4.4: Impact Significance Criteria for Noise Impacts from SI Works

Increase above background, dB(A)	Duration		
	< 1 month	1 to 6 months	> 6 months
<3B(A)	Negligible	Negligible	Minor
3-5dB(A)	Minor	Minor	Moderate
5-10dB(A)	Minor	Moderate	Moderate
>10dB(A)	Moderate	Major	Major

Vibration

Local regulations in Singapore with regards to vibration are currently focused on the prevention of structural damage due to pile installation. There is no legislation or guideline in Singapore which stipulates vibration limits for construction works located near to sensitive land uses so as to avoid disturbance of human receptors. International standards such as BS 5228-2:2009[2] and those referenced therein, have therefore been reviewed to identify the vibration limits applicable for this study. Guidance on the vibration thresholds and their corresponding effects on humans are presented in *Table 4.5*. Criteria for sensitive equipment used for critical purposes such as surgery and medical procedures are presented in *Table 4.6*. Similar to the approach to noise, the vibration criteria take into account the sensitivity of the receptor, therefore separate criteria for receptor sensitivity are not applicable and not presented. The corresponding impact significance rating taking into account the duration of exposure is presented in *Table 4.7*.

[2] British Standards Institution (BSi) (2009) Code of practice for noise and vibration control on construction and open sites: Part 2 – Vibration.

Table 4.5: Impact Magnitude Criteria for Vibration Impacts on Humans

Impact Magnitude	Vibration Magnitude (PPV[Note 1])	Effect[Note 2]	Impact Significance Rating
Negligible	0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.	Negligible
Small	0.3 mm/s	Vibration might be just perceptible in residential environments.	Minor
Medium	1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.	Moderate
Large	10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.	Major

Notes
(1) Peak particle velocity
(2) *Source: BSi, 2009*

Table 4.6: Vibration Criteria for Sensitive Equipment

Category	Facility, Equipment or Use	Vibration Velocity (rms[Note 1, 2])
A	Bench microscopes at up to 400x magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators. Microelectronics manufacturing equipment – Class A: Inspection, probe test, and other manufacturing support equipment.	50 µm/s
B	Micro surgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400x; optical equipment on isolation tables. Microelectronics manufacturing equipment - Class B: aligners, steppers and other critical equipment for photolithography with line widths of 3 µm.	25 µm/s
C	Electron microscopes at up to 30000x magnification; microtomes; magnetic resonance imagers. Microelectronics manufacturing equipment - Class C: aligners, steppers and other critical equipment for photolithography with line widths of 1 µm.	12 µm/s
D	Electron microscopes at up to 30000x magnification; microtomes; mass spectrometers; cell implant equipment. Microelectronics manufacturing equipment - Class D: aligners, steppers and other critical equipment for photolithography with line widths of 0.5 µm.	6 µm/s
E	Microelectronics manufacturing equipment - Class E: aligners, steppers and other critical equipment for photolithography with line widths of 0.25 µm; includes electron-beam systems; u-isolated laser and optical research systems.	3 µm/s

Notes
(1) Root mean square
(2) Source: *BSi, 2009*

For the purpose of the assessment presented herein, Category C as outlined in *Table 4.6,* has been adopted given that Magnetic Resonance Imaging machines are likely to be in use at Mt Alvernia hospital, located near the Alignment Option 2.

Based on the above, the overall impact significance ratings for vibration impacts are therefore defined in *Table 4.7.*

Table 4.7: Vibration Impact Significance Criteria

Impact Magnitude	Duration		
	< 1 month	1 to 6 months	> 6 months
Negligible *Humans: Less than or equal to 0.14 mm/s* *Equipment: Less than or equal to 0.003 mm/s*	Negligible	Negligible	Minor
Small *Humans: > 0.14 to 1.0 mm/s* *Equipment: > 0.003 to 0.012 mm/s*	Minor	Minor	Moderate
Medium *Humans: > 1.0 to less than 10 mm/s* *Equipment: > 0.012 to 0.050 mm/s*	Minor	Moderate	Moderate
Large *Humans: Greater than or equal to 10 mm/s* *Equipment: > 0.050 mm/s*	Moderate	Major	Major

4.4.2 Selected Noise & Vibration Sensitive Receptors

The receptors that have been identified as being potentially exposed to noise and vibration from the SI works are presented in *Table 5.1* of *Chapter 5*, *Volume II*. The receptors that are directly exposed to the proposed Project worksites and their indicative horizontal distance relative to the proposed worksite boundary are summarized in *Table 4.8*. The horizontal distances were estimated based on the following information:

- The typical footprint of an SI worksite, ie 2 m by 11 m or 2.5 m by 15 m[3]. It is therefore assumed that the closest possible distance between nearby receptors and the A-frame standard drill rig is approximately 3 m; and

- Based on assumptions at the feasibility engineering stage, the proposed boreholes along Alignment Option 2 will be arranged in a herringbone pattern, at 25 m spacing, with each borehole located approximately 20 m horizontally from the demarcated alignment route.

[3] ARUP Singapore Pte Ltd (12 February 2015) Contract C1002 Engineering Feasibility Study for the Proposed Cross Island Line: Site Investigation Strategy Report – Central Catchment Nature Reserve (CCNR). Ref *DOC/C1002/GEO/OT/0001/B*, Issue 3.

Table 4.8: Identified Noise & Vibration Sensitive Receptors

No	Receptors (Note 1)	Noise Sensitive	Vibration Sensitive	Approximate Distance from Proposed Worksite Boundary (m)(Note2)
1	Residents dwelling in private estates along Upper Thomson Road	✓	✓	3 – 165
2	Residents dwelling in private estates along Lornie Road	✓	✓	3 – 20
3	Residents at St Francis Convent	✓	✓	20
4	Elderly residents of St Theresa's Home	✓	✓	3
5	Patients residing at Assisi Hospice	✓	✓	65
6	Patients undergoing medical treatment at Mt Alvernia Hospital	✓	✓	30
7	Worshippers at the Hai Lam Sua Tee Kong Toa Temple	✓	×	90
8	Golfers utilizing the courses at SICC (Island location)	✓	×	3
9	Recreational users of MacRitchie Reservoir Park	✓	×	65
10	Users of Soo Chow Walk Playground	✓	×	15
11	Users of Taman Permata Park	✓	×	3

Notes

(1) Receptors that are directly exposed (whether fully or partially) to proposed SI worksites, ie there are no other structures shielding the receptor from the worksite.

(2) For receptors not immediately adjacent to proposed SI worksites, distances have been rounded up to the nearest 5 m.

(3) The proposed Alignment Option 2 is shown to be in close horizontal proximity to the receptor. At a minimum, it is presumed that receptors will be located outside the SI worksite which is estimated to be up to 2.5 m by 15 m [4], ie 3 m away from the rig.

4.4.3 Noise Modelling

The SoundPLAN noise prediction software, version 7.1 was used to predict noise generated from proposed equipment associated with SI works. The software implements the widely used international standard ISO 9613-2[4] and the model assumes hemispherical propagation from all noise sources over a non-absorptive ground surface. ISO 9613-2 predicts long-term average downwind noise levels in meteorological conditions favorable to propagation, including moderate inversions.

The purpose of the modelling was to determine indicative noise levels generated from the Project SI worksites, to allow for an assessment of the potential noise impacts and appropriate planning of mitigation measures required for one rig and the simultaneous operation of four standard A-frame rigs along Alignment Option 2.

Model Assumptions

The following assumptions have been made in order to achieve a level of detail that is proportionate to the stage of the overall Project design:

- Four rigs and the associated pumps for the drilling slurry were assumed to be in continuous operation. No correction factors were applied to account for periodic plant shutdown;

[4] International Organization for Standardization (ISO) (1996) International Standard 9613-2: Acoustics – Attenuation of Sound during Propagation Outdoors – Part 2: General Method of Calculation.

- To represent a worst case scenario, four rigs were positioned within 25 m of each other. It is noted that during the Preliminary Investigation phase of the project, borehole locations will be refined to take into account the presence of buildings, utilities, and existing geotechnical information etc. There will therefore be some flexibility to four rigs operating concurrently within 25 m of each other;
- The effect of the relative mean humidity and temperature of Singapore, ie 84% and 27˚C, on noise propagation is factored into the model;
- Shielding effects due to the presence of structures near the noise sources were not accounted for, although the model factors in attenuation due to propagation of noise within a built-up urban area;
- Sound power level inputs for modelled equipment are calculated from empirical sound level data listed in BS 5228-1:2009[1]; and
- Noise receivers (NRs) are input to simulate identified NSRs, and are modelled at 1.5 m elevation for receptors at ground level, and at 30 m elevation for receptors located at height, eg St Theresa's home, and residents in high-rise apartments within the Study Area.

4.5 ASSESSMENT OF NOISE IMPACTS

4.5.1 Operation of Rotary Drilling Rigs

The predicted noise contours from simultaneous operation of four A-frame standard drilling rigs and associated ancillary equipment were generated at elevations of 1.5 m and 30 m, to represent noise levels experienced by receptors at ground level and at height, ie approximately seven storeys high. These are presented in *Figure 4.1* and *Figure 4.2* respectively.

It is noted that as shielding or reflection effects were not accounted for in the model, the noise contours represent free field levels. A correction factor of 3 dB(A) was therefore added to the predicted levels to account for reflection of noise at building facades to estimate predicted noise levels at indoor receptors, in accordance with international guidance[5].

The predicted noise levels at the modelled NRs, ie representative of identified NSRs, are presented in *Table 4.9* along with a comparison against the applicable permissible noise limit. The modelling results indicate that incremental noise levels (based on $L_{Aeq,5min}$) are expected to exceed permissible daytime limits by more than 10 dB(A) at receptors in close proximity to the Project worksites, ie, residences along Upper Thomson Road and Lornie Road, users of Taman Permata Park, golfers in SICC Island Golf Course, St Theresa's Home; and patients in Mt Alvernia Hospital. This corresponds to a *Large* impact magnitude with reference to the criteria provided in *Table 4.2*. It is noted however, that rig operations are estimated to be completed in approximately 18 days (including mobilization and demobilization), ie the exposure of receptors to elevated noise levels will be short-term (as defined in *Table 4.3*). Given that the increase above background limits in several areas (at residences along Upper Thomson Road and Lornie Road, users of Taman Permata Park, golfers in SICC Island Golf Course, St Theresa's Home; and patients in Mt Alvernia Hospital) around Alignment Option 2 is >10 dB(A), however the duration is less than 1 month, the impact significance prior to mitigation is assessed to be *Moderate.* The remaining NR's identified in *Table 4.9* have predicted levels of between 9 dB(A) and 2 dB(A) which equates to *Minor* to *Negligible* significance.

[5] British Standards Institution (2009) Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise. BS 5228-1:2009.

Figure 4.1: Noise Contours ($L_{Aeq,5min}$) at Ground Level (Elevation 1.5 m)

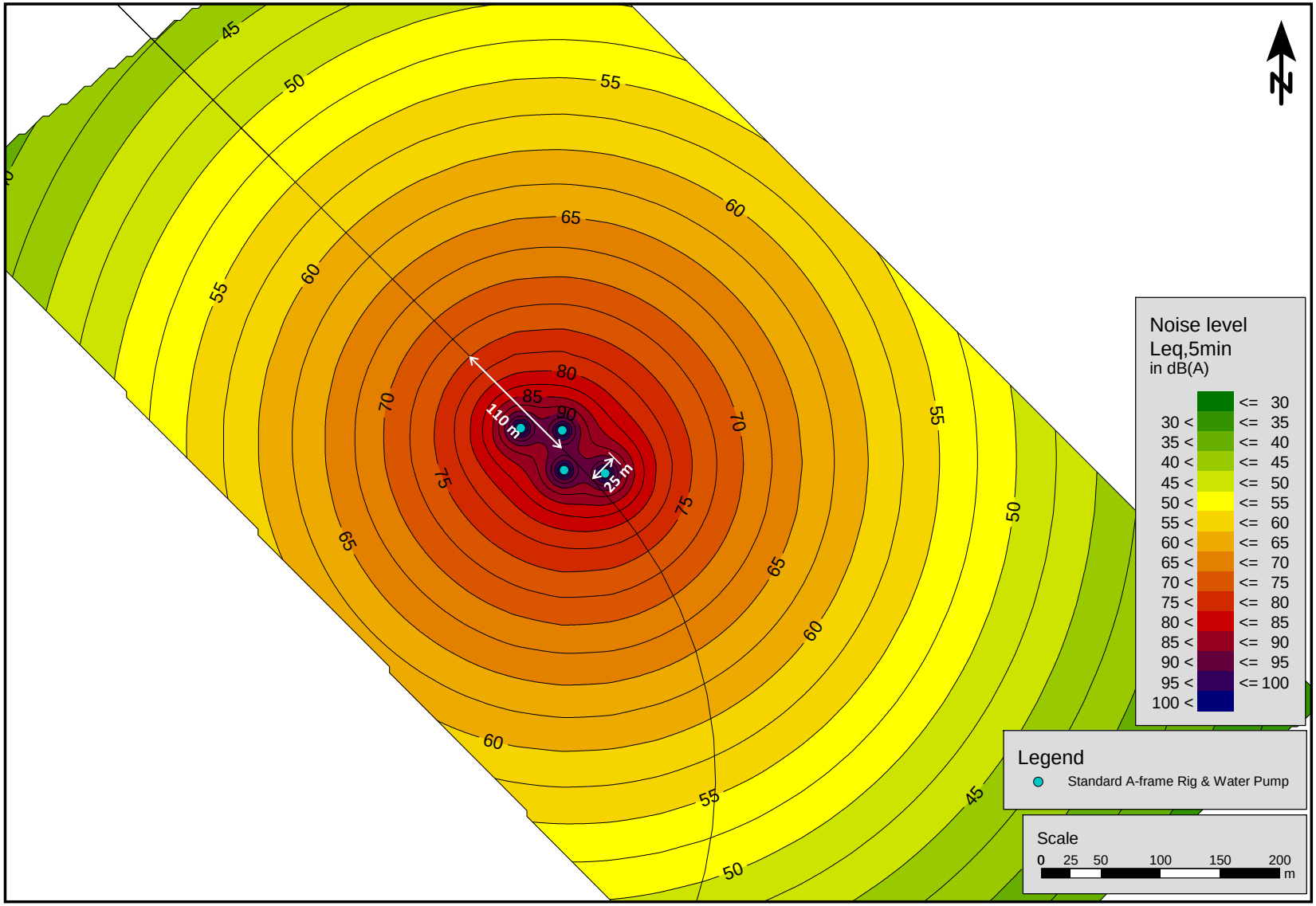


Figure 4.2: Noise Contours ($L_{Aeq,5min}$) at Height (Elevation 30 m)

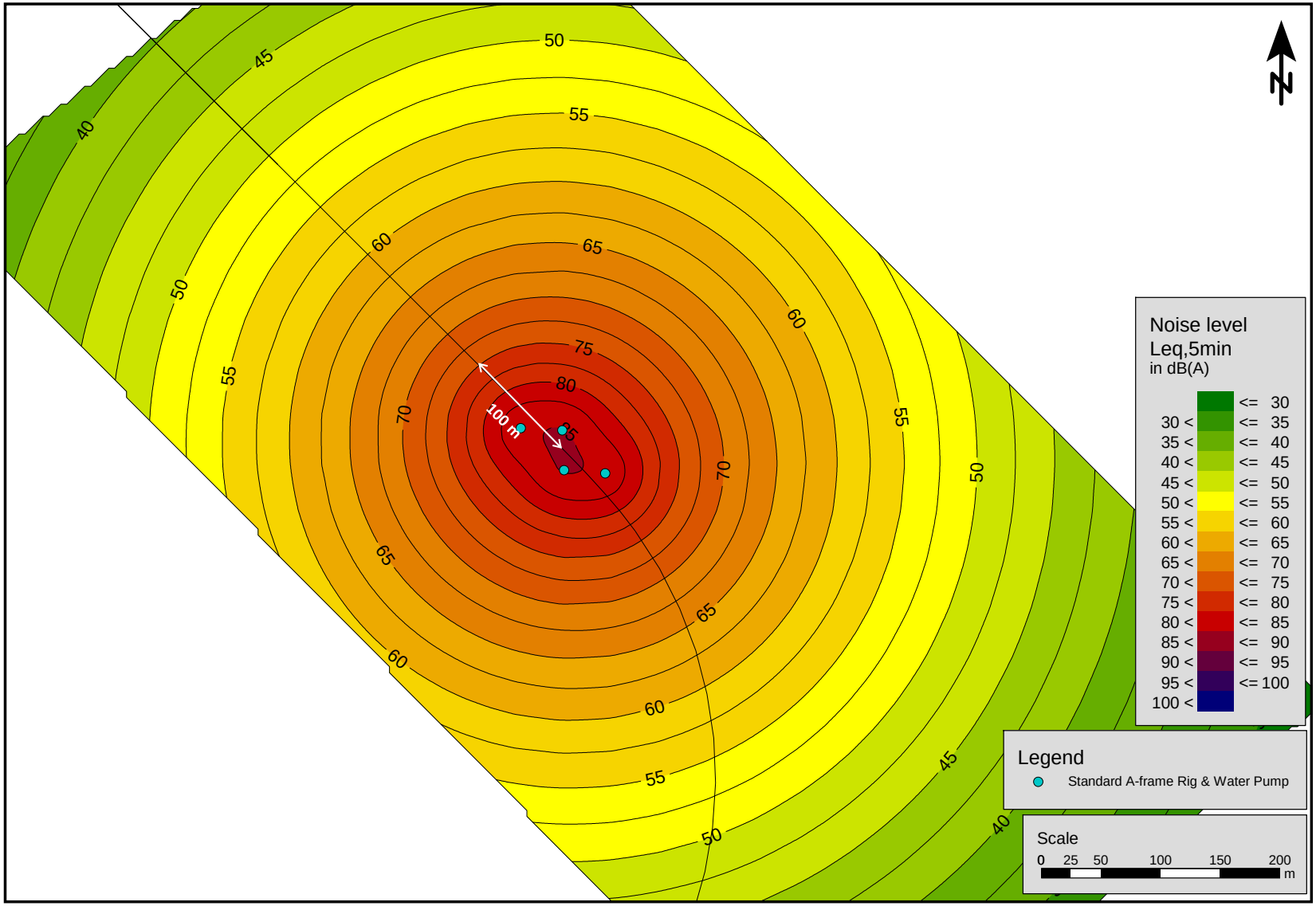


Table 4.9: Comparison of Predicted Noise Levels against Applicable Permissible Noise Limit (Operation of Rotary Drilling Rigs)

Modelled Noise Receiver (NR)	Representative NSR	Horizontal Distance from Worksite (m)	Elevation of Receptor (m)	Predicted Noise Level (dB(A)) (Note 1)		Permissible Limit (dB(A)) (Note 2)		Exceedance of Permissible Limit (dB(A))
				$L_{Aeq, 5min}$	$L_{Aeq, 12hr}$	$L_{Aeq, 5min}$	$L_{Aeq, 12hr}$	
NR1	Residents along Upper Thomson Road & Lornie Road	3	1.5	**106**	**87**	90	79*	$L_{Aeq,5min}$ – 16 $L_{Aeq,12hr}$ – 8
NR1	Users of Taman Permata Park and golfers at SICC (Island location)	3	1.5	**103**	**84**	90	75	$L_{Aeq,5min}$ – 13 $L_{Aeq,12hr}$ – 9
NR2	Residents at St Theresa's Home	3	1.5	**106**	**87**	75	63*	$L_{Aeq,5min}$ – 31 $L_{Aeq,12hr}$ – 24
NR3	Users of Soo Chow Walk Playground	15	1.5	89	70	90	75	-(Note 2)
NR4	Residents along Lornie Road	20	1.5	90	70	90	82*	-
NR5	Residents of St Francis Convent	20	30	86	66	90	76*	-
NR6	Patients at Mt Alvernia Hospital	30	30	**84**	65	76*	67*	$L_{Aeq,5min}$ – 8
NR7	Users of MacRitchie Reservoir Park	65	1.5	80	61	90	76*	-
NR8	Patients at Assisi Hospice	65	30	**79**	60	76*	67*	$L_{Aeq,5min}$ – 3
NR9	Residents along Upper Thomson Road (Lakeview Estate)	75	30	78	58	90	75	-
NR10	Worshippers at the Hai Lam Sua Tee Kong Toa Temple	90	1.5	77	58	90	79*	-
NR11	Residents along Upper Thomson Road (Flame Tree Condominium)	165	1.5	70	50	90	79*	-

Notes

(1) Values in bold exceed the allowable limit.

(2) Values with an asterix have been corrected, ie the correction factor has been applied to the higher of either the permissible noise limit or the baseline measurement.

(3) '–' indicates that predicted noise levels would be within applicable permissible noise limits.

Mitigation Measures

For the areas where NR's were identified to be of *Moderate* significance (ie residences along Upper Thomson Road and Lornie Road located within 3 m of worksites, users of Taman Permata Park, golfers in SICC Island Golf Course, St Theresa's Home and patients in Mt Alvernia Hospital) the following mitigation have been developed and will be implemented by the Project:

- For SI works within housing estates along Upper Thomson Road and Lornie Road and within close proximity of Taman Permata Park, ensure that only one rig is in operation at any one time and that a minimum distance of 15 m is maintained between receptors and the nearest worksite;

- Prior to SI works within the St Theresa's Home compound, engage the management of St Theresa's Home to understand the layout of buildings which would be especially sensitive to noise during the day, eg bedrooms, and particular periods of the day or week to avoid, eg periods of rest or periods of higher visitation such as weekends. Review SI borehole locations so that a minimum distance of 65 m is maintained between noise sensitive buildings within the compound and the nearest worksite;

- For SI works within 30 m of the Mt Alvernia Hospital compound, ensure that only one rig is in operation at any one time;

- Schedule drilling operations in vicinity of residential NR's along Upper Thomson Road; Lornie Road; users of Taman Permata Park; and golfers at SICC Island golf course to be during the weekdays only so as to avoid nuisance from noise during peak periods of recreational use and when more residents are likely to be at home;

- Use silenced engines[6], ie models which are at least 5 dB(A) quieter than 2 other equipment model types commonly used in Singapore;

- Use acoustic enclosures on rig engine throughout operations. For the construction of machinery enclosures, a sheet material mass of at least 10 kg/m^2 is recommended (British Standard *BS5228-1, 2009*). The sound-absorbent inside lining of the enclosure (which may be made of mineral wool, woodwool or absorbent tiles) should be at least 25 mm thick. Panels used in the enclosure should meet a STC rating of 20 or higher, with reference also being made to the *NEA's Quieter Construction Fund*[6]. It is noted that confirmation should be sought from the machinery manufacturer to ensure that enclosures are designed in a way that allows adequate ventilation and provides for access during maintenance;

- Rig/equipment selected for use should have sound power specifications of not more than (i) 105 dB(A) for the A-frame, crawler mounted rotary borehole drilling rig, and (ii) 96 dB(A) for the diesel operated water pump; Train workers to employ equipment handling techniques so as to minimize noise emissions from the worksite, eg metal on metal emissions during mobilization and demobilization of drill casings;

[6] *NEA Guidelines on Quieter Construction Fund*, Retrieved from http://www.nea.gov.sg/docs/default-source/grants-awards/QCF/qcf-guidelines-(oct-2014).pdf?sfvrsn=4

- In alignment with the stakeholder engagement planning of the Project (*Volume I, Chapter 6*), provide information on the SI works schedule, activities and grievance mechanism to the sensitive receivers outlined in *Table 4.9* so as to inform them early of the noise generating activities;

- All vehicles should be maintained at a constant and low speed of less than 5 km /hour within SICC Island Golf Course;

- All rigs and vehicles in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works;

Should there be justifiable technical reasons to undertake SI works within the minimum distances from the NRs as recommended above, the Director-General of Environmental Protection in the NEA shall be notified in writing, in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations*.

Residual Impact Assessment

The incremental noise levels after mitigation, ie residual noise levels, were predicted assuming that the aforementioned mitigation measures are implemented.

The predicted residual noise levels are outlined in *Table 4.10*. The findings illustrate a reduction in the incremental noise levels to within the permissible limits at all receptors as a result of the mitigation measures, ie *Negligible* impact magnitude. A summary of the impact assessment findings for rotary drilling rig operation is provided in *Table 4.11.*

Table 4.10: Comparison of Predicted Noise Levels against Applicable Permissible Noise Limits After Mitigation (Drilling Rig Operation)

Modelled NRs	Receptor	Horizontal Distance from Worksite (m)	Elevation Height (m)	Predicted Noise Level (dB(A)) (Note 1)		Permissible Limit (dB(A)) (Note 2)		Exceedance of Permissible Limit (dB(A)) (post mitigation)
				$L_{Aeq, 5min}$	$L_{Aeq, 12hr}$	$L_{Aeq, 5min}$	$L_{Aeq, 12hr}$	
NR1	Residents along Upper Thomson Road & Lornie Road	15	1.5	82	63	90	79*	- (Note 3)
NR1	Users of Taman Permata Park	15	1.5	82	63	90	75	-
NR1	Golfers at SICC (Island location)	15	1.5	83	64	90	75	-
NR2	Residents at St Theresa's Home	65	1.5	75	55	75	63*	-
NR3	Users of Soo Chow Walk Playground	15	1.5	83	64	90	75	-
NR4	Residents along Lornie Road	20	1.5	84	64	90	82*	-
NR5	Residents of St Francis Convent	20	30	80	61	90	76*	-
NR6	Patients at Mt Alvernia Hospital	30	30	76	56	76*	67*	-
NR7	Users of MacRitchie Reservoir Park	65	1.5	75	55	90	76*	-
NR8	Patients at Assisi Hospice	65	30	73	54	76*	67*	-
NR9	Residents along Upper Thomson Road (Lakeview Estate)	75	30	77	57	90	75	-
NR10	Worshippers at the Hai Lam Sua Tee Kong Toa Temple	90	1.5	77	57	90	79*	-
NR11	Residents along Upper Thomson Road (Flame Tree Condominium)	165	1.5	69	49	90	79*	-

Notes

(1) Values in bold exceed the allowable limit.

(2) Values with an asterisk have been corrected, ie the correction factor has been applied to the higher of either the permissible noise limit or the baseline measurement.

(3) '–' indicates that predicted noise levels would be within applicable permissible noise limits.

Table 4.11: Impact Assessment Summary

Criterion	Rating	Comment
Impact – Increased noise levels from operation of four standard A-frame drilling rigs		
Nature	Negative	Operation of four standard A-frame drilling rigs will result in incremental noise levels that are predicted to exceed permissible noise limits by up to 31 dB(A).
Type	Direct	Receptors in close proximity to the SI worksites will be directly exposed to elevated noise levels.
Duration	Short-term	Exposure duration of receptors will be short-term, ie < 1month while the drilling rigs are operating.
Extent	Local	Effects will be on ground level receptors and receptors at height within a radius of approximately 3 to 165 m from the SI worksites
Scale	Large	Human receptors located in close proximity to the rig may be directly exposed to levels up to 106 dB(A) ($L_{Aeq,5\ min}$), which could lead to nuisance impacts.
Frequency	Continuous	Rotary drilling rigs will be in continuous operation in the daytime, over a period of approximately 18 days (rate of drilling depends on geology encountered).
Magnitude	Large	Predicted levels >10 dB(A) at residences along Upper Thomson Road and Lornie Road, users of Taman Permata Park, golfers in SICC Island Golf Course, St Theresa's Home; and patients in Mt Alvernia Hospital and Assisi Hospice.
Receptor Sensitivity	N/A	Receptor sensitivity is accounted for in the impact magnitude criteria.
Significance	Negligible to Moderate	*Negligible – Minor* based on the predicted levels, duration and frequency of the works for the following NR's: users of Soo Chow Walk Playground, residents along Lornie Road within 20 m of the nearest worksites, residents of St Francis Convent, MacRitchie Reservoir Park users, Lakeview Estate, Flame Tree Condominium and Hai Lam Sua Tee Kong Toa Temple. *Moderate* adverse impacts to human receptors are expected from unmitigated noise levels that exceed the permissible noise limits by up to 31 dB(A) ($L_{Aeq,5\ min}$). NR's affected based on predicted levels, duration and frequency of the works: residences along Upper Thomson Road and Lornie Road, users of Taman Permata Park, golfers in SICC Island Golf Course, St Theresa's Home; and patients in Mt Alvernia Hospital and Assisi Hospice.
Residual Impact Magnitude	Negligible	The implementation of controls (ie. enclosures, relocation of boreholes at minimum distances from NR's, limitation of number of borehole rigs operating at any one time) will reduce residual noise levels to at or below the permissible daytime noise limits.
Residual Impact Significance	Negligible	Controls such as use of enclosures, relocation of boreholes and limitation of number of borehole rigs in operation at any one time, will significantly reduce predicted noise levels at all receptors to below the daytime noise limits.

4.5.2 Standard Penetration Tests (SPTs)

Noise measurements were taken during operation of similar standard A-frame drilling rig to that which the Project will use. At the time of noise measurement collection, SPTs were underway at 3 m and 5 m below ground level. Due to the configuration of the worksite, measurements could only be taken at a horizontal distance of 3 m from the rig. The meter was set up at more than 1.2 m from the ground and more than 3 m from the nearest façade, in order to obtain free field noise measurements and avoid reflection from the ground. As the hammering of the 63.5 kg automatic drop weight only occurred

over periods of less than 10 minutes, only $L_{Aeq,5min}$ levels were obtained. The $L_{Aeq,5min}$ levels during the SPTs were measured at 90.1 dB(A).

The predicted noise levels at identified NSRs were calculated using *Equation 1* for sound propagation over distances, and are summarized in *Table 4.13* along with a comparison against the applicable permissible $L_{Aeq,5min}$ noise limits. The SPTs will be undertaken during drilling through the soil layers (ie not through the rock). However, as the depth of the soil layers are not known, it is assumed that the SPTs will take place over the entire course of the drilling works at each worksite, ie 18 days.

Equation 1 Sound Propagation Over Distance

$$L_{p1} - L_{p2} = 20\log(R_2 \div R_1)$$

As shown in *Table 4.12*, noise levels are predicted to be within the permissible daytime limits at most receptors. Noise levels are predicted to exceed permissible limits by up to 3 dB(A) at NRs within 3 m of the SI worksites, ie at residences along Upper Thomson Road and Lornie Road and users of Taman Permata Park and golfers at the SICC Island golf course. Given a duration of <1 month and the predicted levels will exceed the permissible limits by 3 dB(A), the impact due to SPT testing is therefore evaluated to be of *Minor* significance.

Table 4.12: Comparison of Predicted Noise Levels against Applicable Permissible Noise Limits (SPT Testing)

Modelled NR	Representative Receptor	Distance from Worksite (m)	Predicted Noise Level (dB(A)) (Note 1)	Permissible Noise limits ($L_{Aeq,5min}$, dB(A)) (Note 2)	Exceedance of Permissible Limit (dB(A))
NR1	Residents along Upper Thomson Road & Lornie Road	3	93	90	3
NR1	Users of Taman Permata Park and golfers at SICC (Island location)	3	93	90	3
NR2	Residents at St Theresa's Home	3	93	90	3
NR3	Users of Soo Chow Walk Playground	15	79	90	- (Note 4)
NR4	Residents along Lornie Road	20	77	90	-
NR5	Residents of St Francis Convent	36 (Note3)	72	90	-
NR6	Patients at Mt Alvernia Hospital	42 (Note3)	70	76*	-
NR7	Users of MacRitchie Reservoir Park	65	66	90	-
NR8	Patients at Assisi Hospice	65	66	76*	-
NR9	Residents along Upper Thomson Road (Lakeview Estate)	78 (Note3)	65	90	-
NR10	Worshippers at the Hai Lam Sua Tee Kong Toa Temple	90	64	90	-
NR11	Residents along Upper Thomson Road (Flame Tree Condominium)	165	58	90	-

Notes

(1) Values in bold exceed the allowable limit.

(2) Values with an asterix have been corrected, ie the correction factor has been applied to the higher of either the permissible noise limit or the baseline measurement.

(3) Distance has been calculated taking into consideration elevation height of receptors relative to proposed worksite location.

(4) '–' indicates that predicted noise levels would be within applicable permissible noise limits.

Table 4.13: Impact Assessment Summary

Criterion	Rating	Comment
Impact – Increased noise levels from SPTs		
Nature	Negative	The Project will result in incremental noise levels at some NSRs due to SPTs that are predicted to exceed permissible noise limits by up to 3 dB(A).
Type	Direct	Receptors in close proximity to the worksites could be directly exposed to elevated noise levels.
Duration	Short-term	Exposure duration of receptors will be short-term, ie < 1month while the SPTs are occurring.
Extent	Local	Effects will be on ground level receptors within a radius of approximately 3 m from the worksites.
Scale	Small	Human receptors located in close proximity to the rig may be directly exposed to levels up to 93 dB(A) ($L_{Aeq,5\ min}$).
Frequency	Intermittent	SPT testing will be undertaken over 15-30 min periods, at every 2 m interval drill depth. Total duration of borehole drilling approximately 18 days.
Magnitude	Negligible - Small	The predicted noise levels exceedance of permissible daytime limits are less than 3dB(A) (*Negligible*) or 3-5 dB(A) (*Small*)
Receptor Sensitivity	N/A	Receptor sensitivity is accounted for in the impact magnitude criteria.
Significance	Negligible - Minor	Magnitude of impact *Negligible – Small* and intermittent duration over period of 18 days.

4.6 ASSESSMENT OF VIBRATION IMPACTS

Vibration will be generated by the following activities undertaken during the SI works:

- SPTs during borehole operations; and
- The action of the rotary coring during drilling through the surface soil and rock.

As the exact positions of the SI rigs along Alignment Option 2 have not been determined at the time of writing, this assessment reviews a range of vibration levels that may be generated at different distances from a rotary drilling rig.

4.6.1 Vibration Impacts due to Standard Penetration Tests

As described in *Volume III Chapter 4*, SPTs will generate vibration through the action of the 63.5 kg automatic hammer that will be used to drive the split-spoon sampler through the soil only. The test will be carried out every 2 m while drilling through the soil. Vibration arising from this activity was predicted using the empirically derived formulae for percussive piling from BS5228-2:2009[7]. The lower bound of theoretical hammer energy of 1.5 kJ was used in the equation, which is a conservative assumption as it is greater than the nominal hammer energy of approximately 0.48 kJ calculated for a 63.5 kg weight. The pile toe depth was conservatively set to 1 m in the equation.

At a horizontal distance of 2 m from the rig, the equation predicts a Peak Particle Velocity (PPV) of approximately 1.3 mm/s. This drops to approximately 0.8 mm/s at a horizontal distance of 3 m, and to

[7] BSI (2009). Code of practice for noise and vibration control on construction and open sites, Part 2: Vibration.

0.28 mm/s at a distance of 7 m. With reference to *Table 4.7*, the magnitude of impact will therefore range from *Small* to *Medium* for horizontal distances of 7 m and 2 m from human receptors, respectively. As the criteria for sensitive equipment is more stringent (*Table 4.6 and Table 4.7*), the equation from BS5228 predicts that the drilling rig will have to be situated at least 30 m from the receptor to avoid moderate or major vibration impacts at the receptor (ie Mt Alvernia Hospital).

Residential receptors and sensitive equipment will be exposed to vibration from SPTs. The SPTs will be completed every 2 m or approximately 17 tests per borehole over the course of the 18 days at each worksite. The duration of SPTs is therefore short term (ie <1 month).

Based on the above, a *Minor* impact to humans may be generated from SPT works if the drilling rig is located within 2 m of a residential receptor. The vibration levels generated by SPT are predicted to be of *Minor* significance to human receptors if the rig is located 7 m or more away from a residential receptor.

Along Alignment Option 2, it is expected that sensitive equipment may be in use at Mt Alvernia Hospital. At this location, therefore, the rig must be situated at least 30 m away from the hospital to avoid Significant (ie *Moderate* or *Major*) impacts to sensitive equipment, as defined in *Table 4.7*.

4.6.2 Operation of Rotary Drilling Rigs

Drilling through the soil and rock will generate vibration over a period of approximately 12 days for each borehole drilled using an A-Frame rig. To understand the typical vibration levels that will be generated during the SI works, 5 minute vibration measurements were taken with a tri-axial accelerometer at fixed distances from a similar rotary borehole rig, as summarized in *Table 4.14*. Detailed results are appended in *Volume II, Annex 5.0*.

Table 4.14: Vibration Measurements at Operational Rotary Borehole Rig

ID	Distance from Rotary Borehole Rig	Ground Type	PPV (mm/s)		
			X-axis	Y-axis	Z-axis
A	2 m	Grass	2.000	2.030	0.825
B	3 m	Grass	1.170	1.420	0.825
C	5 m	Grass	1.150	1.140	1.070
D	15 m	Bitumen	0.597	0.824	0.660
E	11 m	Grass (Note 2)	0.621	0.911	0.529
F	20 m	Grass (Note 2)	0.515	0.896	0.820
G (Note 3)	5 m	Grass	0.555	0.740	0.698

Notes:
(1) Calculated from maximum and minimum PPV values.
(2) Grass verge was not in continuity with the grassy area on which the rotary borehole rig was operating.
(3) Measurements were taken when the rig was not operating, to establish baseline vibration levels due to extraneous sources.
(4) The highest PPV measured is presented. Vibration magnitudes measured are generally lower (see *Volume II, Annex 5.0*).

As observed at measurement Location G, baseline vibration levels due to extraneous sources were not insignificant, in comparison with measurements undertaken at a similar distance during rig operation, ie measurement Location C. Extraneous vibration sources observed included:

- Construction works undertaken for a high-rise condominium development, within 15 m of the rotary borehole rig. Piling works were not observed during the measurements, although heavy equipment and vehicles such as lifting cranes and semi-trailers were observed to be in operation;
- Footfalls of workers operating the rotary borehole rig, and passing pedestrians;
- Cars travelling at low speeds, at least 25 m from the rotary borehole rig worksite; and
- Underground and aboveground construction of station and railway tunnels for Bright Hill MRT Station, located approximately 470 m southeast of the rotary borehole rig.

In consideration of the contribution of baseline vibration levels, incremental PPV due to the rotary borehole rig operation would likely be less than 1.0 mm/s, from distances at and greater than 3 m from the rotary borehole rig. From distances at 3 m and greater relative to the rotary borehole rig, background vibration levels are likely to be dominant. Outdoor human receptors within 3 m of the rig, ie, the SICC Island Club golfers and recreational users of Taman Permata Park, are therefore likely to be exposed to vibration levels below 1.0 mm/s, ie *Small* impact magnitude (with reference to the criteria in *Table 4.5*).

It is further noted that vibration transfer to human receptors located indoors might be attenuated or amplified depending on the foundation type and the design of the building structure. Typical values for these amplifications or attenuations suggest that the nett effect is likely to be neutral[8]. Therefore the free field measured values have been used directly without application of any correction factors. It is therefore possible that residents along Upper Thomson Road and Lornie Road, and elderly residents at St Theresa's Home might be indirectly exposed to vibration levels above 1.0 mm/s (up to approximately 1.42 mm/s), ie Medium impact magnitude. In view of the short-term duration of the drilling works, ie 18 days, the magnitude of impact to these receptors would therefore be *Minor*.

Mount Alvernia Hospital was identified as the only receptor within the study area that might house vibration sensitive equipment. As shown in *Chapter 5 of Volume II*, the hospital is exposed to baseline PPV levels ranging between 0.508 to 0.635 mm/s in the horizontal axes, and up to 0.889 mm/s in the vertical axis. These baseline PPV levels are similar to vibration measurements undertaken at 20 m from an operational rotary borehole rig. The hospital is located at least 30 m from the nearest proposed SI worksite, and is separated from the nearest proposed borehole location by Lornie Road. Vibration levels due to the borehole rig operations are therefore likely to be masked by vehicular traffic, or attenuated over the distance. In addition, due to the high levels of baseline vibration, it is likely that controls such as vibration isolation of sensitive equipment, would already be implemented within the hospital. Taking into consideration the short-term duration of the SI works, ie 18 days, and the existing vibration levels, the magnitude of impact to vibration sensitive equipment due to drilling works is therefore evaluated to be *Minor*.

A summary of the drilling operation, including SPT impact assessment findings is outlined in *Table 4.15*.

[8] UK ANC (2012) ANC Guidelines: Measurement and assessment of groundborne noise and vibration 2nd edition

Table 4.15: Impact Assessment Summary

Criterion	Rating	Comment
Impact – Nuisance effects to human receptors and damage to vibration sensitive equipment due to vibration generated during drilling rig operation and SPTs		
Nature	Negative	The Project will result in vibration levels that are expected to be higher than ambient levels.
Type	Direct	Residents and sensitive equipment located along Alignment Option 2 could be directly exposed to elevated vibration levels.
Duration	Temporary	Exposure will be continuous during the daytime period for the duration of drilling works (ie up to 18 days per borehole).
Extent	Local	Effects will be on recreational users within a radius of approximately 3 m from the worksites.
Scale	Small to Medium	Receptors at 2 m of the worksites eg residential receptors would be exposed to levels exceeding 1.0 mm/s, though well below 10 mm/s. Receptors located more than 3 m from the worksites would experience levels below 1 mm/s. Sensitive equipment at Mt Alvernia Hospital would be exposed to levels below 0.05 mm/s.
Frequency	Continuous	Borehole drilling rigs will be moved from location to location over a course of approximately four to eight months, and be in continuous operation in the daytime.
Magnitude	Small to Medium	Vibration levels estimated to be <1 mm/s PPV for human receptors located more than 3 m from the worksites (Small magnitude); and > 1mm/s PPV for human receptors located at 2 m of the worksites (Medium magnitude). Vibration levels at Mt Alvernia Hospital where sensitive equipment may be located estimated to be <0.05 mm/s (Medium magnitude).
Receptor Sensitivity	N/A	Receptor sensitivity is accounted for in the impact magnitude criteria.
Significance	Minor	Residents living within 5 m of the alignment might be exposed over a short-term duration, ie 18 days, to levels at or slightly exceeding 1.0 mm/s. Outdoor human receptors will likely be exposed to levels of vibration below 1.0 mm/s due to drilling works. Vibration sensitive equipment at Mt Alvernia may be exposed to levels above 0.012mm/s, however this is predicted to be similar to levels measured in the existing environment.

4.7 CUMULATIVE IMPACTS

As outlined in Volume II, there are a number of committed developments within the Study Area to consider in the assessment of potential cumulative impacts. Of relevance of Alignment Option 2 and identified at the time of writing are the following:

- Upper Thomson MRT Station & Tunnels for Thomson Line (estimated completion in 2020);
- North South Expressway tunnel section that runs east of Assisi Hospice and the Mt Alvernia Hospital compounds (estimated completion in 2020);
- Expansion of Assisi Hospice (estimated completion in 1Q 2017);

- North South Cable Transmission Tunnel, Contract NS3, Marymount equipment building (estimated completion in April 2018)
- Outer Ring Road section transecting Bukit Brown Municipal Cemetery (estimated completion end 2017);
- Construction of Park Connector network along the eastern and southern boundary of CCNR (estimated completion in 2018);
- Construction of MacRitchie Observation Tower (estimated completion in 2018); and
- Development of Windsor Nature Park (estimated completion end 2016).

Of these, the larger surface construction works that may be undertaken concurrently with the SI works near sensitive receptors are associated with the Thomson MRT Line, Assisi Hospice expansion and the North South Expressway. The activities associated with these committed developments can be reasonably expected to result in higher noise levels than those associated with the Project. Some of the activities, eg expansion of Assisi Hospice are in closer or comparable proximity to the identified receptors. For the purpose of this assessment, it is assumed that noise levels from these committed developments will not exceed the maximum permissible noise limits for construction sites in Singapore. Based on this assumption, cumulative impacts would only arise for residences and hospital/institutions that are exposed to noise from the committed developments and are located within 25 m and 110 m of the Project respectively. Furthermore, the duration of the planned activities for most of these committed developments will extend over a longer period than the Project. A summary of the cumulative impact assessment is provided in *Table 4.16*.

Table 4.16: Impact Assessment Summary

Criterion	Rating	Comment
Impact – Nuisance Effects Due to Cumulative Noise Emissions		
Nature	Negative	Contributions from the committed development and Project activities will lead to cumulative noise impacts resulting in greater exceedance of permissible noise limits.
Type	Direct	Receptors in close proximity to the worksites will be directly exposed to elevated noise levels.
Duration	Short-term	Exposure duration of receptors will be short-term, ie < 1 month, due to short duration of Project activities.
Extent	Local	Cumulative impacts will be on residences within a radius of 25 m; and hospitals or homes for the aged sick within a radius of 110 m from the Project worksites.
Scale	Small	Residents and human receptors at hospitals or homes for the aged sick would be exposed to cumulative noise levels that would exceed relevant noise limits by no more than 3 dB(A).
Frequency	Continuous	It is conservatively assumed that noise emissions from committed developments would be continuous during each development activity.
Magnitude	Small	Noise exceedances of relevant noise limits are anticipated to be no more than 3 dB(A).
Receptor Sensitivity	N/A	Receptor sensitivity is accounted for in the impact magnitude criteria.
Significance	Minor	Minor disturbance to human receptors can be expected due to noise levels from the Project and other committed developments at receptors along Alignment Option 2.

5 CLIMATE AND AIR QUALITY

5.1 INTRODUCTION

This chapter presents an assessment of the impacts of activities associated with the SI works along Alignment Option 2 on human health due to emissions to air of airborne gaseous pollutants, airborne dust and dust deposition.

This chapter is structured as follows:

- *Section 5.2* defines the scope of the assessment*;*
- *Section 5.3* presents a summary of the climate, meteorology and baseline ambient air quality of the Study Area*;*
- *Section 5.4* provides an overview of the methodology used to assess the impacts to air; and
- *Section 5.5* presents the impact assessment.

5.2 SCOPE OF THE ASSESSMENT

The following sources of impacts are considered during the SI works associated with alignment:

- Dust generated from drilling operation, including breaking of concrete road surfaces; and
- Vehicular emissions from engines.

Dust generated in the form of $PM_{2.5}$ and PM_{10} are the main emissions[1] associated with construction related activities, of which 85% to 90% is PM_{10}[2]. As a result, the assessment of dust will focus on impact in terms of exposure to PM_{10}.

Vehicular emissions will arise from the use of diesel-fuelled vehicles and equipment including lorry cranes, water delivery and wastewater removal vehicle, pneumatic breakers and engines of the drilling rigs. The total duration of operation of the lorry cranes and pneumatic breakers is assumed to be less than one day for each borehole location since the lorry crane will only be used during mobilisation/demobilisation and pneumatic breakers to break the ground for excavation of starter pits. The ancillary vehicle used to deliver water and remove wastewater from each borehole worksite will be required daily, however will likely operate at each worksite for less than one hour per day. Further, vehicular emissions from on-road and off-road vehicles will comply with standards under *Environmental Protection and Management (Vehicular Emissions) Regulations 2008* and *Environmental Protection and Management (off-Road Diesel Engine Emissions) Regulations 2012,* respectively. Impact from vehicular emissions has therefore been screened out from further assessment.

The scope of the assessment is therefore focused on impacts to human health from changes in air quality as a result of the SI works. With regard to impacts on biodiversity, this chapter includes a

[1] Institute of Air Quality Management (Feb 2014) **Guidance on the Assessment of Dust from Demolition and Construction**. Retrieved from http://www.iaqm.co.uk/text/guidance/construction-dust-2014.pdf

[2] Midwest Research Institute (1 November 2006) **Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emissions Factors**. Retrieved from http://www.epa.gov/ttnchie1/ap42/ch13/bgdocs/b13s02.pdf

screening approach to consideration of impacts of airborne pollution on nature areas. Assessment of impacts to specific habitat, flora and fauna is however, discussed in detail in *Chapter 7: Ecology and Biodiversity*.

5.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

Key environmental baseline findings pertaining to the air quality in the study area are summarised as follows:

- Sensitive receptors within the study area consist of various residential buildings, places of worship, schools, old age homes, hospitals and recreational areas.
- Ecological receptors in proximity to Alignment Option 2 include habitats and flora and fauna within the CCNR, Windsor Interim Green, SICC golf courses, Bukit Brown municipal cemetery and forested area along Adam Drive and Sime Road;
- Vehicular emissions along Upper Thomson Road, Lornie Road and the PIE are the main contributing sources to air emissions at the study area;
- Aside from vehicular emissions, PM_{10} and $PM_{2.5}$ are also generated by ongoing construction works for developments along Upper Thomson Road, for example Thomson Grand, Three 11 and Thomson Three condominiums and Assisi Hospice expansion, the Upper Thomson MRT station, the Thomson Line tunnels and Singapore Power's North South Transmission Cable;
- Based on the NEA monitoring results for period of 2011 to 2013, the short-term and long-term concentrations of PM_{10} and $PM_{2.5}$ in the study area are above the Singapore 2020 and long-term ambient air quality targets; and
- Results of the short-term baseline ambient air monitoring undertaken from November to December 2014 and from January to February 2015 were generally below the Singapore air quality targets for PM_{10} and $PM_{2.5,}$ though levels above the targets were recorded on some days during Round 1 of the survey.

5.4 ASSESSMENT METHODOLOGY

As per the EIA methodology outlined in *Volume I*, the approach to air quality assessment combines impact magnitude with sensitivity to determine impact significance. Dust from construction and drilling activities is typically re-deposited within 350 m of the source[1], thus the scale of impacts predicted are within this range and of a duration of between 4 and 8 months. As the scale and duration of activities is small, a qualitative risk-based approach for the assessment of impacts has been undertaken.

To focus on impacts to human and ecological receptors, criteria for 'earth work ', published in the *Guidance on the Assessment of Dust from Demolition and Construction* by the *UK Institute of Air Quality* Management (IAQM), have been adopted and are outlined in *Table 5.1*. The IAQM guidance does not have a specific set of criteria for dust generation from SI works, therefore criteria for general earthworks (eg excavation) have been used.

Table 5.1: Criteria for Impact Magnitude Based on IAQM Guidance

Magnitude of Impacts	Description
Negligible	- Total site area <500 m^2; - Soil type with large grain size (eg sand); - Total material moved < 5,000 tonnes; and/or - No more than 2 heavy earth moving vehicles active at any one time.
Small	- Total site area 500 m^2 to 2,500 m^2; - Soil type with large grain size (eg sand); - Total material moved 5,000 to 20,000 tonnes; and/or - < 5 heavy earth moving vehicles active at any one time.
Medium	- Total site area 2,500 m^2 to 10,000 m^2; - Moderately dusty soil type (eg silt); - Total material moved 20,000 tonnes to 100,000 tonnes; and/or - 5 to 10 heavy earth moving vehicles active at any one time.
Large	- Total site area > 10,000 m^2 - potentially dusty soil (eg clay, which will be prone suspension when dry due to small particle size) - Total material moved 100,000 tonnes; and/or - > 10 heavy earth moving vehicles active at any one time.

The criteria for determining sensitivity of human receptors are described in *Table 5.2*. For the nature areas, the sensitivity is defined on the basis of their designated importance as an ecological resource and for their amenity value. This is typically determined on the basis of the statutory protection of the receptor. The sensitivity criteria adopted for assessment of air quality impacts on nature areas are also presented in *Table 5.2*.

Table 5.2 Determination of Receptor Sensitivity

Sensitivity	Description
Low	*Human Receptors* - Locations where human exposure is transient (Note 1). - Indicative examples include public footpath, playing fields, park and shopping streets. *Nature Areas* - Locally designated sites; and/or - Areas of specific ecological interest, not subject to statutory protection (for example, as defined by the project ecology team).
Medium	*Human Receptors* - Locations where the people exposed are workers (Note 2), and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day)(Note 3). - Indicative examples include office and shop workers. *Nature Areas* - Nationally designated sites.

Sensitivity	Description
High	*Human Receptors* - Locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day). - Indicative examples include residential properties, hospitals, schools and residential care homes. *Nature Areas* - Internationally designated sites.

Notes

(1) In accordance with the IAQM guidance, there are no standards that apply to short-term exposure, eg one or two hours, but there is still a risk of health impacts, albeit less certain.

(2) Notwithstanding the fact that the air quality objectives and limit values do not apply to people in the workplace, such people can be affected to exposure of PM_{10}. However, they are considered to be less sensitive than the general public as a whole because those most sensitive to the effects of air pollution, such as young children are not normally workers. For this reason workers are included in the medium sensitivity category.

(3) This follows Department for Environment Food and Rural Affairs (DEFRA) guidance as set out in Local Air Quality Management –Technical Guidance published in 2009.

5.5 ASSESSMENT OF IMPACTS

5.5.1 Impacts Due to Dust Emissions from Drilling Operation, Mobilization and Demobilization

Sensitive receptors located within 350 m^1 from the borehole worksites are associated with a mix of different land uses. Subsequently the duration of human receptors exposure to the dust emission from the SI works will vary. As the land uses are largely comprised of residential properties, hospitals, school and residential care homes, the overall sensitivity for the human receptors is deemed *High*. The sensitivity for the nature areas, ie stretch of CCNR within 350 m of the SI worksites along Lornie Road, is considered to be *Medium*.

During the SI works, up to four boreholes could be drilled simultaneously at any one point of time along the alignment. Dust generating activities associated with each worksite would include excavation of starter pits, drilling of boreholes and temporary stockpiling of excavated materials onsite. It is assumed that the SI works will mainly be undertaken on paved roads or grassy roadside verges (eg along PIE and Venus Drive); therefore the quantity of soil tracked out will be minimal.

The total footprint of four worksites is approximately 88 m^2 as each worksite will occupy an area of 22m^2. Following cable detection works, starter pits will be excavated using a hand auger. Each starter pit is assumed to have an area of 1 m x 1 m and a depth of 3 m. One starter pit will be excavated at any one time and total material that will be removed is estimated to be 3 m^3. Based on review of various borehole logs[3] available for areas surrounding the study area, soils underlying the tarmac surface are likely to be Fill material that consists of sandy silt with rock fragments. This soil type is classified as moderately dusty as per *Table 5.1*.

The SI works will be required to comply with numerous legal requirements. In particular, as per the *General Specifications, Appendix A, Safety, Health and Environment (for Rail Projects) December 2014 Edition,* dust generated from the SI works will be managed by implementation of the following:

[3] Land Transport Authority Various geotechnical borehole logs for areas surrounding the CCNR, from 1982 to 2009

- All temporary stockpiles will be covered with canvas sheet if not removed immediately from the worksites;
- The borehole drilling operation will be shielded to prevent dust being dispersed; and
- Measures will be in place to ensure that all roads, pavement and public footpaths are kept clear of dust.

Although the spoil removed from each borehole is considered to be "moderately dusty"; the volume of material which will be removed and stockpiled is considered to be negligible (<5,000 tonnes) and will be covered at all times at each worksite. Heavy earth moving vehicles will not be required to manage the spoil material and it will be used to infill each borehole following completion of the works or bagged and removed from the site by a licensed third party contractor. Furthermore, any impacts associated with dust emissions from each worksite are considered to be short-term given that operations will last approximately 18 days at each worksite, or up to 8 months for completion of all boreholes along the alignment. With reference to the criteria detailed in *Table 5.1*, the magnitude of impact is therefore evaluated to be *Negligible*. Combined with a *Medium* (for nature areas, ie the CCNR) and *High* (human receptor) sensitivity, the overall impact significance due to dust emissions from SI works is therefore *Negligible* for human and nature areas.

Table 5.3: Impact Assessment Summary

Criterion	Rating	Comment
Human Disturbance Impacts Due to Dust Emissions from Borehole Drilling Operation		
Nature	Negative	Generation of dust.
Type	Direct	Direct exposure to dust – no barrier between source and human receptors
Duration	Short-term	Each worksite approximately 18 days duration while SI works along full alignment expected to be completed within 8 months.
Extent	Local	PM_{10} may disperse up to a distance of 350 m from the worksites
Scale	-	Slight elevated concentrations of $PM_{10.}$
Frequency	Frequent	Daily during borehole drilling operations
Magnitude	Negligible	No heavy earth moving vehicles will be used; worksites <500 m^2; limited spoil removed from each borehole.
Receptor Sensitivity	Medium (nature areas) High (human receptor)	Sensitivity of human receptors is High as residential properties, schools and residential care homes are located within 350 m from the worksite. The CCNR is a nationally designated protected area in terms of ecology and is therefore of medium sensitivity.
Significance	Negligible	Negligible adverse impacts can be expected as a result of generation of dust during drilling operation.

5.5.2 Cumulative Impacts

The sensitivities of the human and ecological receptors that will be affected by the cumulative impacts are human and ecological receptors located within 350 m of the SI works and the proposed

developments outlined in *Volume II, Chapter 2*. Receptors include those within residential properties, hospitals and schools along Alignment Option 2 and nature areas, ie the CCNR which is a nationally designated protected area. The sensitivities of the human and ecological receptors are therefore evaluated as *High* and *Medium*, respectively.

The SI works are likely to commence in 2016 Q1 and last 4 to 8 months. During this period, the SI works will coincide with the construction of several developments outlined in *Volume II, Chapter 2.* As discussed in *Section 5.3*, these developments are underway and were observed during the site surveys conducted in July and December of 2014. It is therefore assumed emissions to air from these developments have been captured in the baseline air monitoring undertaken in November to December 2014 and January to February 2015, the results of which were found to below the Singapore Air Quality Target.

Results of the baseline monitoring are considered representative of emissions generated from the construction site for Upper Thomson MRT Station and tunnels for Thomson Line since the sources of emission are similar (ie vehicular movement and construction activities). Further the LTA typically undertake EIAs for their major infrastructure projects in Singapore; therefore in addition to compliance with legal requirements, this development will also be required to implement any mitigation measures recommended within its EIA to ensure that impacts are ALARP, if not insignificant.

The developments which are planned but not yet underway are considered in the assessment of cumulative impact and these include the park connector around the boundary of the CCNR and the MacRitchie observation tower. Both developments will be ready by 2018 and the construction activities could coincide with the SI works. Based on information available at the time of writing, the observation tower will be seven-storeys tall and located in MacRitchie Reservoir Park[4]. The new park connector will have a length of 19.5 km surrounding the Upper Seletar Reservoir, Upper and Lower Peirce, and MacRitchie Reservoirs[5] by connecting to the 10.5 km existing park connector and biking trails. The scale of the construction will likely be small with minimal construction activities involved. Similar to the large infrastructure projects, it is assumed that dust emitted from these construction sites will be managed in accordance with local regulatory requirements. Furthermore, the duration of overlap will be short-term, ie not more than 8 months. Therefore, the magnitude of the incremental impact from these two developments is evaluated as *Negligible*.

As the incremental impact of dust emissions from SI works is also deemed *Negligible*, as discussed in *Section 5.5.1*, the magnitude of impact for the cumulative impacts is evaluated to be *Negligible*. This results in an overall impact significance of *Negligible* for both human and ecological receptors.

[4] National Parks Board (26 May 2012) **NParks to Improve Access to Central Catchment Nature Reserve to Bring Singapore Closer to Nature**. Retrieved from http://www.nparks.gov.sg/cms/index.php?option=com_news&task=view&id=296&Itemid=247

[5] Tan A (27 May 12) **Bringing Nature Closer to Residents.**

Table 5.4: Impact Assessment Summary

Criterion	Rating	Comment
Cumulative Impacts Due to the Overlap Construction Period Between Committed Developments and the SI works		
Nature	Negative	Generation of dust
Type	Direct	Direct exposure to dust
Duration	Temporary	Temporary for not more than eight months when the construction of committed developments and SI works coincide
Extent	Local	Effects will be on human and ecological receptors within 350 m from the worksites
Scale	-	Slight elevated concentrations of PM_{10}
Frequency	Frequent	Daily when the construction of the 19.5 km park connector and MacRitchie observation tower and SI works coincide.
Magnitude	Negligible	Construction of the 19.5 km park connector and MacRitchie observation tower is likely to be small scale. Dust emissions from these construction sites will be managed in accordance with local regulatory framework. Impact of dust emissions from the SI works is deemed Negligible.
Receptor Sensitivity	Medium to High	Sensitivity of human receptors is High as residential properties, schools and residential care homes are located within 350 m from the worksite. The CCNR is a nationally designated protected area in terms of ecology and is therefore of medium sensitivity.
Significance	Negligible	Negligible adverse impacts as a result of the cumulative impacts arise during the overlap period between the SI works and construction activities of the 19.5 km park connector and MacRitchie observation tower

6 ECOLOGY & BIODIVERSITY

6.1 INTRODUCTION

This chapter presents an assessment of the potential impacts on the ecological values of the Project Study Area, as a result of Site Investigation (SI) works associated with Alignment Option 2.

The remainder of this chapter is structured as follows:

- *Section 6.2* details the scope of the assessment undertaken;
- *Section 6.3* summarizes the baseline conditions and ecological values;
- *Section 6.4* outlines the impact assessment methodology;
- *Section 6.5* details the assessment of potential impacts, including proposed mitigation measures; and
- *Section 6.6* provides the residual impact assessment.

6.2 SCOPE OF THE ASSESSMENT

6.2.1 Project SI Works

This assessment of impacts to ecological values in the Project Study Area has been prepared in the context of the proposed SI works as generally outlined in *Volume I, Chapter 2* and fully described for Alignment Option 2 in *Volume IV, Chapter 2*. The SI works for this option will include Preliminary Investigations and Rotary Boreholes. The activities associated with the SI works, that have the potential to impact ecological resources, have been considered in the screening and scoping described in *Volume I, Chapter 5*.

The Preliminary Investigations, which comprise desktop study and a site reconnaissance involving two people tracing the alignment and proposed intrusive ground investigation locations are all outside the CCNR and were not considered to have any significant impacts on ecological values. Although the Project design has evolved since the scoping, the Preliminary Investigations are still not expected to have significant interaction with ecology or biodiversity and therefore no further detailed assessment has been undertaken.

This chapter therefore focuses on the impacts on ecological values associated with rotary borehole works for Alignment Option 2, as well as undertaking an assessment of any cumulative impacts.

6.2.2 Resources and Receptors

For this assessment of impacts on ecology and biodiversity, the key resources and receptors identified are:

- Habitats and flora identified in the baseline, with a particular focus on trees;

- Terrestrial wildlife/fauna identified in the baseline including;
    - avifauna;
    - mammals;
    - herpetofauna;
    - butterflies (generally considered as a good indicator of forest quality);
    - odonates (generally considered as a good indicator of wetland/ stream habitat quality);
- Freshwater fauna and flora identified in the baseline.

The selection of these resources and taxa groups for the purpose of the impact assessment has been based on the secondary data already available; the ability to draw meaningful conclusions from data for impact assessment according to availability of relevant information (eg species-habitat relationships); and the approach to adopt non-intrusive survey techniques for development of the environmental baseline.

As detailed in *Section 3.5.1*, impacts to surface water quality due to sediment loading, contaminated run off and/or generation of wastewater during rotary rig operations was assessed to be *Negligible*. Given that there will be negligible changes to water quality, and the proximity of the SI worksites far from any ecologically sensitive receptor, it is anticipated that aquatic habitats and fauna are unlikely to be impacted by rotary borehole drilling. Therefore, disturbances to aquatic habitats and fauna have been screened out of the assessment.

Furthermore, as no vegetation clearance or tree cutting within forest areas is required for access to and set up of worksites, clearance of vegetation leading to reduction in habitat has also been scoped out of the assessment. Disturbance to planted ornamentals along Lornie Road or grasses in landscaping and managed areas may be required, but if undertaken, all will be reinstated immediately after the works.

As mentioned in *Section 5.5.1*, dust emissions from the rotary drilling rig are expected to be generated from excavation of the starter pits, drilling of boreholes and temporary stockpiling of excavated materials onsite. The quantity of soil tracked out will be minimal as SI works are largely undertaken at grassy roadside verges or pavements and embedded controls will be in place to manage dust emissions. Finally, animals are likely to move away from worksites and for less mobile animals, exposure is short term at approximately 18 days per worksite. Vegetation is not expected to be further impacted as SI worksites are already located along existing heavy use roads (ie Lornie Road, Thomson Road, PIE) and they have been continuously exposed to dust. Therefore, impacts on ecological resources due to dust emissions from borehole drilling operations have also been screened out from the assessment.

6.2.3 Study Area

The Study Area used for the assessment of impacts to ecology and biodiversity from SI Works associated with Alignment Option 2 is shown in *Figure 6.1*. It consists of two key areas – the area comprising a small southern section of the CCNR and Venus Drive (generally termed the MacRitchie area), and the area outside the CCNR, generally navigating around its boundary.

6.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

Literature concerning the Study Area as well as data collected from field surveys (October 2014 to June 2015) suggest that while the majority of the Study Area falling within the CCNR and NParks managed areas is of important ecological value to Singapore, with high biodiversity and a large number of species considered of conservation value, areas found outside are generally of relatively lower value. The Study Area along Alignment Option 2 includes six habitats[1] as illustrated on *Figure 6.1*, namely:

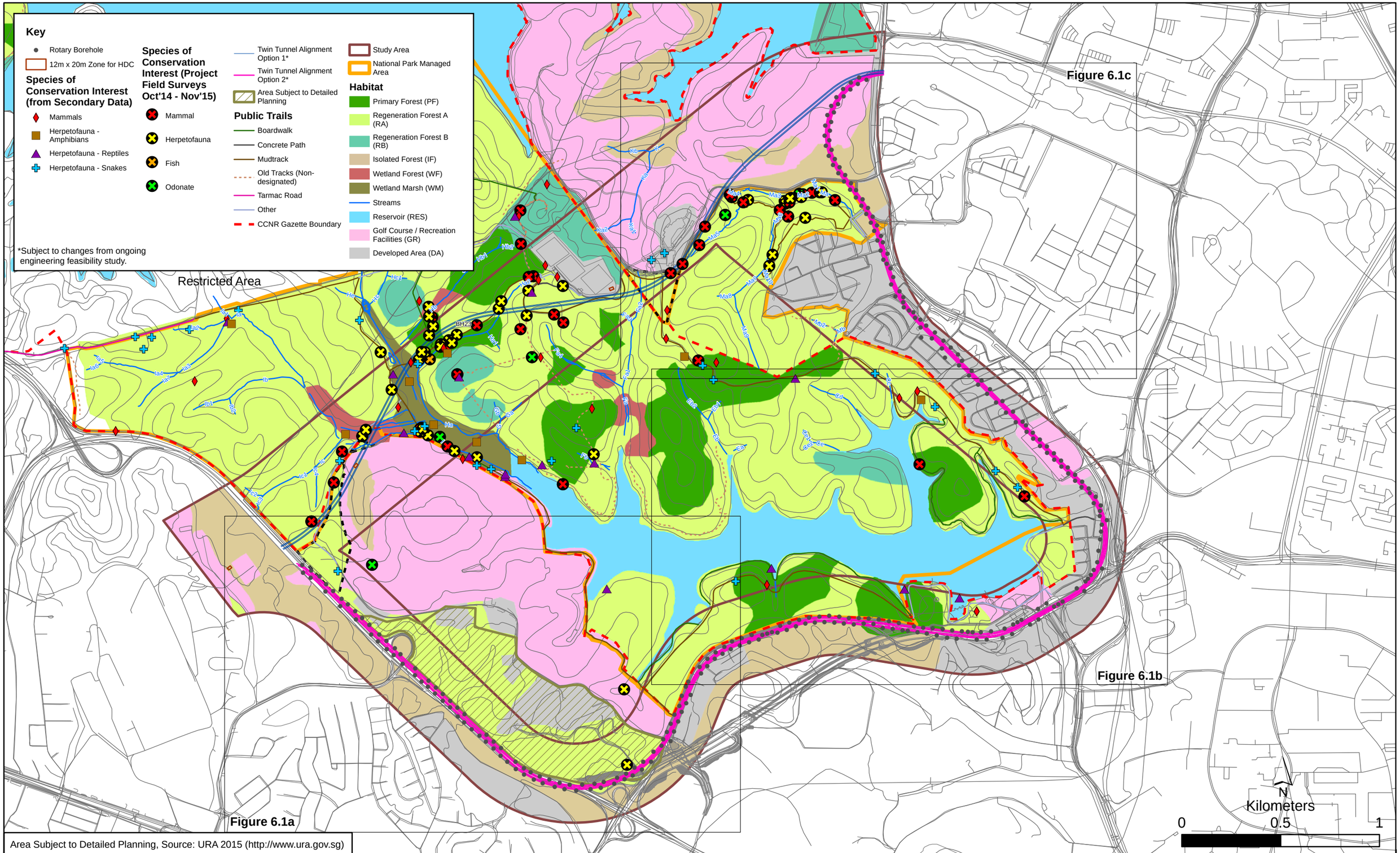
- Developed Area (including roads);
- Golf Course/ Recreational Facilities;
- Isolated Forest;
- Regeneration Forest A;
- Primary Forest; and
- Some small lengths of streams.

Alignment Option 2 will run below Lornie Road, along the CCNR boundary (*Figure 2.1*). Site observations note that there is a concrete pedestrian pavement along Lornie Road adjacent to the CCNR at a distance of approximately 0.5 m to 0.75 m away from the CCNR boundary where the rotary drilling rig will be located. A metal fence separates the pavement and the forest at most parts along the length of Lornie Road along the CCNR boundary, terminating after the CCNR boundary as Lornie Road transitions to Adam Road.

The CCNR forest that is adjacent to Lornie Road comprises two fragmented stands of *Primary Forest* embedded within a larger area of forest classified as *Regeneration Forest A*. The following summarizes the vegetation observations that were made along the CCNR/ Lornie Road:

Fence separating pavement along Lornie Road and Forest (ERM 17.06.15)

[1] Classification of areas used (eg, Regeneration Forest A; Regeneration Forest B; Primary Forest; Wetland Forest etc) as per the classification outlined in Cheong LF, Chua MAH, D'Rozario V, Jamal F, Khoon SK, Koh JKH, Lim KKP, O'Dempsey T and Rajathurai S (2014) Cross Island Line Working Group Report and included in SI EIA Volume II.



Area Subject to Detailed Planning, Source: URA 2015 (http://www.ura.gov.sg)

Figure 6.1 Study Area and Habitat Showing Proposed Borehole Locations and Species of Conservation Interest - Alignment Option 2

File: T:\GIS\CONTRACT\0256660\Mxd\Final_EIA_Report\Vol4\0256660_Habitat_Species_Borehole_Op2_Key_v1.mxd
Date: 16/12/2015

Environmental Resources Management

ERM

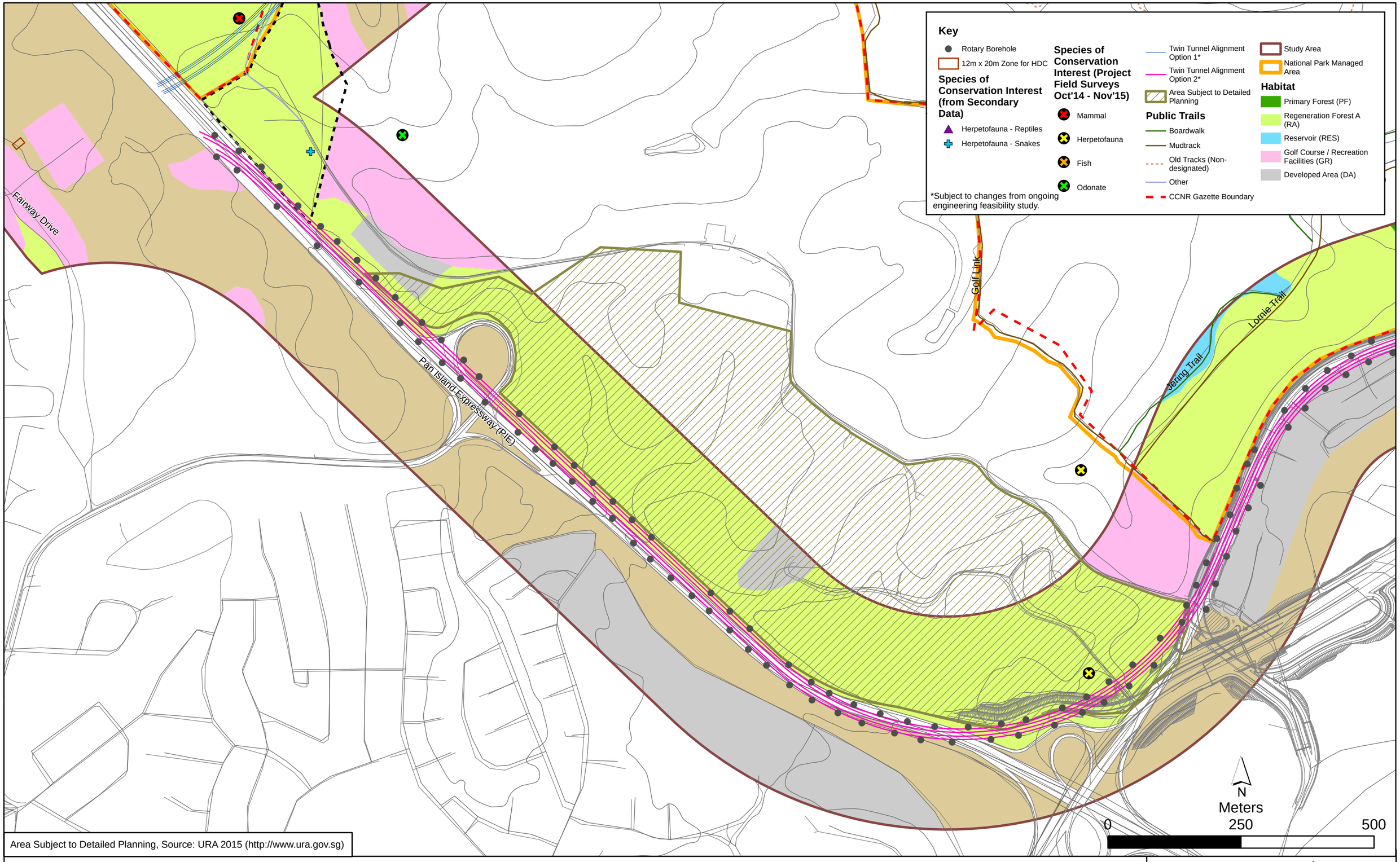


Figure 6.1a Study Area and Habitat Showing Proposed Borehole Locations and Species of Conservation Interest - Alignment Option 2

File: T:\GIS\CONTRACT\0256660\Mxd\Final_EIA_Report\Vol4\0256660_Habitat_Species_Borehole_Op2_1_v1.mxd
Date: 16/12/2015

Environmental Resources Management

ERM

Key

- Rotary Borehole

Species of Conservation Interest (from Secondary Data)

- Mammals
- Herpetofauna - Amphibians
- Herpetofauna - Reptiles
- Herpetofauna - Snakes

Species of Conservation Interest (Project Field Surveys Oct'14 - Nov'15)

- Mammal
- Herpetofauna
- Fish

- Twin Tunnel Alignment Option 2*

Public Trails

- Boardwalk
- Concrete Path
- Mudtrack
- Old Tracks (Non-designated)
- Other
- 30m Buffer from Stream
- 30m Buffer from Wetland Marsh and Wetland Forest
- CCNR Gazette Boundary

- Study Area
- National Park Managed Area

Habitat

- Primary Forest (PF)
- Regeneration Forest A (RA)
- Regeneration Forest B (RB)
- Wetland Forest (WF)
- Streams
- Reservoir (RES)
- Golf Course / Recreation Facilities (GR)
- Developed Area (DA)

*Subject to changes from ongoing engineering feasibility study.

MacRitchie Nature Trail

Petai Trail

Pruinus Trail

MacRitchie Nature Trail

Chemperai Trail

Lornie Trail

Lornie Road

Jering Trail

N

Meters

0 250 500

Figure 6.1b Study Area and Habitat Showing Proposed Borehole Locations and Species of Conservation Interest - Alignment Option 2

File: T:\GIS\CONTRACT\0256660\Mxd\Final_EIA_Report\Vol4\0256660_Habitat_Species_Borehole_Op2_2_v1.mxd
Date: 16/12/2015

Environmental Resources Management

ERM

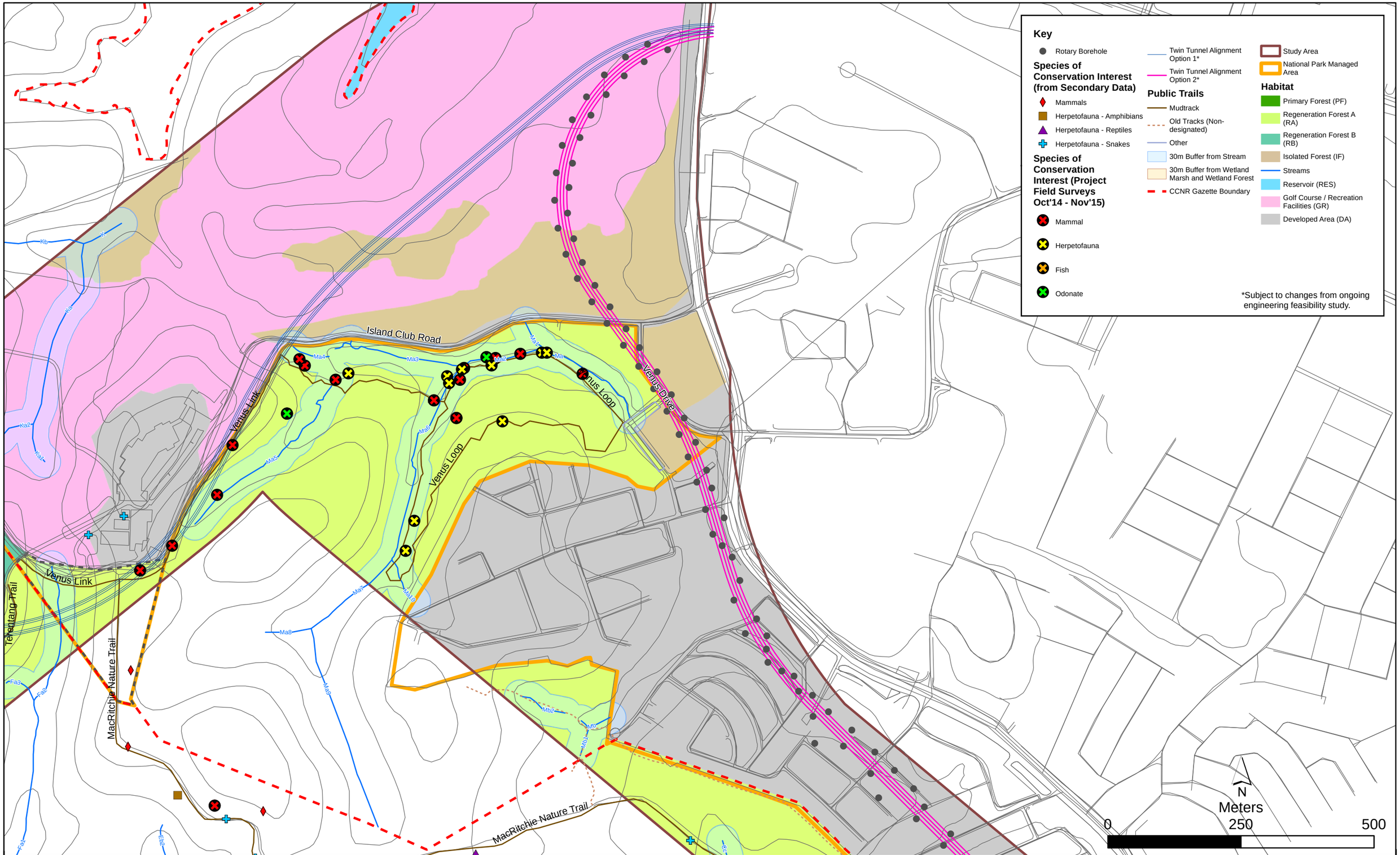


Figure 6.1c Study Area and Habitat Showing Proposed Borehole Locations and Species of Conservation Interest - Alignment Option 2

File: T:\GIS\CONTRACT\0256660\Mxd\Final_EIA_Report\Vol4\0256660_Habitat_Species_Borehole_Op2_3_v1.mxd
Date: 16/12/2015

Environmental Resources Management

ERM

- An abundance of species such as *Cratoxylum formosum, Macaranga gigantea, Ficus grossularioides*, *Melastoma malabathricum* and *Dillenia suffruticosa* which are commonly found along disturbed forest edges;

- Planted ornamentals such as *Syzygium campanulatum, Khaya senegalensis* and *Peltophorum pterocarpum*;

- *S*pecies of conservation interest such as *Ficus lamponga*, *Shorea sp*. and *Nephelium lappaceum.* Some of these trees were located within the forest at least 3 to 5 m away from the pavement while some were located immediately on the pavement at breaks in the fencing that allow for paths leading into the CCNR trails; and

- Climbers and branches of trees and shrubs were observed to extend onto the pavement at some areas.

A stormwater drainage channel was observed running between the forest and pavement at a distance of approximately 0.5 m from general SI worksites. This channel is likely in continuity with the stormwater drainage channel which runs parallel to the PIE as mentioned in *Chapter 3, Section 3.3*. There were no ecological sensitivities observed in this drain.

Stormwater drainage channel between the pavement and CCNR forest. (ERM 17.06.15)

Ficus lamponga *identified at breaks along the fence to accommodate paths leading into the CCNR trails. (ERM 17.06.15)*

Regeneration Forest A found within the CCNR is considered to be of high ecological and biodiversity value (*Volume II, Chapter 7, Table 7.7*). However, two notable patches of high-value *Regeneration Forest A* can be found outside the CCNR boundary. One is located in the north east of the Study Area and one in the west.

Most of the area in the north east is currently managed by NParks as Windsor Interim Green with a small area that is continuous with the patch officially falling just outside the CCNR boundary as well as the Windsor Interim Green boundary (outlined in by black dotted boundary in *Figure 6.1c*). This whole patch of *Regeneration Forest A* possesses a number of highly sensitive streams; has had a large number of species of conservation interest recorded within it; and is considered as a key buffer area to the CCNR, which it is contiguous with. Alignment Option 2 will undercross the northern corner of Windsor Interim Green and mainly run below Venus Drive, an adjacent road (ie *Developed Area*). During the field surveys, it was observed that the proposed area for rotary boreholes within the NParks managed land parallel to Venus Drive consisted of a grassy verge. The area where boreholes are located is at least 54 m from the nearest stream, Ma (*Figure 6.1*). No floral species of conservation concern was

observed on the grass verge. Troupes of long-tailed macaques are commonly seen venturing onto Venus Drive due to its proximity to forested areas.

Grass verge at Windsor Interim Green, along Venus Drive (ERM 17.06.15)

In this north eastern edge of the Study Area, Alignment Option 2 will also undercross part of the SICC Island Golf Course as shown in *Figure 6.1*. The area in question is located to the west of the golf course and the habitat type, as assessed in *Volume II Chapter 7*, is comprised of *Isolated Forest* (fragmented and lacking continuity with the CCNR forests) and *Golf Course/ Recreational Activities*. The alignment falls outside any stream buffer zones and the landscape in the golf course is fairly open with wide fairways, but also contains several mature trees scattered within it and birds such as the Besra (*Accipiter virgatus*) and Brahminy Kite (*Haliastur indus*) have previously been observed over golf course habitats.

The other notable patches of high-value *Regeneration Forest A* to the west of the Study Area, is located between Sime Road and the PIE. The majority of this area is currently zoned for residential development and is 'Subject to Detailed Planning' under the URA Masterplan 2014[2]; no further information is currently available on the schedule of any development works planned within this area. As shown in *Figure 6.1,* Alignment Option 2 will not encroach onto this forested area and instead skirts around it by running along the grass verge bordering the PIE. The grass verge comprises planted wayside trees and common species of disturbed forests in Singapore such as *Spathodea campanulata*, *Falcataria moluccana* and various grasses. While Alignment Option 2 will skirt around this forested area, baseline surveys were still carried out to enable characterization of the general ecological and biodiversity features of the area. Bird species found included the Olive-backed sunbird (*Cinnyris jugularis*), Dark- necked tailorbird (*Orthotomus atrogularis*), Asian koel (*Eudynamys scolopacea*), Pink-necked green pigeon (*Treron vernans*) and Long tailed parakeet (*Psittacula longicauda*), potentially attracted to the several mature fig trees and gardens at residences in the area. The banded bullfrog (*Kaloula pulchra*), copper cheeked frog (*Hyalarana labialis*) and four lined tree frog (*Polypedates leucomystax*) were also found in ditches and surrounding vegetation along Adam Drive.

[2] Retrieved from http://www.ura.gov.sg/maps/

Most of the species of conservation interest that have been recorded along the Study Area around Alignment Option 2 have been found within the CCNR or the NParks managed Windsor Interim Green (*Volume II, Chapter 7*). However a few species of conservation interest fall outside the CCNR or NParks managed boundaries and within the Alignment Option 2 Study Area, as shown in *Figure 6.1*. These include:

- One Malayan Water Monitor (*Varanus salvatori*) was recorded in a tree hole near Adam Drive in the Regeneration Forest A towards the south west of the Study Area. This species is considered common in Singapore and is not listed on *IUCN Red List of Threatened Species* (IUCN 2015.01) or *Singapore Red Data Book* (*Singapore RDB, 2008*). It is however, listed on CITES Appendix II which limits any international trade in specimens of the species without authorization.

- The Dog-toothed Cat Snake (*Boiga cynodon*) was recorded from secondary data along the Sime Road in the *Regeneration Forest A* near PIE[3]. This species is of Least Concern on *IUCN* (2015.01) but listed as Endangered by the *Singapore RDB, 2008;*

- Apart from commonly found bird species, a juvenile Changeable Hawk Eagle was found in *Regeneration Forest A* located between Sime Road and the PIE. This species is of Least Concern on *IUCN* (2015.2) and listed as Endangered in the Singapore RDB, 2008; and

- Trees with girths of more than 1.0 m located at the SICC Island Golf Course. These are protected under the *Parks and Trees Act*, 2006.

6.4 ASSESSMENT METHODOLOGY

The impact assessment is based on the baseline ecology and biodiversity conditions and sensitivities as detailed in *Volume II Chapter 7* and summarized above. *Volume I Chapter 4* describes the overall approach used for the assessment of impacts and the identification of mitigation options. Similar to the other biophysical topics, evaluation of the significance of impacts on ecology and biodiversity, including direct, indirect and induced impacts, takes the following two factors into consideration.

- The sensitivities of ecology and biodiversity resources/ receptors; and

- Impact Magnitude.

It is noted that the value of a resource (habitat) or receptor (species) may be upgraded (eg from medium to high) under certain circumstances, for example, if especially large numbers of a vulnerable species could be impacted.

6.4.1 Sensitivities of Ecology and Biodiversity Resources/ Receptors

Volume II, *Chapter 7*, *Tables 7.7* and *7.8* present the evaluated sensitivities of ecological and biodiversity resources (habitats) and receptors (species) found within the Study Area of Alignment Option 2. However, sensitivity assignments should also be tempered with field observations with regard to the conditions of the exact locations where SI activities will be sited. Therefore, evaluations of sensitivities

[3] Teo R and Rajathurai S (1997) Mammals, Reptiles and Amphibians in the Nature Reserves of Singapore - Diversity, Abundance and Distribution. Gardens' Bulletin Singapore 49: 353–425

of identified ecological and biodiversity resources/receptors will be based on a combination of field observations and an understanding of the baseline conditions from surveys and secondary data.

6.4.2 Impact Magnitude

The impact magnitude is a function of a range of considerations including extent (eg local, regional or national), impact duration (eg temporary, short-term, long-term or permanent), scale (ie size of the impact), frequency (ie constancy or periodicity of the impact), and likelihood (for unplanned events only, eg unlikely, possible, or likely). By considering these characteristics, magnitudes of impacts to ecology and biodiversity are defined into the following five qualitative scales as outlined in *Table 6.1* for habitats and *Table 6.2* for species.

Table 6.1*: *Magnitude Criteria for Effect on Baseline Habitats

Magnitude	Definitions
Positive	The effect brings beneficial outcomes to ecology or biodiversity. No magnitude will be assigned to a positive impact
Negligible	Effect is within the normal range of natural variation
Small	Affects only a small area of habitat, such that there is no loss of viability/function of the habitat
Medium	Affects part of the habitat, but does not threaten the long-term viability/function of the habitat.
Large	Affects the entire habitat, or a significant proportion of it, and the long-term viability/function of the habitat is threatened.

Table 6.2: Magnitude Criteria for Effect on Baseline Species

Magnitude	Definitions
Positive	The effect brings beneficial outcomes to flora or fauna taxa. No magnitude will be assigned to a positive impact
Negligible	Effect is within the normal range of variation for the population of the species.
Small	Effect does not cause a substantial change in the population of the species, or other species dependent on it.
Medium	Effect causes a substantial change in abundance and/or reduction in distribution of a population over one, or more generations, but does not threaten the long term viability/function of that population, or any population dependent on it
Large	Affects entire population, or a significant part of it causing a substantial decline in abundance and/or change in and recovery of the population (or another dependent on it) is not possible either at all, or within several generations due to natural recruitment (reproduction, immigration from unaffected areas).

6.4.3 Assigning the Impact Significance

Once the sensitivity of ecology and biodiversity resources/ receptors have been determined (as detailed in *Volume II, Chapter 7*) and the impact magnitude has been determined according to the definitions

detailed in *Table 6.1* and *Table 6.2*, a Significance Matrix is used to determine the significance of the impact. The matrix used with respect to ecology and biodiversity is as per *Volume I*, *Chapter 4*, *Figure 4.3*.

6.5 ASSESSMENT OF IMPACTS

6.5.1 Impacts Due to Rotary Borehole Works

Key receptor areas identified around the alignment were Lornie Road (bordering the CCNR boundary), Venus Drive, and the SICC Island Golf Course. As mentioned in *Section 6.2.4*, these areas comprise forest habitat types that are considered sensitive ecological resources (eg primary forests, streams, regeneration forest) ranging from *Low* to *High* sensitivities. Although it was investigated as part of the baseline surveys, the forest classified as *Regeneration Forest A* located between Sime Road and the PIE was not considered as an ecological receptor given it's distance from the SI worksites along the PIE.

SI activities for Alignment Option 2 will occur along Lornie Road bordering on the CCNR boundary (*High ecological sensitivity* as per *Volume II*, *Chapter 7, Table 7.8)* however SI works will be undertaken on the pavement at least 0.5 m to 0.75 m from the CCNR. While a drain was found to run along Lornie Road, no ecological sensitivities were observed. As mentioned in *Section 6.*2, no vegetation clearance will be carried out. As such, while vegetation was observed to extend onto the pavement at some areas, these will be pushed aside or avoided by shifting the rig slightly during set up (*Section 6.2*). Although the drain is not expected to be of ecological concern, water containment measures will still be implemented during drilling to control site run-off; therefore it is unlikely that drilling water will flow uncontrolled into the drain.

Due to Venus Drive's proximity to Windsor Interim Green, it is recognized that ecological sensitivities may be encountered there as well. However, SI works will be conducted on the grassy patch in the northern corner of Windsor Interim Green where no flora species of conservation concern has been identified; other boreholes will be located on Venus Drive. Both the northern corner of Windsor Interim Green and Venus Drive have collectively been assessed to be of *Low* sensitivity. Nevertheless, water containment measures will still be implemented to further minimize the possibility of uncontrolled site runoff reaching the stream. Vegetation clearance to access these points is not required as they are located beside a road.

The final ecological receptor identified was the SICC Island Golf Course where part of Alignment Option 2 will undercut. As mentioned in *Section 6.2.4*, conserved mature trees can be found in the golf course and a number of bird species. Therefore the sensitivity of this area of SICC Island Golf Course is assessed to be *Medium*. Due to the patchiness of the forest in the golf course and openness in the landscape, boreholes can be shifted locally to avoid forested areas. In addition, the borehole locations are fairly accessible due to the presence of wide fairways. Borehole locations on Island golf course are located more than 130 m away from the nearest stream (ie Ma2) at Windsor Interim Green, making the possibility of uncontrolled site runoff reaching this stream is unlikely.

The following embedded controls will be implemented to manage impacts to ecology and biodiversity receptors:

- Controls detailed in *Section 3.5.1* to manage wastewater generation and impact of run-off to ground and surface water quality;

- Controls detailed in *Section 5.5.1* to manage generation of dust from SI works; and
- Protection provided to trees (>1.0 m girth) located in proximity to rigs, mobilization and demobilization routes as per the *Parks and Trees Act, 2006*.

The potential impacts to ecology and biodiversity receptors that will reasonably arise from the SI works along Alignment Option 2 are likely to be associated with wildlife disturbance from human interference and noise and vibration generated from operation of rigs, mobilization and demobilization activities. These impacts are further assessed in the following sections.

Disturbance to Wildlife Behavior Due to Human Interference

The human interference element of this impact is concerned with personnel at each worksite during rig operations. Up to 5 personnel are required to operate the A-frame rig and will therefore be present at each worksite during operations. However, once the work site has been set up, these personnel will work within the small worksite area (2 m X 11 m or similar) and therefore are unlikely to disturb any wildlife. These low numbers of personnel will not result in a significant variation from the numbers of public users in these locations.

In addition, SI worksite locations along Lornie Road parallel to a busy road. As this is a heavily disturbed area, wildlife is not expected to be found on Lornie Road or in the immediate vicinity. In turn, wildlife is unlikely to be attracted to worksite areas as they already avoid these disturbed sites. Venus Drive is located beside Windsor Interim Green where several long-tailed macaques have been observed. These animals are highly mobile and there is a possibility that they may venture close to worksite areas out of curiosity or if food is available. The SICC Island Golf Course may also experience the same issue with long-tailed macaques due to its proximity to Windsor Interim Green. Embedded measures will be implemented to ensure workers bag and remove solid waste (including general food waste) from worksites on a daily basis minimizing the attraction for macaques and other wildlife to each worksite.

Disturbance to Wildlife Behavior due to Noise and Vibration

As per *Section 6.2.4*, noise sensitive receptors identified include organisms within three areas: Venus Drive, Lornie Road and *Regeneration Forest A* between Sime Road and the PIE. These include mammals, birds, herpetofauna and invertebrates. As noted by Radford *et al* (2014)[4] it is largely recognized that anthropogenic noise can disrupt acoustic communication in animals and communication gets more difficult as background sounds increase for all vertebrates that have been studied, including birds and amphibians. Individual fitness can consequently be compromised, either through effects on survival (eg a predation threat goes unheard), or reproductive success (eg from incorrect assessment of the quality of rivals or potential mates) or from disrupted communication between parents and offspring. However, while there is some evidence of changes in communication (eg of singing frequency for reed bunting *Emberiza schoeniclus*) and foraging behavior (eg of bats, birds and toads), strong conclusions are mainly not possible due to a lack of sufficient controls to rule out potential confounding factors (eg differences in lighting, disturbance or habitat differences, rather than noise)[5]. With regard to invertebrates, the hearing sensitivity and capability of the vast majority remains

[4] Radford AN, Kerridge E, Simpson SE (2014). **Acoustic communication in a noisy world: can fish compete with anthropogenic noise?** Behavioral Ecology 25(5), 1022 – 1030. doi:10.1093/beheco/aru029

[5] Radford A, Morley E, Jones G (2011). **The effects of Noise on Biodiversity NO0235.** Final Report for DEFRA, UK.

unknown, although it can be roughly divided into those that can detect sound pressure and those which are sensitive to particle velocity. Furthermore, it is known that different invertebrates have different hearing ranges.

Chapter 4 indicates that ambient noise levels at representative monitoring locations within the Study Area were observed to be generally high and fluctuate over the course of the day, in proportion to traffic volume during peak and non-peak hours. Most of Alignment Option 2 is near heavily used roads such as the PIE, Lornie Road and Upper Thomson where ambient noise levels are reportedly 74.3-75.5 dB (A) near the western end of the alignment, 79.1-80.7 dB (A) around Thomson Road junction, and 79.1-80.7dB (A) along Lornie Road. Modelling results from *Section 4.5.1* indicate that incremental noise levels are expected to exceed permissible daytime limits by more than 10 dB (A) at receptors in close proximity to the SI worksites. Specifically, these receptors have been identified to be residences along Upper Thomson Road and Lornie Road, and golfers in SICC Island Golf Course; similarly, wildlife found along Lornie Road, Venus Drive, and the SICC Island Golf Course will be exposed to this increase in noise levels.

Much of the fauna within the Study Area is largely mobile to a distance of over 200 m and could be considered to move away from the noise source. For any fauna that might be considered unable or unwilling to move away from the sound source, the duration at any one borehole will not be more than 18 days. Furthermore, receptors found along Lornie Road and Venus Drive would have already been exposed and potentially accustomed to generally high levels of ambient noise due to presence of heavy traffic on adjacent roads. No drilling will be conducted at night, reducing impacts to nocturnal species that are more dependent on noise detection for foraging and navigation.

With regard to vibration impacts, the main cause of vibration during borehole work is expected to be generated during the SPTs, when a 63.5 kg automatic drop weight repeatedly falls on a split-spoon, metal sampler to drive it into the soil. Hammering is expected be very short duration, lasting 15-30 minutes for any one test, and is scheduled to occur at every 2 m at any one borehole. Drilling will also cause some vibration but it is considered negligible as described in *Chapter 4*. Chapter 4 also concludes that in view of the low levels of vibration that will be generated from SPT and the short duration of the activity and (human) exposure, the impact from vibration generated by this activity on humans is of minor significance. It is recognized that certain fauna such as snakes are able to sense vibration and use it to detect prey[6].

Significance of Impact Prior to Mitigation

Table 6.3 summarizes the overall implications of these impacts on ecology and biodiversity within the affected habitats and *Table 6.4* summarizes the impact assessment findings.

[6] Friedel P, Young BA, Hemmen JLeo (2008) **Auditory Localization of Ground-Borne Vibrations in Snakes**. Physical Review Letters. 100(4)

Table 6.3: *Summary of Impact Significance on Habitats, Prior to Mitigation*

Habitat	Ecology/ Biodiversity Sensitivity	*Magnitude of Impact*		Overall Magnitude of Impact	Significance of Impact
		Disturbance to wildlife behavior due to human interference	*Disturbance to wildlife behavior due noise and vibration*		
Outside NParks Managed boundary					
Lornie Road (Primary Forest and Regeneration Forest A within the CCNR)	High	*Negligible*	*Negligible*	*Negligible*	Negligible
SICC Island Golf Course (Golf course/Recreational facilities; Isolated Forest)	Medium	*Small*	*Small*	Small	Minor
Within NParks Managed boundary					
Venus Drive (Grassy area on Windsor Interim Green; Developed Area ie Road)	Low	*Small*	*Small*	*Small*	Negligible

Table 6.4: Impact Assessment Summary

Criterion	Rating	Comment
Impact – Disturbance to wildlife behaviour due to human interference, noise and vibration from rotary borehole operation		
Nature	Negative	Impacts are considered adverse to ecology and biodiversity
Type	Direct and Indirect	Direct habitat loss due to works footprint. Indirect impacts of noise and vibration will be minimal.
Duration	Temporary (reversible) but long term	While impacts are temporary in nature (with the exception of 20mm diameter Water Standpipes being left in the ground at a few boreholes) and unlikely to exceed 20 days at any one borehole location, the combined working time to complete all numbered boreholes navigating around the CCNR, is likely to be up to eight months. Timeframes have been calculated using the best available information and will vary according to rig used and the field testing schedule drawn up after geophysical survey results.
Extent	Local	Each worksites is 2 m by 11 m or similar; workers will work within the boundaries of this worksite. Only 5 personnel at the most are required to operate the A-frame rig.
Scale	Small	
Frequency	Once	Borehole drilling and field testing will only be carried out once at each location.
Magnitude prior to mitigation	Negligible to Medium	As described in the text above, small/ negligible for most habitats.
Receptor Sensitivity	Low, Medium and High	AS described in the text above, - High for CCNR Forest at Lornie Road - Medium for SICC Island Golf Course (Golf course/recreational facilities; Isolated Forest) - Low for Venus Drive and grassy northern corner of Windsor Interim Green
Significance of Impact	Negligible to Minor	Boreholes along Lornie Road are sited along a pavement and will not encroach into the CCNR forests. Lornie Road is a heavily used road where animals are unlikely to frequent and organisms have been exposed to existing levels of noise from traffic. Boreholes within the SICC Island Golf Course can be locally adjusted to avoid vegetation clearance and fairways are large enough to support vehicular movement

		for mobilization/demobilization and supplementation of materials during drilling. Similarly due to its proximity to Windsor Interim Green, long-tailed macaques may pose an issue but embedded measures are in place. Boreholes near Venus Drive are either located on the road or on a grassy patch in the northern corner of Windsor Interim Green where ecological sensitives are Low. The only concern is from long-tailed macaques that may venture close to worksites, but embedded measures are in place to ensure workers are trained in managing these encounters.

6.5.2 Cumulative Impacts

Cumulative impacts are those that arise from the combined effects of the Project's activities with external ones. The assessment of these impacts is strongly influenced by the status of the other activities (eg, already in existence, approved or proposed) and how much data are available about them.

Potential Impacts

For this Project, a number of Projects and situations have been identified that might be considered to create cumulative impacts and these are outlined in *Volume II Chapter 2 Table 2.1 Committed Developments within the Study Area*. Given the confidential nature of projects and lack of comprehensive and relevant data regarding all these projects, the following assessment will include those considered most relevant and where some information is available, namely:

- Windsor Nature Park, located at Windsor Interim Green and due for completion at the end of 2016;
- Park Link (set to connect the eastern and southern boundary of the CCNR and due for completion in 2018) and MacRitchie Observation Tower (within MacRitchie Reservoir Park, due for completion at the end of 2018);
- Area Subject to Detailed Planning between Sime Road and PIE; and
- New Road at Lornie Road.

The following information is the best that has been made available or is publically available, for each of the Projects outlined above.

Windsor Nature Park

Windsor Nature Park is set to be a 75 ha nature area located off Venus Drive at the Upper Thomson area in the area currently shown as Windsor Interim Green in *Volume II Chapter 7 Figure 7.1* and F*igure 6.1* in this Chapter. It is reported to be a new nature park which will serve as green buffers to the CCNR, helping to reduce visitor pressure on the nature reserves by providing interesting alternative venues for the public to enjoy nature-related activities.[7]

Currently the area is largely forested according to the Baseline data reported in *Volume II, Chapter 7*, as well as secondary data available regarding this area, such as from Neo *et al* (2014)[8] regarding the

[7] National Parks Board (14 February 2015) **Windsor Nature Park.** Retrieved from https://www.nparks.gov.sg/news/2015/2/factsheet-windsor-nature-park

[8] Neo L, Yee ATK, Chong KY, Yeoh YS, Tan HTW (2014) **The Vascular Plant Flora of Abandoned Plantations in Singapore IV: Windsor Forest**. Nature in Singapore 2014 7: 93-019

vascular flora, has a high ecological and biodiversity value. As reported by NParks (2015)[9] also, it is utilized by a large number of fauna species, both native and migratory, including frogs, squirrels, dragonflies and damselflies and the freshwater streams in Venus Drive are home to many native aquatic species such as the Malayan Forest Betta (*Betta pugnax*), the Common Barb (*Puntius binotatus*) and the Tree Fern (*Cyathea latebrosa*).

The Windsor Nature Park project seeks to sensitively enhance the forest habitats and restore existing trails through such works as building boardwalks to complement the existing trails and create 4.1 km of trails in the area. Basic amenities such as restrooms and shelters will also be provided. It is understood that an Environmental Impact Assessment is being carried out for the Project but is not yet complete. Works for the site are targeted to start in mid-2015 however and to be completed by the end 2016

The Windsor Nature Park project overlaps spatially with the current SI works. As shown in *Figure 6.1* and magnified in *Figure 6.1b* the relevant area is classified as Regeneration Forest A and a number of species of conservation interest has been found here, supporting the conclusion that it is a highly sensitive area ecologically. SI activities for Alignment Option 2 will occur on the northern corner of Windsor Nature Park, in an open grassy location as noted through site surveys where no plant species of conservation concern was observed. Therefore, impacts to Windsor Nature Park from the SI Works are expected to be minimally adverse. Furthermore, it is assumed that the works of the Windsor Nature Park, given its objective to enhance the area, will be designed and scheduled in such a way as to have minimal adverse impacts on ecology and biodiversity and therefore cumulative impacts will be minimal. However, it is recommended that close liaison continue between both Project Proponents, to ensure there are no conflicts in scheduling or proposed works (eg new trail enhanced in an area where boreholes are proposed following enhancement work).

Park Link & MacRitchie Observation Tower

These projects to create a new cycle link approximately 30 km long and build a seven-storey tower within MacRitchie Reservoir Park by 2018 are part of a wider strategy of NParks, to make nature more accessible to Singaporeans, [10] (also see below re Nature Park at Chestnut Drive). Limited information is available for these works, apart from knowing the new loop will also be linked to the Western Adventure Park Connector Loop and other park connectors and visitors will be able to travel from heartland areas such as Bishan-Ang Mo Kio Park, and other areas such as Dairy Farm Nature Park. It is also reported that the loop will be built around the perimeters of the forests to safeguard the high biodiversity cores of the reserve. With regards to the MacRitchie Observation Tower, this is reported to be planned near the car park and other amenities of MacRitchie Reservoir Park towards the south of the Project Study Area.

Given the limited specific information regarding these projects, cumulative impacts cannot be fully assessed. Given the purpose of these projects to bring people close to nature, however, it is assumed that any works will be designed and scheduled in such a way as to have minimal adverse impacts on ecology and biodiversity and any cumulative impacts that might occur would be minimal. However, it

[9] National Parks Board (14 February 2015) **Windsor Nature Park.** Retrieved from https://www.nparks.gov.sg/news/2015/2/factsheet-windsor-nature-park

[10] National Parks Board (26 May 2012) **NParks to Improve Access to Central Catchment Nature Reserve to Bring Singapore Closer to Nature.** Retrieved from https://www.nparks.gov.sg/news/2012/5/nparks-to-improve-access-to-central-catchment-nature-reserve-to-bring-singaporeans-closer-to-nature

is recommended that close liaison continue between both Project Proponents to ensure there are no conflicts in scheduling or proposed works or understand where there may be any synergies in plans.

Area Subject to Detailed Planning between Sime Road and PIE

There is an area between Sime Road and PIE that is currently set as a residential area 'subject to detailed planning' according to the Urban Redevelopment Authority (URA) Masterplan 2014.[11] No further details of any design for the area or proposed schedule of works or works are available, as discussed in *Section 6.6.2*, and therefore cumulative impacts cannot be assessed.

It is recommended that further action is taken to investigate the planned schedule of works for this area, to enable a better understanding of how the projects might interact.

New Road at Lornie Road[12]

Toward the south of the current Study Area, a new road is being built to connect Lornie Road and the PIE. According to a press release by the LTA in 2011, construction of the new road started in Q1 2013 and is due to complete in mid 2016.[13] Some of the SI works may potentially overlap the schedule with the new road at Lornie Road. Given the boreholes are mainly located in Developed Area in the section near the new road at Lornie Road and negligible/ minimal ecological impacts is expected due to these SI works, cumulative impacts will be negligible/ minimal.

Overall Significance of Cumulative Impacts

Projects that might be considered to cause cumulative impacts have been discussed above. No cumulative impacts to ecology and biodiversity are anticipated from the Windsor Nature Park project or the Park Link & MacRitchie Observation Tower although close liaison between the Project Proponents for these projects is recommended. This will ensure all parties are aware of proposed scheduling and are able to exchange relevant and useful information.

For the Area Subject to Detailed Planning between Sime Road and PIE, a further understanding of the proposed development here, particularly the scheduling, it necessary before a clear understanding of any cumulative impacts can be assessed.

[11] Retrieved from http://www.ura.gov.sg/maps/

[12] LTA. Retrieved from http://www.lta.gov.sg/apps/news/page.aspx?c=2&id=rj2i4o1u3d7018466v86y82epxjj32mwbvnhu6rpwt8lplkgo6

[13] LTA. Retrieved from http://www.lta.gov.sg/data/apps/news/press/2011/12092011_Jt%20Release_Project%20time%20line.pdf

7 MANAGEMENT AND MONITORING

7.1 ENVIRONMENTAL MANAGEMENT REQUIREMENTS

This Environmental Management and Monitoring Plan (EMMP) sets out actions for the Site Investigation (SI) Phase of CRL Project alignment option skirting the CCNR (Alignment Option 2). This encompasses standard rotary borehole excavation at 25 m spacing in a herringbone pattern, either side of the alignment (refer to *Chapter 2* for the project description details). The EMMP establishes actions that need to be undertaken in order to avoid, alleviate, mitigate and remedy the potential impacts that were systematically identified during the development of the Project's SI EIA. It also assigns responsibilities for implementing and monitoring the actions required prior to and during the SI works.

In order to ensure adequate handover and interpretation, *Section 7.6.1* includes provisions for training on the requirements of the EMMP.

7.2 PURPOSE OF THE EMMP

The objectives of this EMMP include:

- Ensuring compliance with the mitigation measures as identified in the SI EIA; and
- Determining the project's actual environmental impacts so that, if necessary, corrective actions can be taken and the necessary modifications can be made to the Project.

7.3 DEVELOPMENT OF THE EMMP

The EMMP was developed following the assessment of impacts, which was undertaken in accordance with the approach adopted for the SI EIA study. The Project activities were reviewed to identify potential impacts across a range of environmental aspects eg, ecology and biodiversity, ambient air quality, ambient noise *etc*. Embedded controls[1] were taken into account during the impacts assessment and mitigation measures or precautionary measures identified to reduce potential impacts identified.

7.4 STRUCTURE OF THE EMMP

The EMMP planning table is provided in *Table 7.1* and details the following:

- Environmental **Topic** to which the action pertains, eg ecology and biodiversity, noise, and air quality;
- The **SI Phase** of the works to which the specific actions apply. For Alignment Option 2 there are only two phases as outlined in *Chapter 2*, abbreviated as follows: preliminary investigation (Prelim Investigation); and rotary boreholes (Rotary BH);

[1] Physical or procedural controls that are already planned as part of the Project design, eg in the case of CRL, use of a fluid containment tank during rotary drilling for Alignment Option 1; compliance with statutory requirements; and LTA requirements such as the *Particular Specifications, Safety, Health and Environment*. The mitigation measures presented herein are over and above the Project "embedded controls". For further details refer to *SI EIA, Volume I, Chapter 03*

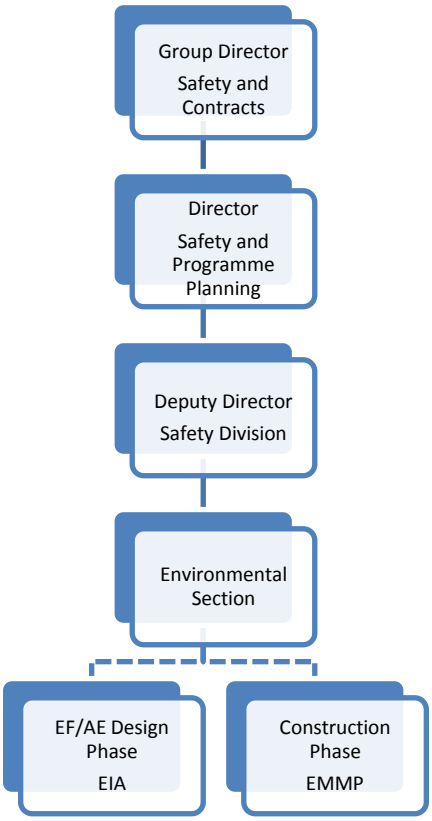
- The **Aspect** of the SI works and potential environmental impact/issue;
- **Reference** to the relevant statutory requirement, LTA requirement, and Chapter within the SI EIA;
- **Specific Actions** (ie mitigation) that require implementation. Actions are detailed from the mitigation measures identified within the Project EIA;
- **Responsible person for ensuring action implementation.** Further details on the roles and responsibilities are provided in the subsequent section;
- **Means of verification that commitment has been met**;
- **Monitoring** measures, where applicable to the **Action**; and
- Any **Related Management Plans** within which the Action would need to be appropriately captured.

7.5 EMMP ROLES AND RESPONSIBILITIES

7.5.1 LTA

Environmental management of LTA projects is guided by the *LTA Safety Health and Environmental System* and supported by the *Safety and Contracts Group* as illustrated in the organizational structure outlined in *Figure 7.1*.

Figure 7.1: Safety and Contracts Division Organizational Structure



LTA Environmental Policy

LTA's *Environmental Policy Statement* commits the Project to put in place measures to manage and protect the environment, during implementation of activities. In order to achieve its environmental commitment, LTA aims to:

- Incorporate environmental protection into LTA's strategic decision-making to ensure that both the environmental and economic needs of the communities are met;
- Ensure compliance with all relevant environmental legislation and regulations;
- Ensure good environmental practices are met or exceeded;
- Work with partners, eg other government agencies and contractors, to operate in an environmentally responsible manner; and
- Monitor, evaluate and continually improve their environmental management practices to ensure efficient use of limited resources.

Land Transport Authority

ENVIRONMENTAL POLICY STATEMENT

LTA is committed to nurture its staff to care and protect our environment. We incorporate environmental protection in our strategic decisions and conduct our business in a manner that balances the environmental and economic needs of the communities in which we operate.

We will:

- Comply fully with all relevant environmental legislation and regulations and meet or exceed good environmental practices;
- Work with our partners i.e., transport operators, contractors, suppliers, interest groups and other government agencies in a concerted effort to operate in an environmentally responsible manner;
- Create a cleaner and greener environment by making continuous efforts to be energy-efficient and to practice Reduce, Reuse and Recycle; and
- Monitor, evaluate and continually improve our environmental management practices to ensure efficient use of the limited resources.

Chew Men Leong,
Chief Executive

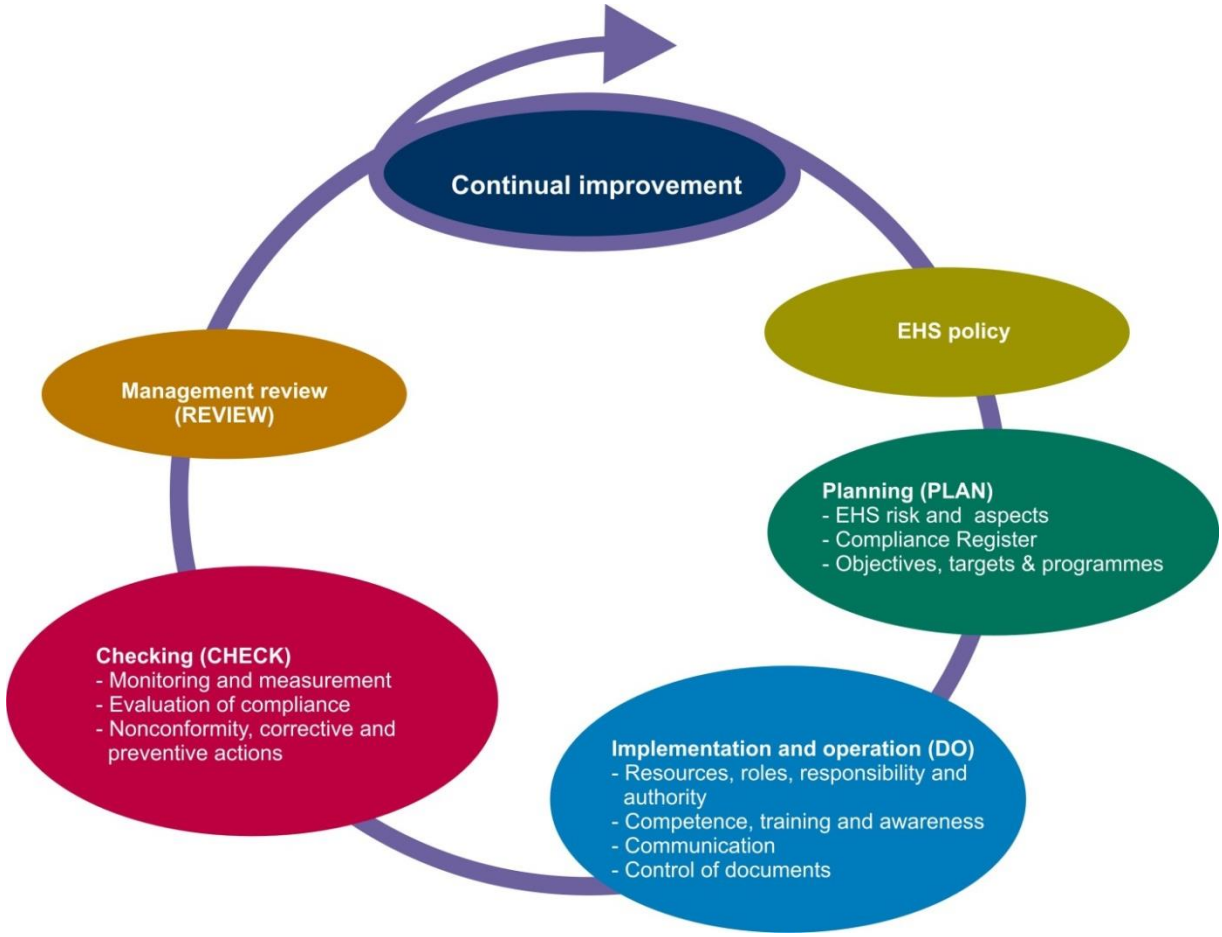
Date : 1 December 2014

In adherence to this *Environmental Policy Statement,* all Project personnel including LTA staff, contractor(s) and subcontractor(s) are expected to be responsible for their own environmental performance and the environmental impact to others due to Project activities.

LTA Environmental Management System

Environmental management systems (EMS) provide a framework to support the process by which a company puts its general principles into practice. The LTA's EMS is understood to be based around the requirements of ISO 14001, which follows the general principles of the "*Plan, Do, Check, Review*" cycle as illustrated on *Figure 7.2*.

Figure 7.2: Plan, Do, Check, Review Cycle



LTA EMMP Role and Responsibility

In accordance with *LTA's Environmental Policy Statement,* the LTA Project Team will be overall accountable for the environmental performance during the SI works, and assume ultimate ownership over the Project compliance with relevant legislation, guidelines and best practice. In addition, LTA will undertake routine audits/verification checks of the EMMP implementation; and establish and maintain a corrective action/ grievance mechanism and lines of communication within the Project Organization to ensure stakeholder (including other government agencies such as NParks and PUB) concerns are addressed in a timely manner.

7.5.2 Contractor

The LTA Contractors will be required to comply with the LTA's EMS requirements; take ownership of the EMMP and ensure that the SI works are undertaken in accordance with the mitigation measures outlined within this EMMP along with the LTA's *Particular Specifications Appendix B, Safety Health and Environment (for Road Projects), December 2014 Edition* and statutory requirements. The Contractor will be responsible for establishing an Environmental Team (ET) for the SI works, ensuring inclusion of an *Environmental Control Officer (Environmental Public Health, Employment of Environmental Control Offices, Order)*. The ET is expected to hold the requisite and relevant experience to carry out various tasks such as monitoring as per the *LTA Particular Specifications*, data analysis, compliance checking, site

inspections as well as provide advice on corrective actions to environmental issues/mitigation measures during the works.

7.5.3 Environmental Advisor

For SI works within the CCNR, a third party Environmental Advisor[1] will be required to verify and monitor some mitigation measures identified through the EIA process, eg noise verification and ecology survey of access route to be cleared through the *Regeneration Forest A*, east of PIE and west of the SICC Bukit Golf Course. Further details are outlined in *Table 7.1*.

7.6 COMMUNICATION PLAN

7.6.1 Training and EMMP Implementation

The planning table outlined in *Table 7.1* and the project description from the SI EIA will be incorporated into the Contractor contracts for the SI works. In order to arrange appropriate handover of the EMMP to the SI Contractors, the LTA Project Team will arrange a planning meeting with the Contractor during the Preliminary Investigation Phase to provide training on the EMMP. The training should include:

- Safety procedures and guidelines;
- SHE management plans to be prepared by the Contractor;
- Communication procedures, including tool box talk and reporting requirements;
- Briefing by the Environmental Advisor on the potential environmental impacts, ecological sensitivities within CCNR and mitigation measures as detailed in the EMMP;
- Corrective action procedures (refer to *Section 7.6.3* for further details); and
- Stakeholder grievance process.

In addition, specific environmental training will also be provided to the Contractors on the applicable environmental sensitivities working in areas close to the CCNR or the forest areas east of the PIE and west of the Bukit Golf Course. The training will include Do's and Don'ts for the SI workers; and reinforcement of the corrective action procedures.

All training attendance records will be submitted to LTA immediately following completion of the training to maintain in the Project records.

While the Contractor is responsible for implementation of the EMMP, the whole implementation process will require supervision, checking, documentation and verification so that any potential problems are identified and properly addressed. In order to ensure proper execution of the EMMP, periodic reviews will be conducted by the LTA Project Team throughout the SI works. This will include the preliminary EMMP training; weekly progress calls and corrective action discussions; and spot check site audits.

[1] Environmental Resources Management will act as the Environmental Advisor during the SI Works

7.6.2 Reporting

Records of training, progress, calls, agreements and verification reports throughout the SI works will be maintained with a unique identifier so that they can be distinguished from any other material and can be easily retrieved. It is suggested to develop suitable templates for reports during the Preliminary Investigation Phase prior to commencement of the works, for consistency and efficiency. Further, all the templates shall be clearly communicated to all potential users during the initial training outlined in *Section 7.6.1*.

In summary, the documentation generated during the SI works will comprise:

- Training attendance records;
- Management Plans (Contractor);
- SHE Inspection Report (Contractor);
- Monitoring Records (Contractor);
- Technical Notes (Environmental Advisor);
- Minutes of Meeting of weekly progress calls and management review meetings (LTA); and
- SI works SHE audit reports (LTA).

7.6.3 Management of Change

The aim of the EMMP is to be a live document and to allow environmental performance to be monitored – this means there must be scope for things to be acted on and corrective action taken if required. It may be necessary to make modifications to the EMMP over the course of the SI works when:

- Unanticipated impacts arise that require additional mitigation;
- When mitigation proposed proves ineffective or unable to be implemented; and
- When the project changes in a way that is substantially different to that described in the SI EIA.

Contractors may propose changes to the EMMP at any time throughout the course of the SI works. The steps for managing change to the EMMP are as follows:

- Identify and describe unanticipated impacts, ineffective mitigation or changes in the Project description.
- Suggest mitigation to manage the identified issues for existing EMMP Planning Table (*Table 7.1*). Issues should be raised and discussed initially through weekly (or sooner if required) progress calls with LTA;
- Record recommended corrective action into the progress call Minute of Meeting;

- Circulate proposed modification through the call Minutes of Meeting and seek advice on the proposed new mitigation measure, from the Environmental Advisor of other SHE personnel / Technical Agencies, as appropriate. LTA will confirm or reject suggested modifications normally within one working day of the daily progress call; and

- Record corrective action/mitigation measures implemented in weekly SHE Inspection report, and modify the EMMP planning table.

Changes will become effective immediately following LTA approval of the suggested modification.

In addition to the steps for managing change outlined above, a Management Review meeting shall be led by the LTA Project Team every 1 month during the SI, at least, or whenever there is a major incident of non-compliance to which the EMMP relates[1]. The following will be reviewed and assessed and a view taken to whether the EMMP needs to be updated to reflect the findings and ensure continued compliance with LTA's objectives and goals:

- Status of performance regarding objectives and targets;

- Internal audit report findings;

- Non-compliances to the EMMP by the Contractor and the status and effectiveness of corrective actions;

- Improvement proposals or suggestions; and

- Review of the effectiveness of mitigation measures and whether they continue to reflect best practice.

[1] In the context of this Project we recommend that a major incident of non-compliance be defined as any incident that has resulted, or could potentially result, in - serious damage to flora; any pollution of soil or water bodies; and any injury or death of wildlife.

s/n	Topic	SI Phase (All Phases; Prelim Investigations, Rotary BH)	Aspect, Potential impact /issue	Reference	Specific Actions (developed from the mitigation measures identified in the Project SI EIA)	Responsible person for ensuring action implementation	Means of verification that commitment has been met	Monitoring				Related Management Plans
								Timing and frequency of monitoring	Parameters	Location	Reporting requirements	
1.01	General Management	All	Permitting	LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition SI EIA Vol I	Environmental management plans developed as per *LTA General Specifications* to include specific actions outlined within this Site Investigation (SI) works EMMP	Contractor	Approval of Management Plans and LTA Auditing Implementation	-	-	-	-	Air Pollution Control Plan Noise Management Plan Earth Control Measures Plan Waste Management Plan Water Pollution Management Plan Emergency Preparedness Plan Fire Safety Plan Biodiversity Monitoring and Management Plan
1.02	Noise and Vibration, Ecology and Biodiversity	Rotary BH	Human and Ecological Disturbance from Noise generated during Rotary BH operations	Code of Practice for Noise Control on Construction and Demolition Sites, CP 49:1998 LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition LTA's Handbook for Best Environmental Practices: Noise Control at LTA Sites, July 2008	All Rotary BH operators to attend a pre-works tool box (~ 15 minutes) on equipment handling/ noise minimization measures	Contractor	SHE Inspection Training Record	-	-	-	-	Noise Management Plan
1.03	Noise and Vibration	Rotary BH	Human Disturbance from noise generated during SPT testing and Rotary BH operations	LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition Code of Practice for Noise control on construction and demolition sites, SS602:2014	As per LTA General Specification, Noise Management Plan to ensure equipment/rigs are operating within the manufacturers specifications. In addition, rig /equipment selected for use should have sound power specifications which are similar to or less than those used in the SI EIA: i) Rotary borehole drilling rig (A-frame, crawler mounted): 105 dB(A) ii) Water pump (diesel operated): 96 dB(A)	Contractor	Review of vendor specifications against Code of Practice and SI EIA SHE Inspection	During Preliminary Investigation Phase, prior to commencement of SI works	-	-	Method Statement	Noise Management Plan
1.04	Noise and Vibration	Rotary BH	Human Disturbance from noise generated during SPT testing and Rotary BH operations	LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition	All rigs and equipment used must have both the noise emission levels of: a) engine noise and b) operational noise under normal operating conditions, clearly indicated on a weather-proof sticker pasted at the equipment.	Contractor	SHE Inspection	During Preliminary Investigation Phase, prior to commencement of SI works	-	-	-	Noise Management Plan
1.05	Noise and Vibration	Rotary BH	Human Disturbance from noise generated during SPT testing and Rotary BH operations	LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition LTA's Handbook for Best Environmental Practices: Noise Control at LTA Sites, July 2008	All rigs and vehicles in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works.	Contractor	SHE Inspection	Weekly	Visual inspection	All Rotary BH worksites	SHE Inspection Report	Noise Management Plan

s/n	Topic	SI Phase (All Phases; Prelim Investigations, Rotary BH)	Aspect, Potential impact /issue	Reference	Specific Actions (developed from the mitigation measures identified in the Project SI EIA)	Responsible person for ensuring action implementation	Means of verification that commitment has been met	Monitoring				Related Management Plans
								Timing and frequency of monitoring	Parameters	Location	Reporting requirements	
1.06	Noise and Vibration	Rotary BH	Human disturbance due to Noise from operation of Rotary BH Rigs	SI EIA Vol IV, CPT 4.5.1 Environmental Protection and Management Act, 2008	Silenced / low noise generators to be used at all times (With reference to criteria provided under the NEA's Guidelines on Quieter Construction Fund, quieter equipment may be defined as equipment that is at least 5 dB quieter than two similar pieces of equipment commonly used for the same type of work in Singapore)	Contractor to provide Silenced / Low Noise Generator and/or engine Environmental Advisor	SHE Inspection Complete verification monitoring and technical note with outline of corrective measures to reduce potential impact to As Low As Reasonably Practicable for submission to LTA	- Once during first week of Rotary BH operation at the locations prescribed	- Laeq,5min	- As per the vendor specifications for the silenced / low Noise generators and/or engines at the following: 1) Residences along Upper Thomson Road within 3 m of proposed Rotary BH worksite, eg Private residences in Yew Lian Estate 2)St Theresa's Home 3) Golfers at SICC (Island & Bukit location)	- Technical Note to be submitted to the LTA within one week of verification monitoring.	Noise Management Plan
1.07	Noise and Vibration	Rotary BH	Noise from operation of Rotary BH Rigs	SI EIA Vol IV, CPT 4.5.1 Environmental Protection and Management Act, 2008 Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008	Acoustic enclosures to be placed on rig engines throughout operations. (For the construction of machinery enclosures, a sheet material mass of at least 10 kg/m2 is recommended (British Standard BS5228-1, 2009). The sound-absorbent inside lining of the enclosure (which may be made of mineral wool, woodwool or absorbent tiles) should be at least 25 mm thick. Panels used in the enclosure should meet a STC rating of 20 or higher, with reference also being made to the NEA's Quieter Construction Fund. It is noted that confirmation should be sought from the machinery manufacturer to ensure that enclosures are designed in a way that allows adequate ventilation and provides for access during maintenance.)	Contractor to provide and ensure enclosures in place Environmental Advisor to complete verification monitoring	SHE Inspection as per *Action Item No 1.06*	- as per *Action Item No 1.06*	- as per *Action Item No 1.06*	- as per *Action Item No 1.06*	- as per *Action Item No 1.06*	Noise Management Plan
1.08	Water Quality, Ecology and Biodiversity	All Phases	Waste Management throughout SI works	SI EIA Vol IV CPT 2.3.2 LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition Environmental Protection and Management Act, 2008 LTA Guidebook for Best Environmental Practices: Construction Waste Management at LTA Sites	Waste Management Plan (*Action Item No. 1.01* to include the following: • Waste hierarchy and classification; • Daily inspection of waste management, such as the wastewater collection system (eg from starter pit), bagged waste, wastewater collection tote tank for leaks and damage; • Bagging and daily removal of all solid waste from each worksite; • Mobilization and demobilization procedures for the waste collection vehicle; • Logging of waste generation and removal from each worksite; • Sanitary facility location, maintenance and waste removal procedures; • Inspection procedures to ensure waste management implementation; • Disposal protocols and documentation requirements by licensed third party contractors; and • Complaints procedures.	Contractor	SHE Inspection	Daily	-	-	SHE Inspection Report	Waste Management Plan Feedback Management Plan

s/n	Topic	SI Phase (All Phases; Prelim Investigations, Rotary BH)	Aspect, Potential impact /issue	Reference	Specific Actions (developed from the mitigation measures identified in the Project SI EIA)	Responsible person for ensuring action implementation	Means of verification that commitment has been met	Monitoring				Related Management Plans
								Timing and frequency of monitoring	Parameters	Location	Reporting requirements	
1.09	Stakeholder Engagement	Prelim Investigations	Complaints from noise during SI works	SI EIA Vol IV, CPT 4.5.1, CPT 4.5.2 & CPT 4.5.3	Ensure the community is informed beforehand on the SI works schedule and details to include noise generating activities; progress of SI work; and complaints reporting procedure. The community includes all persons that may be affected by the SI Works and its environmental emissions, ie the recreational users of CCNR and the golf courses and nearby residents.	LTA	Feedback Mechanism	-	-	-	-	Feedback Management Plan
1.10	Stakeholder Engagement	Prelim Investigations	Stakeholder Feedback / Complaints from SI Works	SI EIA Vol I, CPT 6.5	Have Public Relations Plan in place prior to commencement of SI works. Plan to include, feedback mechanism and complaints reporting procedure.	LTA	Feedback Mechanism	-	-	-	-	Feedback Management Plan
1.11	Water Quality, Ecology and Biodiversity	Rotary BH	Wastewater runoff to ground and/or surface watercourses / erosion Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas	SI EIA Vol IV, CPT 6.5.2	Strictly no discharge of wastewater to ground or nearby ditches. Fluid Containment Tank (FCT) to be used at all times during operation of rotary rigs to contain slurry. FCT to be positioned on absorbent mat or within secondary containment to contain potential spill / leak to ground.	Contractor	SHE Inspections	Weekly	Visual inspection of overflow to ground from FCTs	All rotary rig operation locations	SHE Inspection Report (to include Corrective Action)	Water Pollution Management Plan
1.12	Water Quality, Ecology and Biodiversity	All Phases	Contamination of ground and surface watercourses and impact to aquatic and wildlife communities	SI EIA Vol IV, CPT 6.5.2; Environmental Protection and Management Act, 2008 LTA Guidebook for Best Environmental Practices: Water Resource Management at LTA Sites, 2011	The small amounts of hazardous fluids (ie, <5 liter oil and diesel) are required to be stored within a dedicated locked hazardous material storage box at each worksite and during mobilization/demobilization to and from each worksite. Spill kits such as absorbent pads and drip trays to be provided at each worksite. Storage box and spill kits to be secured at all times to prevent access from wildlife and members of the public.	Contractor	SHE Inspections	Weekly	Visual inspection	All Rotary BH worksites	SHE Inspection Report (to include Corrective Action)	Water Pollution Management Plan
1.13	Ecology and Biodiversity	All Phases	Disturbance to wild plants and animals	SI EIA Vol IV, CPT 6.5.2	Entry by Contractor personnel and all SI works are strictly prohibited in the CCNR eg in areas in close proximity to Lornie Road.	Contractor	SHE Inspection	Daily	-	At boundaries of CCNR and Bukit Golf Course	-	Biodiversity Monitoring and Management Plan
1.14	Ancillary Facilities	All Phases	Waste	SI EIA Vol IV, CPT 6.5.2	Provision of onsite or nearby facilities including sanitary facilities.	-	-	-	-	-	-	-
1.15	Ecology and Biodiversity	All Phases	Disturbance to wild plants and animals	SI EIA Vol IV, CPT 6.5.2	Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside the *Regeneration Forest A* areas and the golf courses daily.	Contractor	SHE Inspection	Daily	-	All worksite areas	-	Waste Management Plan
1.16	Noise and Vibration	Rotary BH	Human disturbance due to noise from vehicles used in ecologically sensitive areas during clearance and SI works Disturbance to wild animals during Rotary BH operations	SI EIA Vol III, CPT 6.5.2	All vehicles should be maintained at a constant and low speed of less than 5 km /hour at all off main road locations (ie, within SICC Island Golf Course)	Contractor	SHE Inspection	-	-	-	-	Noise Management Plan

s/n	Topic	SI Phase (All Phases; Prelim Investigations, Rotary BH)	Aspect, Potential impact /issue	Reference	Specific Actions (developed from the mitigation measures identified in the Project SI EIA)	Responsible person for ensuring action implementation	Means of verification that commitment has been met	Monitoring				Related Management Plans
								Timing and frequency of monitoring	Parameters	Location	Reporting requirements	
1.17	Noise and Vibration	Prelim Investigations Rotary BH	Human Disturbance from noise generated during SPT testing and Rotary BH operations	SI EIA Vol IV, CPT 4.5.1 Environmental Protection and Management Act, 2008 Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008	When scheduling and finalizing the location of rotary borehole worksites during the Preliminary Investigation phase, ensure the following: - Only one drilling rig is in operation at any one time and a minimum distance of 15 m is maintained between noise sensitive receptors and the nearest worksite within housing estates along Upper Thomson Road and Lornie Road and within close proximity of Taman Permata Park. - For SI works within 30 m of the Mt Alvernia Hospital compound, ensure that only one rig is in operation at any one time. - Where a residential NR's is within 3 m of a SI worksite along Upper Thomson Road; Lornie Road; user areas of Taman Permata Park; and golfers at SICC Island golf course, drilling operations to only be undertaken during weekday only so as to avoid nuisance from noise during peak periods of recreational use and when more residents are likely to be at home. - Prior to SI works within the St Theresa's Home compound, engage the management of St Theresa's Home to understand the layout of buildings which would be especially sensitive to noise during the day, eg bedrooms, and particular periods of the day or week to avoid, eg periods of rest or periods of higher visitation such as weekends. Review SI borehole locations so that a minimum distance of 65 m is maintained between noise sensitive buildings within the compound and the nearest worksite. (Should there be justifiable technical reasons to undertake SI works within the minimum distances from the NRs as recommended above, the *Director-General of Environmental Protection* in the NEA shall be notified in writing, in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations*)	Contractor	Approval of SI Works Schedule at Preliminary Investigation Phase, prior to commencement of SI works	-	-	-	-	Noise Management Plan
1.18	Noise and Vibration	Prelim Investigations	Stakeholder Engagement of noise generating activities	SI EIA, Vol I, CPT 6 and Vol 5, CPT 4.5.1	Provide information on the SI works schedule, activities and feedback mechanism (refer to SI EIA Vol I, CPT 6) to residents within housing estates along Upper Thomson Road and Lornier Road, recreational users of Taman Permata Park and SICC Island Golf Course, Mt Alvernia Hospical, so as to inform them early of the noise generating activities.	LTA	LTA corporate communications process	-	-	-	-	Noise Management Plan Stakeholder Engagement Plan
1.19	Water Quality, Ecology and Biodiversity	Rotary BH	Wastewater runoff to ground and/or surface watercourses	SI EIA Vol IV, CPT 3.5.1	No drilling operations to be undertaken during rainfall. Worksites to be covered with a tarpaulin during rainfall and FCTs be fitted with a tight lid to ensure no overflow when operations halted. Drilling operations can resume at each worksite when rainfall has stopped and no surface pooling of rainwater observed at the worksite.	Contractor	SHE Inspections	Weekly	Visual inspection for signs of flooding and overflow from FCT.	All Rotary BH worksites	SHE Inspection Report (to include Corrective Action)	Water Pollution Management Plan

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