


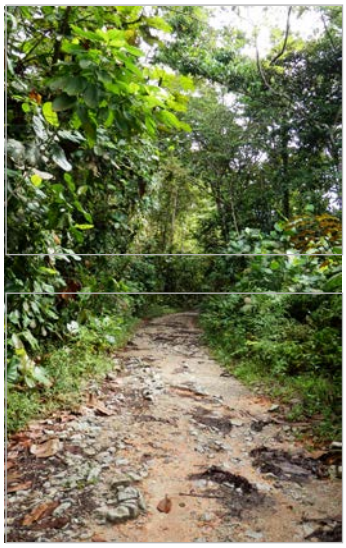







Land Transport Authority

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

**SITE INVESTIGATION ENVIRONMENTAL IMPACT ASSESSMENT REPORT – *VOLUME III, ALIGNMENT OPTION 1***

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 III, Alignment Option 1*

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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 III*** 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*

| Revision | Description | By | Checked | Approved | Date |
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Distribution

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# 1 INTRODUCTION

This Volume of the SI EIA report presents the IA and EMMP for the proposed SI of Alignment Option 1. 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 (III) is structured as follows:

- *Chapter 2* details the proposed SI works that will be undertaken for Alignment Option 1 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 1 SI works.

# 2 ALIGNMENT OPTION 1 – 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 1. The extent of the SI described in this chapter covers the proposed activities associated with the alignment from 400 m west of the PIE to Upper Thomson road to the east as illustrated on *Figure 2.1.*

The SI will involve three components[1]:

- Preliminary investigations including desktop work, site reconnaissance, geological mapping and topographical survey;
- Geophysical surveys; and
- Intrusive ground investigation[2] using various drilling techniques (ie boreholes; mackintosh probes; and horizontal directional coring).

The remainder of this chapter is structured as follows:

- *Section 2.2* details the preliminary investigations;
- *Section 2.3* outlines the geophysical surveys proposed for the Alignment Option 1 area within and in close proximity to the CCNR; and
- *Section 2.4* details the intrusive ground investigation works.

## 2.2 PRELIMINARY INVESTIGATIONS

The preliminary investigation phase will primarily consist of site reconnaissance surveys with the Contractors for familiarization of the Project area; induction training to working within and in proximity to CCNR; and to confirm the existing site conditions immediately prior to commencing the SI works. During the preliminary investigations, permits and management plans for the works will also be put in place (eg access permissions, safety planning, the LTA management plans etc).

### 2.2.1 Geological Mapping and 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 investigations.

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

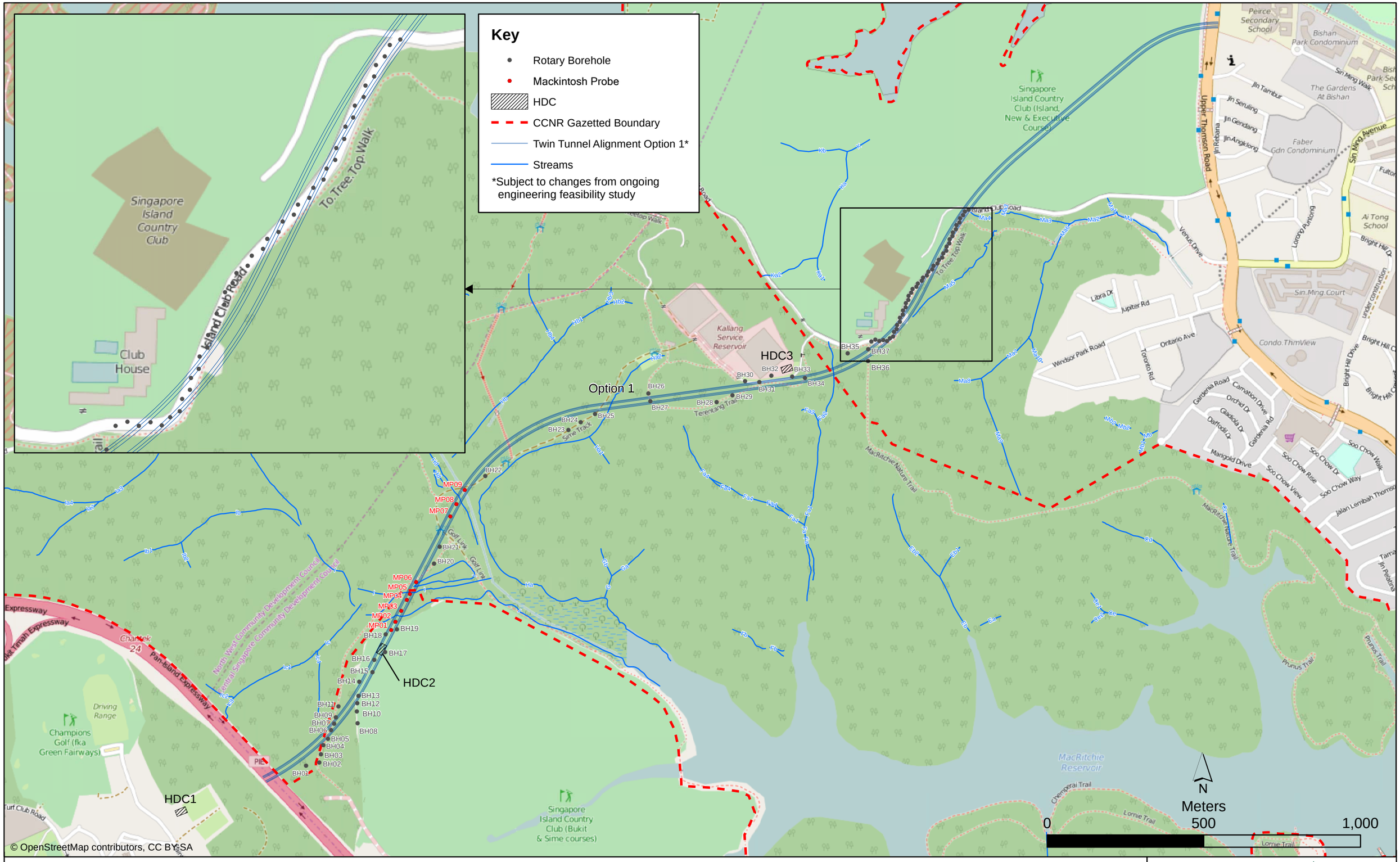


Figure 2.1 SI Locations – Alignment Option 1

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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 where accessible 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 such as the presence of overhead foliage; ground flora sensitivities such as seedlings identified during the baseline data gathering which may have developed in the interim period between the EIA and the site reconnaissance; and the presence of underground services (eg, electricity cables or gas pipes).

### *2.2.2 Topographical Survey*

The topography of the ground surface above the tunnel alignment will be surveyed for the SI works and tunnel design. As the forest cover restricts the use of conventional ground surveying techniques, existing Light Detection and Ranging (LiDAR) survey data will be utilized.

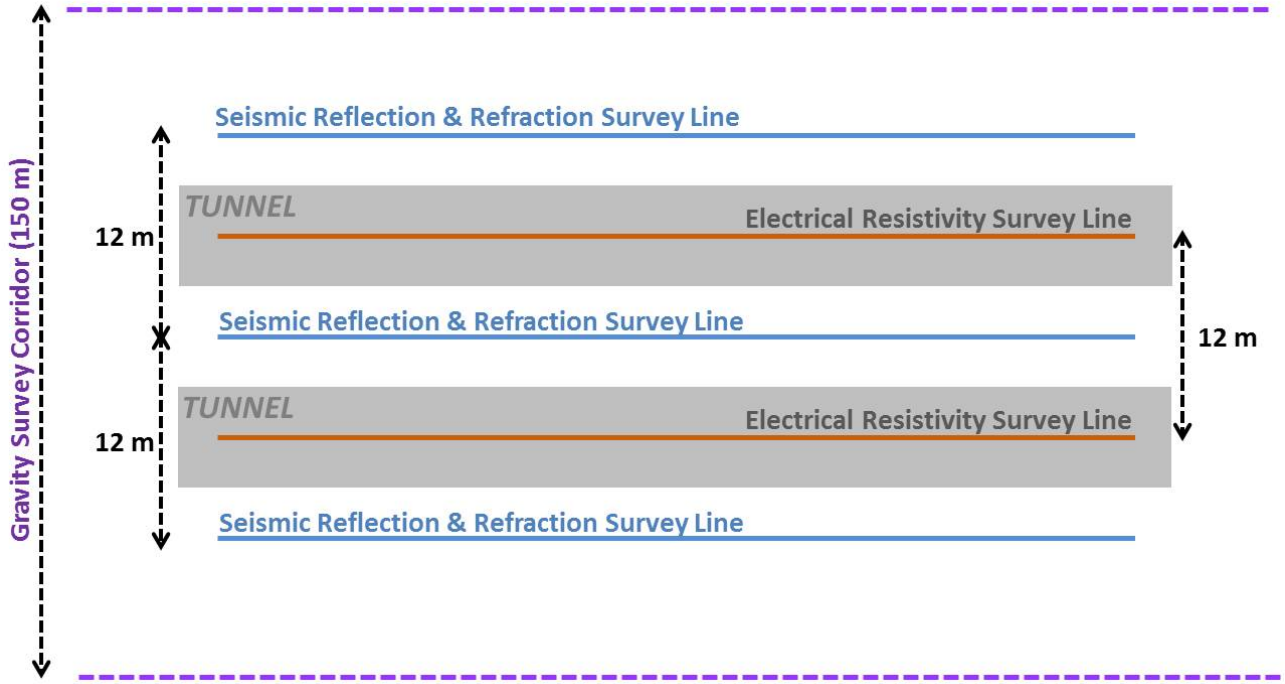
LiDAR can penetrate dense forest canopy, enabling it to capture ground surface that cannot be seen by satellites. The LiDAR unit is mounted either in a pod below a helicopter or through a hole in the fuselage of fixed wing aircraft and will require less than one day survey time in the field. At the time of writing, LTA were in consultation with the Singapore Land Authority (SLA) regarding the availability of an existing LiDAR survey of the Study Area. Spot levels of ground elevation will also be surveyed during the geophysical and rotary borehole surveys as outlined further in the subsequent subsections.

Topographic surveys of the SI locations will also need to be undertaken to support interpretation of the findings. Further details of the specific topographical survey requirements are included in the subsequent sub-sections.

## *2.3 GEOPHYSICAL SURVEYS*

Following completion of the preliminary investigations, geophysical surveys will be undertaken to locate the approximate rock head level of the Bukit Timah Granite and assess the presence of geological fracture zones along the section of Alignment Option 1 which will travel beneath the CCNR. It is common to employ two or more techniques so as to provide a correlation with the findings for each technique as well as provide coverage where changes in ground conditions favor one technique over another. In the case of the area of concern within the CCNR, a combination of seismic refraction, seismic reflection, electrical resistivity and gravity surveys will be used. The survey areas will be immediately above and in the vicinity of the tunnel alignment location where accessible within the CCNR. A schematic illustration of the preferred geophysical survey configuration is provided in *Figure 2.2* and an outline of the survey areas above Alignment Option 1 within CCNR provided in *Figure 2.3*.

***Figure 2.2: Schematic Geophysical Survey Layout***



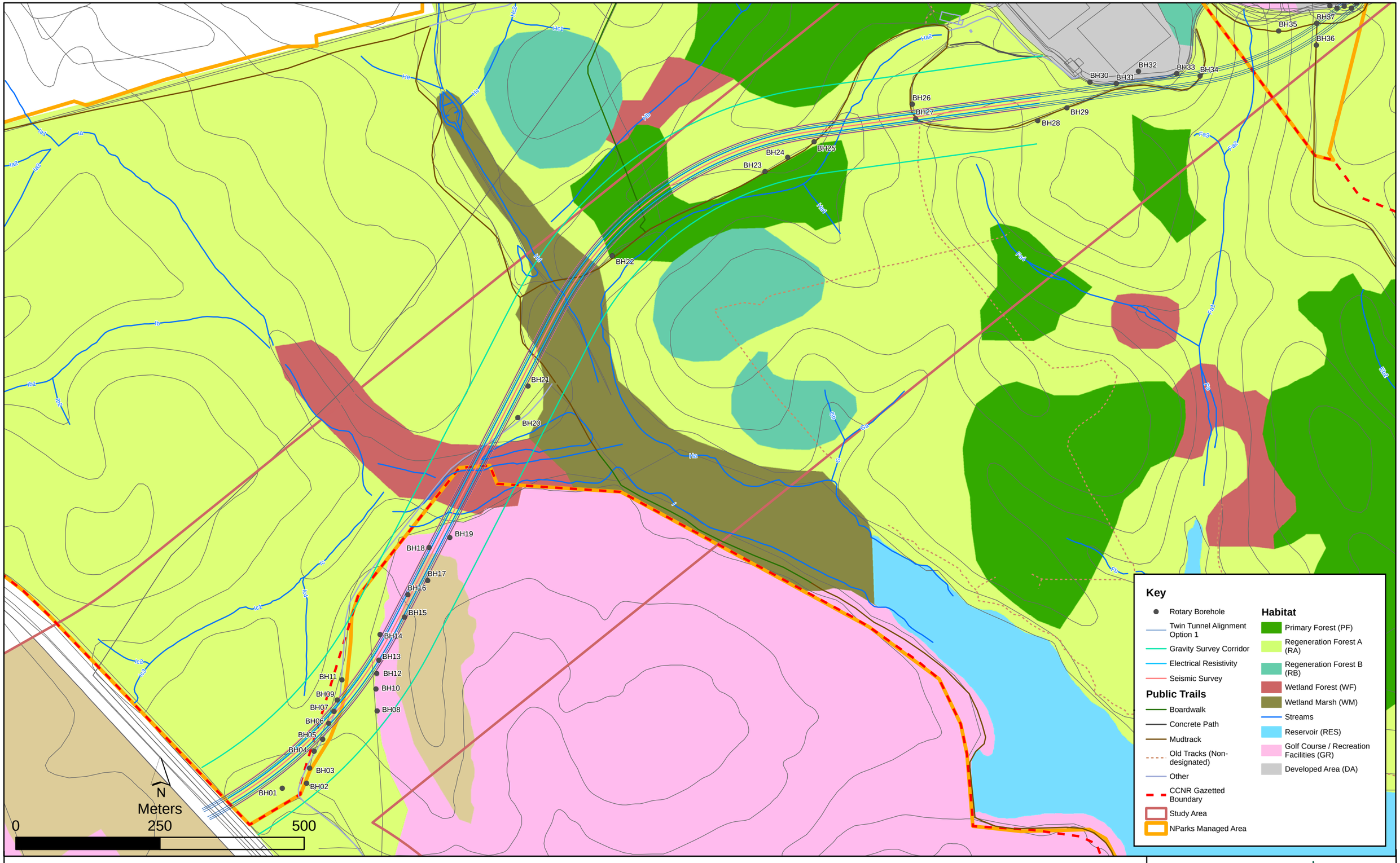



Figure 2.3 Geophysical Survey Areas

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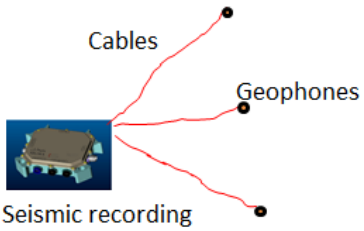
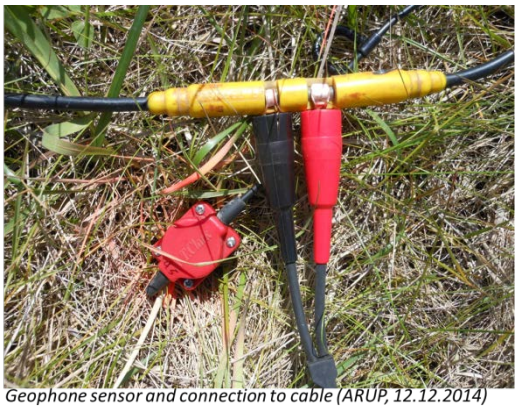
### 2.3.1 Seismic Refraction and Reflection Survey

Seismic refraction and reflection are based on sonic velocities to determine the 2D longitudinal profile of rock head. The surveys will involve setting out an array of geophones at 5 m spacing at ground level. The geophones will need to be positioned in collinear 200 m string lengths either side of and between the tunnel alignments as illustrated on *Figure 2.2*. Each string length will therefore require approximately 40 geophones (it is noted that the spacing and location of each geophone can be locally adjusted to account for access/sensitive constraints). Each geophone will be connected by a cable to a small seismic recording system. Each seismic recording system (see figure insert) can be linked to a maximum of 6 geophones. A seismic recording system weighs around 2.3 kg and will be carried by hand to the location. For the 40 numbers of geophones in each survey line approximately 14 seismic recording systems will be needed to be carried by hand into off trail areas. The seismic recording systems are then connected wirelessly to a data recorder which would be positioned nearby on the public trails. The connecting cable between the seismic recording system and the geophones does not need to be taut and can therefore be laid around physical obstructions or sensitive areas, such as trees, dense areas of vegetation etc.



Seismic recording system connected wirelessly to data recorder

During the refraction survey, seismic waves are then generated at five ground level locations along each string line. During the reflection survey, seismic waves are generated at every geophone positioned along each string line (ie up to 40 locations). The generation of seismic wave sources will comprise different methods along the alignment depending on the depth to rock head. The deeper areas to rock head will require a larger seismic source to ensure good signal return. Provisionally, two seismic source methods will be allowed for: sledge hammer (6 kg) striking a steel plate of < 0.5 $m^2$, or an accelerated drop weight (approximately 15 kg), both of which are hand held and can be manually carried to the survey locations. Up to about five or six blows are undertaken at each seismic source location to enable signal stacking and attenuation of background noise.


*Geophone sensor and connection to cable (ARUP, 12.12.2014)*


*Hand held accelerated drop weight (LTA, 17.06.15)*

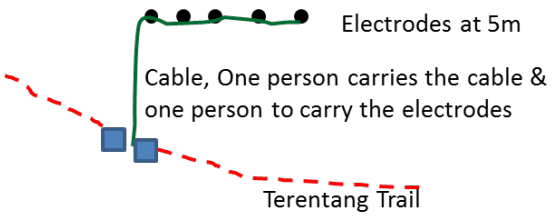
The time taken for waves to travel from the source, through the rock mass to the geophones is then measured and recorded by the data recorder located on the nearby trail. As there is a marked contrast in the velocity profile between the Grade (IV) and Grade (III) weathering profiles in granite it is anticipated that the results will identify rock head to within a few meters of its actual location.

Survey equipment (geophones, seismic source generators, geophone cables, data receivers and data recorders) are portable and will be manually carried along the trail. The off trail alignment will be located by the topographical surveyors. The geophysical surveyors will then lay out the survey equipment. Following completion of one string line (ie 200 m), the geophysicist will review the seismograph and may need to refine the geophone spread and repeat the survey. Following satisfactory completion of the refraction and reflections surveys in the accessible area, the geophones and cable will be removed and set up in the next area. Details of the resources and schedule required are outlined in *Table 2.1*.

*Example seismic refraction survey equipment (ARUP, 12.12.14)*

### 2.3.2 Electrical Resistivity

This method works by measuring an apparent resistivity of the ground. Two pairs of metal stakes will be inserted into the ground connected by a single multicore or telemetry cable with multiple take-out connection points (typically around 60 points along one 200 m cable length, spaced at ~ 5 m intervals). An electrical current will then be passed between the metal stakes from a battery power source (12 volt). Repetition of the process with different probe spacing iteratively builds up a vertical profile to a depth of approximately 60 m. This technique is anticipated to be most useful where rock head is well below the groundwater table such as underlying the CCNR, and where steep weathering zones are present as a result of a highly fractured zone or fault.


The electrical resistivity string lines will be placed immediately above each tunnel alignment as illustrated on *Figure 2.2*. Personnel required and the indicative schedule are outlined in *Table 2.1*.

### 2.3.3 Gravity Survey

The gravity survey involves taking precise measurements at ground surface of the earth's gravitational acceleration (measured in gals) using a gravimeter at gridded survey locations. Measurement locations will be on an approximate 15 m grid spacing over a corridor approximately 150 m wide centered on the alignment. This equates to collection of up to approximately 1,200 readings within the CCNR. The gravimeter is a hand held

*Gravimeter (ARUP, 12.12.14)*

piece of equipment which can simply be placed on the ground. Measurements will take approximately 5 minutes at each location and will be recorded digitally for data interpretation. Personnel required and the indicative schedule are outlined in *Table 2.1*.

### 2.3.4 Survey of Geophysical Investigation Locations

The geophysical survey measurement locations need to be determined to enable accurate collation and review of the data gathered. Surveying will be carried out using GPS system or conventional method of traversing using compass and measuring tape. The topographic surveyors will accompany the field team throughout the survey, to aid initial identification of the survey area, and then survey each location during the geophysical surveys.

### 2.3.5 Geophysical Survey Resources and Schedule

All equipment associated with the geophysical surveys will be hand held and manually carried into the CCNR to the survey locations. The surveys will be scheduled between 09.00 and 17.00, from Monday to Friday, in accordance with NParks requirements. Demobilization each day will generally be between 17.00 and 18.00. It is noted that some of the survey equipment (eg, the geophones and cables) will need to remain set up in the field overnight to allow for repeat surveys in the instance that further measurements need to be taken. No sensitive recording equipment (eg the gravity survey meter, seismic recording system, accelerated drop weight etc) will however be left at the survey locations overnight and will be removed from CCNR. Equipment, including string lines, are not expected to be left at any one location for longer than two nights or three days. An estimate timescale of each survey technique along with accompanying clearance and topographical surveying time is provided in *Table 2.1* and will form the basis of the impact assessment presented herein.

***Table 2.1: Geophysical Field Survey Resources and Schedule***

| Geophysical Survey | Equipment (all dimensions in mm) | Number Personnel Required | Duration |
|---|---|---|---|
| Topographic Surveys | ▪ Controller (200(W) x 120 (L) x 45 (H) and 0.6kg)<br>▪ Receiver (196 (W) x 198 (H) and 3.3 kg) | x2 surveyors | Will be present throughout the geophysical survey to aid identification of the survey area and survey all locations.<br>Up to 1 hour envisaged for initial site reconnaissance.<br>Approximately 5 minutes estimated to survey each geophysical survey location. |
| Seismic Refraction and Seismic Reflection Surveys | ▪ Geophones (40(W) X 50(L) x 140(H) and 90g)<br>▪ Cables (15(W) and 25-30 Kg))<br>▪ Seismic source (6 kg or 15 kg)<br>▪ Data recorder | x3 seismic refraction and reflection surveyors | *Refraction & Reflection (undertaken concurrently)*<br>▪ Up to 4 days for 1 string line of 200 m length (includes mobilization, set up, survey, topographic survey, and equipment demobilization)<br>▪ Total duration for alignment within CCNR (~1.8 km), up to 108 days (4 days x 9 string lines x 3 lines) |

| Geophysical Survey | Equipment (all dimensions in mm) | Number Personnel Required | Duration |
|---|---|---|---|
| Electrical Resistivity | ▪ Geophones 40(W) X 50(L) x 140(H)<br>▪ Cables (15(W) and 25-30 Kg))<br>▪ Voltmeter<br>▪ Battery (290 (W) x 330(L) x 100(H) and 8kg | X3 electrical resistivity surveyors | ▪ Up to 3 days for 1 string line of 200 m length (includes mobilization, set up, survey, topographic survey, and equipment demobilization)<br>▪ Total duration for alignment within CCNR (~1.8 km), up to 54 days (3 days x 9 string lines x 2 lines) |
| Gravity | ▪ Gravimeter (210(W) x 220(L) x 300(H) and 8 kg) | x2 gravity surveyors | ▪ 15 minutes per location (includes mobilization to each location, set up, survey (5 minutes per reading), topographic survey, and equipment demobilization)<br>▪ Total duration for geophysical survey corridor, 43 days |

## 2.4 INTRUSIVE GROUND INVESTIGATION

The intrusive investigation proposed for Alignment Option 1 will involve completion of borings using three techniques, mackintosh probes; rotary boreholes; and horizontal directional coring. The indicative location of the proposed boreholes (illustrated on *Figure 2.1)*, have been selected taking the following into account: aim to be above or in close proximity to Alignment Option 1; utilizing accessible and vegetation free areas such as the public trails, access roads and golf courses; target key areas of concern, eg, where there may be a fault line; and at distance from surface water streams. The assessment assumes that the geophysical surveys will be undertaken at the same time as the intrusive ground investigation works.

### 2.4.1 Mackintosh Probes

Dynamic probing is a simple and quick soil penetration test which involves driving a lightweight metal tipped probe (known as a Mackintosh Probe) into the ground to the final penetration depth. All equipment (see photograph insert) is portable and will require two personnel to carry and operate. Typically a drop weight (approximately 4 kg) of fixed mass and travel is used to drive the probe into the ground. The blow counts and penetration depth are then used to assess the strength of the surface

*Mackintosh Probe (ARUP, 21.01.15)*

soils. Up to nine (MP01 – MP09) borings using a Mackintosh Probe will be undertaken at locations immediately above Alignment Option 1, north and north east of the Bukit golf course (*Figure 2.1 and Table 2.2*). The locations within the CCNR have been selected where access constraints and environmental sensitivities will limit the use of a conventional drilling rig.

***Table 2.2: Mackintosh Probe Locations***

| Reference | Easting | Northing | Depth (m) | Installation | Field Testing & Sampling |
|---|---|---|---|---|---|
| MP01 | 24811.400 | 36768.300 | 15 | - | MP, D |
| MP02 | 24825.100 | 36794.800 | 15 | - | MP, D |
| MP03 | 24843.600 | 36830.600 | 15 | - | MP, D |
| MP04 | 24861.500 | 36865.300 | 15 | - | MP, D |
| MP05 | 24874.800 | 36891.100 | 15 | - | MP, D |
| MP06 | 24891.000 | 36922.600 | 15 | - | MP, D |
| MP07 | 24999.900 | 37130.600 | 15 | - | MP, D |
| MP08 | 25019.800 | 37171.300 | 15 | - | MP, D |
| MP09 | 25046.300 | 37215.300 | 15 | - | MP, D |

***Notes:*** MP: Mackintosh Probe; **D**: Disturbed Samples

### *2.4.2 Rotary Boreholes*

Up to 16 rotary boreholes (BH01, BH20 – BH34) as illustrated on *Figure 2.1* will be completed along the alignment section within the CCNR using either a crawler mounted A-frame or Deltabase 520 (DB520) drilling rig (or a rig with similar specifications to the DB520). 10 of these rotary boreholes are located on the existing trails within CCNR (Sime and Terentang Trails); while 2 rotary boreholes (BH01 and BH21 are located slightly off trail but within existing clearings in the CCNR; and 4 rotary boreholes are located on the Kalang Service Reservoir Road off Island Club Road. The rotary borehole locations and the anticipated field testing in each borehole within the CCNR are detailed in *Table 2.3* while information on the techniques are provided *in Table 2.6*.

The location and number of boreholes outside the CCNR (ie from the CCNR boundary north east to Upper Thomson) will initially be based on LTA's standard 25 m spacing, with the exception of the alignment section at Windsor Interim Green; the section dissecting the SICC Island Golf Club to the east; and the area dissecting the north of the SICC Bukit Golf Course. Only three boreholes will be located in Windsor Interim Green (BH35, BH36, BH37) while eighteen (18) boreholes (BH02 – BH19) will be located outside CCNR in the northern part of Bukit Golf Course (BH08, BH10, BH12 – BH19) and along Sime Trail (BH02-BH07, BH09 and BH11). At a later stage in the engineering design, the number and location of geotechnical boreholes outside the CCNR (draft illustration outlined in *Figure 2.1*) will then be refined and finalized to account for: access restrictions; utilities; presence of buildings/structures/roads; and environmental sensitivities identified in the EIA (eg, trees). The exact number, location and indicative drilling schedule of the boreholes outside the CCNR, is not therefore finalized and the locations outlined in *Figure 2.1* assumed for the purpose of this SI EIA.

***Table 2.3: Rotary Borehole Locations within CCNR***

| Reference | Easting | Northing | Depth (m) | Installation | Field Testing & Sampling |
|---|---|---|---|---|---|
| BH01 | 24539.900 | 36337.300 | 70 | WSP or PZS | SPT,UD, PMT |
| BH20 | 24948.400 | 36980.600 | 80 | WSP or PZS | SPT,UD, PKT, PMT |
| BH21 | 24966.000 | 37035.200 | 80 | WSP or PZS | SPT,UD, PKT, PMT |
| BH22 | 25112.090 | 37260.890 | 80 | WSP or PZS | SPT,UD, PKT, PMT |
| BH23 | 25377.100 | 37407.300 | 90 | - | SPT,UD |
| BH24 | 25416.400 | 37431.700 | 90 | WSP or PZS | SPT,UD, PMT |
| BH25 | 25462.100 | 37458.700 | 90 | WSP or PZS | SPT,UD, PKT, PMT |
| BH26 | 25632.600 | 37524.000 | 90 | - | SPT,UD |
| BH27 | 25638.400 | 37498.900 | 90 | WSP or PZS | SPT,UD, PKT, PMT |
| BH28 | 25850.200 | 37495.800 | 100 | - | SPT,UD |
| BH29 | 25900.700 | 37517.500 | 100 | WSP or PZS | SPT,UD, PKT, PMT |
| BH30 | 25940.800 | 37562.400 | 100 | - | SPT,UD |
| BH31 | 25986.300 | 37559.800 | 100 | WSP or PZS | SPT,UD, PKT, PMT |
| BH32 | 26024.800 | 37581.200 | 100 | - | SPT,UD |
| BH33 | 26091.200 | 37576.900 | 100 | WSP or PZS | SPT,UD, PKT, PMT |
| BH34 | 26131.600 | 37572.900 | 100 | WSP or PZS | SPT,UD, PKT, PMT |

***Notes:***

- **BH**: Borehole (Soil boring, with rotary core follow-on. Rotary coring to consist of triple barrel coring, with a minimum core diameter of 54mm, maximum diameter of 100 mm)
- **WSP**: Water Standpipe
- **PZS**: Piezometer Standpipe
- **UD**: Undisturbed samples (Every 2 m or there is a soil change until rock head)
- **SPT**: Standard Penetration Test (Conducted at 2 m intervals until rock head)
- **PKT**: Packer Test
- **PMT:** Permeability Test (Rising Head tests to be completed in WSP. The proposed monitoring durations are as follows: 0, 5, 10, 20, 30, 60 minutes, 2 hours, daily for 1 week, twice a week for 2 weeks or until equilibrium is achieved)

The tentative drilling sequence for boreholes located within CCNR is presented in *Table 2.4* and *Table 2.5*. Given the proximity of boreholes within Bukit Golf Course and in Windsor Interim Green to CCNR, some of the drilling works in these areas will be scheduled concurrently and is also detailed in *Table 2.4* and *Table 2.5*. The aim will be to undertake the works to the west of CCNR and within Bukit Golf Course first, prior to moving easterly to complete the boreholes on Sime trail and then Terentang trail and Windsor Interim Green. This purpose of aiming to complete the works as much as possible within each area before moving to the next, is to limit disturbance of fauna movement around the CCNR.

***Table 2.4: Indicative Drilling Sequence and Access Routes for Rotary Rigs and Ancillary Vehicles within CCNR, Windsor Interim Green and Sime Trail outside CCNR***

| Sequence | Borehole ID | Rig Mobilization (demobilization via same Route) | Ancillary Equipment Transportation Method [1] | Water Delivery / Wastewater Removal Method [2] |
|---|---|---|---|---|
| 1 | BH01 | Sime Road - Bukit Golf Course Road - Sime Trail | Lorry crane to access Sime Trail from Bukit Golf Course Road and then drive t to BH01 worksite. (3 point turn to be completed outside CCNR) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH02 | Sime Road - Sime Trail (West) | Lorry crane to access Sime Trail from Bukit Golf Course Road and then drive to BH02 worksite. (3 point turn to be completed outside CCNR) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH08* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | Water transport and wastewater collection bowser along Bukit Golf Course Road and through Bukit Golf Course, subject to detailed discussion with SICC |
| 2 | BH03 | Sime Road - Sime Trail (West) | Manually carried from BH02 along Sime Trail west (approximately 30m) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH10* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| | BH12* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| 3 | BH04 | Sime Road - Sime Trail (West) | Manually carried from BH03 along Sime Trail west (approximately 30m) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH13* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| | BH14* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| 4 | BH05 | Sime Road - Sime Trail (West) | Manually carried from BH04 along Sime Trail west (approximately 40m) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH15* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| | BH16* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to Detailed discussion with SICC | - |

| Sequence | Borehole ID | Rig Mobilization (demobilization via same Route) | Ancillary Equipment Transportation Method [1] | Water Delivery / Wastewater Removal Method [2] |
|---|---|---|---|---|
| 5 | BH06 | Sime Road - Sime Trail (West) | Manually carried from BH05 along Sime Trail west (approximately 40m) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH17* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to SICC approval | - |
| | BH18* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| 6 | BH07 | Sime Road - Sime Trail (West) | Manually carried from BH06 along Sime Trail west (approximately 40m) | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH19* | Bukit Golf Course Road - Bukit Golf Course | Cabstar/lorry crane accessing via Bukit Golf course route subject to detailed discussion with SICC | - |
| | BH30 | Island Club Road - PUB Service Reservoir Road | Lorry crane lifting equipment from PUB Service Reservoir Road to BH30 worksite | Water transport and wastewater collection bowser along PUB Service Reservoir Road |
| 7 | BH11 | Sime Road - Sime Trail (West) | Manually carried from BH07 along Sime Trail west (approximately 60m) | S25A along Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail west |
| | BH09 | Sime Road - Sime Trail (West) | Cabstar lorry accessing Sime Trail from Sime Trail (west) and manually lifting equipment from Cabstar lorry to BH09 from BH19 worksite. | S25A along Sime Road - Bukit Golf Course Road - Sime Trail west |
| | BH31 | Island Club Road - PUB Service Reservoir Road | Lorry crane lifting equipment from PUB Service Reservoir Road to BH31 worksite | Water transport and wastewater collection bowser along PUB Service Reservoir Rd |
| 8 | BH33 | Island Club Road - PUB Service Reservoir Road | Lorry crane lifting equipment from PUB Service Reservoir Road to BH33 worksite | Water transport and wastewater collection bowser along PUB Service Reservoir Road |
| | BH32 | Island Club Road - PUB Service Reservoir Road - PUB Kalang Reservoir Compound | Lorry crane lifting equipment to adjacent to PUB Kalang Service Reservoir Compound and then drive to BH32 worksite | Water transport and wastewater collection bowser along PUB Service Reservoir Road |
| | BH20 | Sime Road - Sime Trail (West) | Use a S25A vehicle or similar to transport equipment from BH11 worksite along Sime Trail west (approximately 650m) | S25A along Sime Road - Sime Trail west |
| 9 | BH21 | Sime Trail (West) from and Sime Road | Manually carried from BH20 along Sime Trail west (approximately 60m) | S25A along Sime Road - Sime Trail west |
| | BH22 | Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail | Use a S25A vehicle or similar to transport equipment from BH32 worksite along Sime Trail | S25A along Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail |
| | BH35 * | Island Club Road - MacRitchie Nature Trail | Lorry crane lifting equipment from Island Club Road onto MacRitchie Nature Trail and manually carried to BH35 worksite | S25A along Island Club Road - MacRitchie Nature Trail |

| Sequence | Borehole ID | Rig Mobilization (demobilization via same Route) | Ancillary Equipment Transportation Method [1] | Water Delivery / Wastewater Removal Method [2] |
|---|---|---|---|---|
| 10 | BH23 | Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail | Manually carried from BH22 along Sime Trail (approximately 300 m) | S25A along Sime Trail West – Sime Trail |
| | BH24 | Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail | Use a S25A vehicle or similar to transport equipment from BH21 worksite along Sime Trail (from BH21 to exit via Sime Trail West using Cabstar lorry and enter via Terentang Trail using S25A vehicle or similar) | S25A along Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail |
| | BH36* | Island Club Road - MacRitchie Nature Trail | Manually carried from BH35 (approximately 90 m) | S25A along Island Club Road - MacRitchie Nature Trail |
| 11 | BH26 | Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail | Use a S25A vehicle or similar to transport equipment from BH24 worksite along Sime Trail (approximately 550m) | S25A along Island Club Road - PUB Service Reservoir Road - Terentang Trail |
| | BH25 | Island Club Road - PUB Service Reservoir Road - Terentang Trail - Sime Trail | Manually carried from BH23 along Sime Trail (approximately 90m) | S25A along Sime Trail West – Sime Trail |
| | BH37 * | Island Club Road - MacRitchie Nature Trail | Manually carried from BH36 (approximately 40 m) Demobilization of equipment from BH37 worksite by lorry crane positioned on Island Club Road | S25A along Island Club Road - MacRitchie Nature Trail. |
| 12 | BH28 | Island Club Road - PUB Service Reservoir Road - Terentang Trail | Manually carried from BH26 along Terentang Trail (approximately 225 m) | S25A along Island Club Road - PUB Service Reservoir Road - Terentang Trail |
| | BH27 | Island Club Road - PUB Service Reservoir Road - Terentang Trail | Manually carried from BH25 along Terentang Trail (approximately 525 m) | S25A along Sime Trail West – Sime Trail – Terentang Trail |
| 13 | BH34 | Island Club Road - PUB Service Reservoir Road - Terentang Trail | Manually carried from BH28 along Terentang Trail (approximately 300 m) | S25A along Island Club Road - PUB Service Reservoir Road - Terentang Trail |
| | BH29 | Island Club Road - PUB Service Reservoir Road - Terentang Trail | Manually carried from BH27 along Terentang Trail (approximately 250 m) | S25A along Sime Trail West – Sime Trail – Terentang Trail |

***Notes:***

[1] *Frequency* - During mobilization to each borehole worksite and demobilization from each borehole worksite

[2] *Frequency* - 2 round trips - during day of mobilization of rig and ancillary equipment to each borehole worksite;
- per day throughout rig operations; and - on day of demobilization from each borehole worksite

* borehole locations within Bukit Golf Course and Windsor Interim Green, outside gazetted CCNR boundary

***Table 2.5: Indicative Borehole Schedule Assuming Works Commence March 2016)***

| Month | Mar-16 | | | | Apr | | | | | May | | | | Jun | | | | Jul | | | | | Aug | | | | Sep | | | | | Oct | | | | Nov | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (week ending) | 4 | 11 | 18 | 25 | 1 | 8 | 15 | 22 | 29 | 6 | 13 | 20 | 27 | 3 | 10 | 17 | 24 | 1 | 8 | 15 | 22 | 29 | 5 | 12 | 19 | 26 | 2 | 9 | 16 | 23 | 30 | 7 | 14 | 21 | 28 | 4 | 11 | 18 | 25 |
| Number Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| BOREHOLES | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH01 - CCNR | Rig 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH02 - CCNR | Rig 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH08 - SICC BGC | Rig 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH03 - CCNR | | | | Rig 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH10 - SICC BGC | | | | Rig 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH12 - SICC BGC | | | | Rig 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH04 - CCNR | | | | | | | Rig 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH13 - SICC BGC | | | | | | | Rig 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH14 - SICC BGC | | | | | | | Rig 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH05 - CCNR | | | | | | | | | | Rig 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH15 - SICC BGC | | | | | | | | | | Rig 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH16 - SICC BGC | | | | | | | | | | Rig 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH06 - CCNR | | | | | | | | | | | | | Rig 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH17 - SICC BGC | | | | | | | | | | | | | Rig 2 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH18 - SICC BGC | | | | | | | | | | | | | Rig 3 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BH07 - CCNR | | | | | | | | | | | | | | | | Rig 1 | | | | | | | | | | | | | | | | | | | | | | | |
| BH19 - SICC BGC | | | | | | | | | | | | | | | | Rig 2 | | | | | | | | | | | | | | | | | | | | | | | |
| BH30 - KSR | | | | | | | | | | | | | | | | Rig 3 | | | | | | | | | | | | | | | | | | | | | | | |
| BH09 - CCNR | | | | | | | | | | | | | | | | | | Rig 1 | | | | | | | | | | | | | | | | | | | | | |
| BH11 - CCNR | | | | | | | | | | | | | | | | | | Rig 2 | | | | | | | | | | | | | | | | | | | | | |
| BH31 - KSR | | | | | | | | | | | | | | | | | | Rig 3 | | | | | | | | | | | | | | | | | | | | | |
| BH20 - CCNR | | | | | | | | | | | | | | | | | | | | | | Rig 1 | | | | | | | | | | | | | | | | | |
| BH32 - KSR | | | | | | | | | | | | | | | | | | | | | | Rig 2 | | | | | | | | | | | | | | | | | |
| BH33 - KSR | | | | | | | | | | | | | | | | | | | | | | Rig 3 | | | | | | | | | | | | | | | | | |
| BH21 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | Rig 1 | | | | | | | | | | | | | | |
| BH22 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | Rig 2 | | | | | | | | | | | | | | |
| BH35 - Windsor | | | | | | | | | | | | | | | | | | | | | | | | | Rig 3 | | | | | | | | | | | | | | |
| BH23 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 1 | | | | | | | | | | | | |
| BH24 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 2 | | | | | | | | | | | | |
| BH36 - Windsor | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 3 | | | | | | | | | | | | |
| BH25 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 1 | | | | | | | | |
| BH26 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 2 | | | | | | | | |
| BH37 - Windsor | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 3 | | | | | | | | |
| BH27 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 1 | | | | | |
| BH28 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 2 | | | | | |
| BH29 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 1 | | |
| BH34 - CCNR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | Rig 2 | | |

Outside the CCNR up to four drilling rigs may be operational concurrently with the exception of BH02-BH07, BH09 and BH11 along Sime Trail. Due to the ancillary vehicle needs, access constraints and proximity to CCNR boundary, it is anticipated that BH02-BH07, BH09 and BH11 will be undertaken sequentially following completion of BH20 (refer to *Table 2.5* for BH20 schedule). Ancillary equipment will be transported to BH11 using a Cabstar and then manually moved between BH11, BH09, BH07 – BH02 before being demobilized from BH02 on Sime Trail using a Cabstar lorry. Two types of rotary drilling rig have been screened[1] for consideration in the SI EIA, a crawler mounted A-Frame and a DB 520. The specifications of each drilling rig are provided in *Table 2.6*.

***Table 2.6: Crawler Mounted A-Frame and Deltabase 520 Drilling Rig Specifications***

| Item | Crawler Mounted A-Frame Drilling Rig | Deltabase 520 Drilling Rig |
|---|---|---|
| |  |  |
| Mobilisation Speed | Up to 1.5 km /hr | 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<br><br>(axel to axel width 1.3 m) | 2.24 m long x 1.9 m wide / 2.5 m high<br><br>(mast protrudes to make total length during mobilization 4.5 m. Mast can be erected during mobilization of smaller radius corners) |
| Extended mast height | 7 m | 7.35 m |
| Weight | Approximately 2 tons | Approximately 6.5 tons |
| Worksite footprint during operation | 2 m x 11 m<br><br>Maximum worksite required for: rig, drilling rods; hydraulic fluid; water bowser; waste water bowser; pumps; mud tub; 2/3 operators; loading/unloading area for refilling water bowsers and removal of wastewater. | 2.2 m x 13 m<br><br>Maximum worksite required for: rig, water bowser; waste water bowser; mud tub; 2/3 operators; loading/unloading area for refilling water bowsers and removal of wastewater.<br><br>Note: drilling rods, hydraulic fluid *etc* stored on the DB520. |
| Fuel type | Diesel | Diesel |
| Motor Size | 10 - 15 kW | 53 – 72 KW |
| Drilling Type | Rotary | Hollow stem auger for overburden<br>Rotary through rock |
| Rate of drilling | 15 m/day for SPT borings.<br>5-7m/day for rock coring.<br>(depends on ground conditions encountered) | 30 m/day for SPT borings.<br>10-12 m/day for rock coring.<br>(depends on ground conditions encountered) |
| Manpower Required | 4-5 for mobilization/demobilization & set up<br>3-4 for operation | 3-4 mobilization/demobilization & set up<br>2-3 for operation |
| Maintenance | Monthly maintenance required – will be undertaken on site with drip trays. | Monthly maintenance required – will be undertaken on site with drip trays. |
| Other | • Ancillary vehicle required during mobilization/demobilization for transport of pumps, generator and drill rods and casing, drip | • Hydraulic pump built into rig.<br>• Exhaust emission compliance with DEUTZ |

| Item | Crawler Mounted A-Frame Drilling Rig | Deltabase 520 Drilling Rig |
|---|---|---|
| | tray for motor, customized fluid containment tank, standard penetration test hammer, fluid containment tank, metal tubes for undisturbed samples, core barrel and boxes.<br>• Ancillary vehicle also required for daily transport of fresh water and wastewater removal from each borehole worksite location.<br>• Refueling is carried out with piston pumps and no fuel is stored within the CCNR. Valves will be included on the refueling pipework to limit leaks/spills during refueling process. | D914L04 air cooled engine and EU Stage IIIA/ US EPA Tier 3.<br>• Customized fluid containment tank used at borehole surface. Ancillary equipment can be transported on rig itself.<br>• Ancillary vehicle required for daily transport of fresh water and wastewater removal from each borehole location.<br>• Built in environmental management features include environmental oil in hydraulic system; fire suppression and mist pump for dust suppression |

### *Mobilization*

Prior to mobilization, all drilling and mobilization equipment will have a comprehensive maintenance inspection and cleaning (decontaminated). Typical ancillary equipment that will need to be mobilized to each rotary borehole worksite 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 (3 m lengths requires 24 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
- Fluid containment tank for drilling slurry.

All the rotary boreholes will be located on publicly accessible areas or on the golf course. Mobilization will therefore be via the nearest accessible road; MacRitchie Nature Trail; or within the CCNR along the Sime Track, Golf Link and Terentang public trails. Within CCNR, BH22 – BH29 and BH 34 will be accessed via Terentang Trail from the Kalang Service Reservoir Road. For some of these locations the S25A vehicle transporting water and removing wastewater from each borehole location will need to access the borehole via Sime Road and Sime Trail from the west; while BH01, BH20 and BH21 will be accessed through the Bukit Golf Course, along Sime Trail. Further details of the access routes to each worksite within CCNR and the proposed drilling sequence are provided in *Table 2.4.* For areas outside CCNR, access will be via public roads or private roads; MacRitchie Nature Trail (in the case of BH35-BH37) and tracks within the SICC golf courses.

Both drilling rigs are fitted on crawlers and have the capability to be driven along the aforementioned trails to each worksite. In addition to a rig mobilizing to each worksite, the ancillary equipment will be transported to each worksite along Alignment Option 1 as follows:

- BH01, BH20, BH21, BH22 – BH29, and BH34 – BH37: Given the off road conditions ancillary equipment will be transported using a combination of methods depending on the access conditions, ie manually carried by the drilling contractors; use of a S25A vehicle, Cabstar lorry; or, outside of the CCNR, a lorry crane. Key specifications of the S25A, Cabstar lorry and lorry crane used to transport ancillary equipment are provided in *Table 2.7*, while details of the route each vehicle will take to the worksites are provided in *Table 2.4*; and

- BH30 - BH33 and boreholes along Island Club Road, through Island and Bukit golf courses: standard lorry crane vehicle.

***Table 2.7: Ancillary Vehicle Specifications***

| Item | Ancillary Vehicles | | |
|---|---|---|---|
| | S25A or equivalent | Lorry Crane (outside forested areas only) | Cabstar Lorry |
| |  |  <br>PK50002 EHC Hino (Crane)<br>HINO E13-TM (Lorry) |  <br>Cabstar 300 |
| Mobilization Speed | Up to 11 km/hr | Up to 100 km/hr | 140 km/hr |
| Footprint of vehicle / Vehicle height during mobilization | Crawler footprint: 1.96 m long x 1.775 m wide<br>Vehicle Height: 1.685 m (without roll over protective structure); or 2.37 m (with roll over protective structure) | Footprint: 10.685 long x 2.5 m wide<br>Vehicle Height: 3.9 m | Footprint: 4.69 m long x 1.695 m wide<br>Vehicle Height: 1.99 m |
| Weight | Up to 2,430 kg | Curb weight, including weight of crane: 14,825 kg | Curb weight: 1,760 – 1,780 kg |
| Trips required on trail for CCNR rotary borehole worksite locations | 2 round trips per day during rotary borehole operations for transportation of water/wastewater<br><br>If required to transport ancillary equipment to and from worksites, 5-10 round trips per day estimated. | Used along Sime Road, through Bukit Golf Course Road and Sime Trail only to transport ancillary equipment to BH01 worksite, and for mobilization of equipment to boreholes along Island Club Road and through Island Club golf course (*refer to Table 2.5*). | Used along Sime Road, through Bukit Golf Course and Sime Trail only to transport ancillary equipment to BH20 and BH21 worksite (*refer to Table 2.5*) |
| Fuel type | Diesel | Diesel | Diesel |
| Motor Size | 34 kW (46 horsepower) | 3102 kW (410 horsepower) | 81 kW (108 horsepower) |
| Maximum load | 2,500 kg | Gross vehicle weight: 35,000 kg | Gross vehicle weight: 3,500 kg |
| Ground Pressure | Loaded: 5.5 psi (38.2 kPa)<br>Unloaded: 2.7 Psi (18.4 kPa) | Not specified | Not specified |
| Manpower Required | x1 for operation<br>X2 for loading/unloading | x1 for operation<br>X2 for loading/unloading | x1 for operation<br>X2 for loading/unloading |
| Other | Turning point not required | Turning point required | Turning point required |

At all times during movement of rigs between all borehole worksites, the rig mast will remain lowered. Turning points, if required, will be established during the preparatory works and development of the detailed drilling program. The preliminary program outlined however, has been developed so no turning points will be required, with the exception of at the Kalang Service Reservoir. Within the CCNR, turning points will likely be at the NParks ranger station and trail junctions. Access to the proposed worksites by the rigs and ancillary vehicles may have some overhanging branches which will be temporarily tied back or cut (cutting will only be undertaken if tying the branches is not possible and will be undertaken in conjunction with NParks). This will also be identified during the site reconnaissance (*Section 2.2.1*) and undertaken in conjunction with NParks requirements, prior to mobilization along the trails.

### *Set up*

The worksite will initially be cleared of utilities and demarcated for safety purposes; an erosion control blanket (ECB) will then be positioned at the work site and the fluid containment tank (FCT) and rig placed into position. All ancillary equipment to be positioned on ECB within each worksite only (ie, lockable steel container, water, pump, water storage and wastewater collection tanks, drill rods, spill kits).

For rotary borehole locations within the CCNR and in proximity to the Island Golf Course, the rig will be positioned so that is on the public trail, with the exception of BH01 and BH21 which are located slightly off trail but within clearings. No ground clearance for rig and equipment mobilization/demobilization and rig operations will be undertaken. For safety reasons, the access route and trail in proximity to each worksite will be temporarily closed during the rotary drilling works. Appropriate “No Entry” signs will be put up to inform public of the trail closures.

As noted, for safety reasons the access route and trail in proximity to some worksites will be temporarily closed during the rotary drilling works within CCNR. Trail diversion will not be required for the operation of the drilling rigs at BH35, 36 and 37 as the section of trail in these areas is relatively wide. It is anticipated that visitors will be able to walk around the drillings rigs without encroaching on vegetated areas at the sides of the trail.

A diversion plan will be put in place throughout the duration of drilling at BH 26, 27, 28, 29, 31 and 34. Footfall can be diverted to Bukit Kalang Service Reservoir Road, where visitors can enter or leave the CCNR from two trails extending from along the fence of the Bukit Kalang Service Reservoir Compound. Access points will be manned to prevent people from venturing into Terentang Trail during the drilling phase. This is because the trail is particularly narrow at certain sections and visitors may not be able to walk around the rigs without trampling on vegetation at the side.

A diversion route will also be required during the drilling operations at BH 23, 24 and 25. Visitors may circumvent the rigs by using the HSBC Treetop Walk and head down Petaling Trail boardwalk. It is noted, however, the HSBC Treetop Walk is a one-way route (originating from the Ranger Station).

A full closure of Sime Trail and Petaling Trail will be required when BH22 is being drilled. Similarly, visitors may be diverted up the trail along the Ranger Station leading to the HSBC Treetop Walk only.

### *Operation and Sampling*

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 is proposed. This provisional depth will be reviewed following assessment of the topographical and geophysical surveys.

During drilling of the rotary boreholes, standard penetration tests (SPT), undisturbed and disturbed sample collection, packer tests and permeability tests will be undertaken to determine geotechnical properties of the underlying geology. The indicative ground investigation schedule is detailed in *Table 2.6*. As a minimum, the drilling contractor will undertake the drilling works in 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 boreholes will have a 20 mm piezometer 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.

A summary of the indicative timescale for mobilization, drilling set up and operation, sampling and demobilization of a rotary borehole using the A-Frame and Deltabase 520 is provided in *Table 2.8*.

***Table 2.8: Indicative Schedule for Rotary Borehole Completion***

| Activity | Crawler Mounted A-Frame Drilling Rig | Deltabase 520 Drilling Rig | Remarks |
|---|---|---|---|
| Utility clearance / site preparation | 1 day | 1 day | Includes placement of erosion control blanket |
| Mobilisation of equipment to borehole worksite and rig set up | 1 day | 1 day | |
| Drilling through soil / overburden | 2 days | 1 day | Assume 30 – 40 m depth of overburden |
| SPT tests | 1 hr/test | 1 hr/test | Typical SPTs every 2 m or approximately 17 tests per borehole. Actual test assumed use of hammer for 15 – 30 minutes. |
| Drilling through granite | 10 days | 5 days | Assume coring through 50 m of granite;<br>- A-frame drill speed 15m/day for SPT and UDs; 5-7m/day for rock coring<br>- DB520 drill speed 30 m/day for SPT and UDs; 10-12 m/day for rock coring. |
| Undisturbed sampling | 0.5 hr/test | 0.5 hr/test | Approximately 17 UD per scheduled borehole |
| Packer test | 2 hrs/test | 2 hrs /test | Approximately 5 PKT per scheduled borehole |
| Permeability test | 1 hr/test | 1 hr/test | Typical 1 PMT per scheduled borehole (after |

| Activity | Crawler Mounted A-Frame Drilling Rig | Deltabase 520 Drilling Rig | Remarks |
|---|---|---|---|
| | | | demobilization from borehole worksite) |
| Well decommissioning | 0.25 day | 0.25 day | |
| Demobilization | 1 day | 1 day | |
| Total estimated duration of rotary rig operations at each worksite, including mobilization to and demobilization from each worksite* | 18 days | 1 days | |

***Note:***
* This indicative timeframe assumes no stoppage in works due to rain or other adverse weather conditions.

### *2.4.3 Horizontal Directional Coring*

Due to the distance between rotary boreholes and potential for faults in the Project area, horizontal borings will be undertaken using horizontal directional coring (HDC) to confirm the rock strata along the proposed tunnel alignment. HDC equipment will be positioned and operated at each of the worksite locations as illustrated on *Figure 2.1* and *Table 2.9*:

- HDC1, located between the Pan Island Expressway and Fairway Drive;
- HDC2, located to the north of Bukit Golf Course; and
- HDC3, located within the Kalang Service Reservoir compound, immediately to the east of the CCNR.

***Table 2.9: Horizontal Directional Coring Locations and Sampling Schedule***

| Reference | Easting | Northing | Depth (m) | Installation | Field Testing & Sampling |
|---|---|---|---|---|---|
| HDC1 | 24141.300 | 36190.100 | - | - | PKT |
| HDC2 | 24780.300 | 36707.900 | - | - | PKT |
| HDC3 | 26073.900 | 37602.200 | - | - | PKT |

***Notes:***
- **HDC**: Horizontal Directional coring
- **PKT**: Packer Test

HDC will be undertaken after interpretation of all other ground investigations. The work site areas are expected to be 35 m by 20 m. Drilling is a continuous 24 hour operation and the duration is expected to be twenty four months for all HDC works.

### 2.4.4 Ancillary Facilities

#### Power Supply

A small generator will be required to provide power for the water pumps. As noted in *Table 2.7*, a pump is built into the DB520 rig and directly powered from the rig hydraulics. Where the A-frame rig is employed, a separate generator will be required.

#### Maintenance Oil Storage

Equipment will require some oil for maintenance purposes. During operations, a small quantity of oil will be stored within a locked cabinet (<1 liter) with secondary containment. Spill kits and secondary containment trays will also be available and used in the event that oil needs to be used during operations.

#### Equipment Refueling

Any refueling required will be carried out using piston pumps and pipes fitted with flow control valves to avoid any spillage to ground during refueling works. Spill kits and secondary containment trays will also be available and used during refueling operations. No diesel fuel will be stored at each worksite.

#### Water Supply

Water will be required for both types of drilling. Water is added to the borehole to provide lubrication, cooling of the drill bit and to aid in the removal of cuttings. The volume of water required will vary with the geology encountered and drilling method. For the purpose of the EIA, it is assumed an average of 1,000 l/d of freshwater will be required for drilling each borehole.

For all rotary borehole worksites outside CCNR, a tote tank will be positioned at each worksite to store water. Daily re-supply of water will be undertaken by bowser and small vehicle and transferred to the drilling tote tank by hose.

Water transport to each worksite within CCNR along the access trails will be undertaken by the S25A vehicle outlined in *Table 2.7*. 2 round trips of a vehicle would be required along the access trails to each worksite location per day for delivery of freshwater and removal of wastewater.

#### 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 comprise of drilling fluids, oil (from maintenance change over) and sanitary wastes.

Drilling fluids will be pumped from the FCT to a wastewater collection tote tank and removed from the worksite daily or as required. To minimize vehicle trips, waste will be collected daily and removed from each worksite by the S25A vehicle used to provide the freshwater.

Sanitary facilities for all workers will consist of portable lavatories positioned outside the CCNR. Sanitary facilities at the Ranger Station within the CCNR may also be utilized. Use of other areas within the CCNR for sanitation purposes will be strictly prohibited.

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 FCT, 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.

### 2.4.5 *Intrusive Ground Investigation Resources and Schedule*

The Mackintosh Probes, rotary boreholes, rigs and ancillary vehicles will operate in the project area between 09.00 and 17.00 in accordance with NParks requirements, while the HDC boreholes will operate 24 hours. The equipment, personnel and indicative duration of the surveys are summarized in *Table 2.11*.

***Table 2.11 Intrusive Ground Investigation Resources and Schedule***

| Ground Investigation | Primary Equipment | Number of Personnel Required | Duration (including mobilization and demobilization) |
|---|---|---|---|
| Mackintosh Probes | ▪ Mackintosh probe.<br>▪ Tripod.<br>▪ ~4.5 kg weight.<br>▪ Topographic survey equipment. | Up to 3 | Up to 5 days |
| Rotary Boreholes :<br><br>Crawler Mounted A-Frame Rig | ▪ Drilling rig.<br>▪ Drip tray for motor.<br>▪ Drill rods sufficient to reach provisional depth of 70 m (assume 24 x 3 m rods).<br>▪ Borehole casing, potentially full depth of borehole (3 m lengths requires 24 sections of casing).<br>▪ SPT hammer (1).<br>▪ Metal tubes for undisturbed samples in superficial materials (assumed 5 per hole).<br>▪ Core barrel for rock coring (1), core boxes for rock core recovery (assume 30 m coring requires 6 core boxes).<br>▪ Lockable steel container.<br>▪ Water and pump.<br>▪ Water storage and wastewater collection tote tanks.<br>▪ Fluid containment tank.<br>▪ Topographic survey equipment. | Up to 5 (per rig) | Up to 18 days per borehole<br><br>(excluding permeability test and well decommissioning) |
| Rotary Boreholes :<br><br>Deltabase 520 or similar | | Up to 3 (per rig) | Up to 12 days per borehole<br><br>(excluding permeability test and well decommissioning) |
| Horizontal Directional Coring | ▪ HDC Drilling Rig.<br>▪ Drip tray for motor.<br>▪ Drill rods.<br>▪ Borehole casing.<br>▪ Lockable steel container.<br>▪ Water and pumps.<br>▪ Water storage and wastewater collection tote tanks.<br>▪ Topographic survey equipment. | Up to 5 | Up to 24 months at each location |

# 3 WATER ENVIRONMENT

## 3.1 INTRODUCTION

This chapter presents an assessment of the potential impacts of the SI works on the surface and groundwater environment in terms of water quality within and adjacent to the Project.

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 that may have significant interactions with the water environment in the Study Area. These include mobilization of drilling rigs, transportation of waste water tanks and other equipment *etc*. Taking these into consideration along with the SI presented in *Chapter 2*, the assessment considers the following types of impact:

- Potential impacts on surface water and groundwater quality arising from site run-off during rotary borehole and HDC drilling works;
- Potential impacts on surface water and groundwater quality associated with the MP operations; and
- Cumulative impacts with committed developments in the Project area.

Impacts to groundwater quality associated with the operation of the HDC were screened out as drilling will be primarily through granite at depth and in accordance with BS and ISRM standards which have specific methodologies to limit interaction with groundwater. Similarly impacts to the water environment associated with solid and sanitary waste generation and geophysical surveys have been screened out since all solid waste (such as spoil and packaging) generated throughout the SI will be bagged and removed for disposal by a licensed third party waste contractor. Sanitary waste associated with the Project will be managed by the use of existing sanitary facilities at the ranger station and temporary sanitary facilities provided outside of the CCNR. Sanitary waste collected at the temporary sanitary facilities will be disposed of by a licensed third party waste collector. The geophysical surveys and MPs will not use hazardous materials that would interact with water resources. As a result, it is highly unlikely that surface water features and groundwater will be impacted by solid and sanitary wastes or the geophysical surveys.

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. There may also be unplanned events, such as accidents resulting in wastewater generation, which need to be considered. While this chapter focuses on the impacts to the water environment during normal operations, the resulting impacts as a

result of unplanned events are addressed in *Chapter 6, Section 6.6*. This includes assessment of uncontrolled site runoff, accidental spills during transportation, vehicle accidents and firewater.

## 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.
- The tropical climate contributes to daylight of 12 hours, of which 46% (ie 5.7 hours) of the time is sunshine with the highest UVI measured at between 11 am and 3 pm.
- Total rainfall received within the Study Area in 2013 was more than 2,900 mm, 10 % to 30% above the national average.
- MacRitchie reservoir and the streams within its catchment area form the main surface water receptors identified within the Study Area.
- Water in the reservoir was generally clear. Aquatic plants were observed on the reservoir water surface adjacent to the Bukit Golf Course.
- There are numerous small streams feeding into MacRitchie Reservoir (*Figure 4.1 in Volume II Chapter 4*) with lengths varying from 6 m to 1,350 m and widths range from 0.002 m to 6 m. These streams are perennial with measured water levels ranging from 0.02 m to 1 m during the surveys conducted in October and November 2014.
- Streams Ha, Hd, I, Ma are located within 10 m down topographic gradient of SI locations. The following physical observations of these streams were recorded during field surveys in October and November 2014:
  - The streams flow towards the south;
  - Due to the dense vegetation cover of the area, vegetation litter was in abundance in all streams;
  - Stream width ranged from 1 to 4 m while water level was measured below 0.2 m at stream Ha and ranged from 0.3 to 0.5 m at streams Hd, I and Ma;
  - Stream flow at streams Hd, I and Ma was fast and smooth, whereas at stream Ma was slow and stagnant at some point; and,
  - Water temperature ranged between 25.7 ˚C and 27.9 ˚C. Levels of pH, electric conductivity and total dissolved solids were highest in Stream Ha (ie 6.3, 100 µS/cm and 50 mg/L, respectively).

- During rainfall events, the public trails within the CCNR become stormwater drainage channels and numerous stormwater gullies traverse the Study Area. In particular gullies are abundant near

borehole locations BH 20, BH 22, BH 23, BH 24 and BH 25 (see photo insert of gully adjacent to Sime track).

- Concentrations of surface water quality indicators taken at nine locations during the baseline surveys indicated physical and chemical parameters to be well within the raw water quality standards, the *Environmental Public Health (EPH) (Quality Piped Drinking Water) Regulations, 2008* and the *World Health Organization (WHO) Guidelines for Drinking-water Quality*. Concentrations of *E.coli* were between 1 and 540 cfu/100mL.

- Groundwater is not currently abstracted for use in Singapore.

- Groundwater underlying the Study Area is anticipated to be encountered up to approximately 6 m bgs.

- Based on its shallow depth and the geological composition of surface soils, groundwater is likely to interact with surface water in the Study Area.

- 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; and

- The hydraulic conductivity of competent bedrock is likely to be low. Substantially higher hydraulic conductivity values, and therefore the potential for higher groundwater flow rates are anticipated in areas of faulted or highly fractured bedrock.

## 3.4 ASSESSMENT METHODOLOGY

For assessment of the water environment, the sensitivity and magnitude criteria outlined in *Tables 3.1* and *Table 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.<br><br>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.<br><br>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.<br><br>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.<br><br>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.<br><br>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.<br>• Discharges are expected to be well within statutory limits.<br>• Potential short-term localized 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.<br>• Discharges are expected to be within statutory limits.<br>• Potential short-term localized 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.<br>• Occasional breach(es) of statutory discharge limits (limited periods) expected.<br>• Potential localized 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.<br>• Repeated breaches of statutory discharge limits (over extended periods) expected.<br>• 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 Borehole and HDC Drilling Works

Numerous streams flowing into MacRitchie Reservoir and associated wetland areas are located within the area of influence (AOI) of Alignment Option 1. Streams and wetland areas in close proximity to the proposed rotary and HDC borehole locations may be impacted during the drilling operations. All streams, including streams Ha, Hd, I and Ma which are down gradient of the nearby borehole locations BH 20, BH 22, BH 23, BH 24 and BH 25 (as illustrated on *Figure 2.1*) are at least 30 m away from the nearest boreholes due to the buffer zone placed around the stream and wetland areas during development of the SI Strategy. To access some of the borehole locations however, rigs and vehicles transporting axillary equipment will be required to use trails which are in closer proximity to streams, for example, when travelling along Sime track. The streams and wetland areas of the Project area not only replenish the MacRitchie Reservoir, which is one of the main potable water supplies in Singapore, but also provide critical habitat to several biologically unique aquatic species, for instance the critically endangered Grey sprite (*Pseudagrion pruinosum*), the common Yellow Featherlegs (*Copera marginipes*), and Harlequin rasbora (*Trigonostigma heteromorpha*). Although groundwater abstraction and utilization is prohibited in Singapore by the *Sewerage and Drainage Act, 2001,* it is likely to interact with the surface water bodies within the Study Area and is therefore considered to be in continuity with the streams and watercourses which feed into MacRitchie Reservoir. The overall sensitivity of water resources within the AOI to the borehole drilling operations along Alignment Option 1 is therefore considered to be *High*.

The water quality of watercourses down gradient of the borehole locations and access trails may be affected by erosion and sedimentation. Given the high rainfall levels in Singapore (average 2,348 mm/yr) and the requirement for vehicles to utilize the trails and golf courses during the SI, exposed ground, such as the trails in the CCNR or golf courses, will be susceptible to erosion and runoff to watercourses. During operation of a rig within the CCNR (11- 18 days depending on the rig type and location), a vehicle will need to be mobilized and demobilized on average twice daily, to bring freshwater and remove wastewater from each borehole location as well as fuel. The transportation will be undertaken within the existing trails and some trips will pass the wetland area to the west of BH22. Freshwater delivery and wastewater collection from the HDC locations may be less frequent as a more permanent worksite with larger tanks would be set up for 24-hour operations. Nevertheless, some vehicular access to the HDC worksites via the golf course would also occur and periodically over a much longer timeframe.

In the event of rain, the trails within the CCNR can become stormwater channels. The physical presence of drilling rigs and equipment on the trails for a period of up to 18 days at each borehole location may therefore disrupt the surface runoff along the trails. This may create small erosion channels around the worksite, particularly at the edges contributing to sediment loading of stormwater runoff to streams. The presence of an ECB at each worksite will help limit the erosion potential and the buffer zones around the wetland areas and streams inhibit the potential for any eroded material from each worksite washing into streams.

Surface water is also vulnerable to contamination from mobilization of any contamination present in the soil by rainfall and run-off, for instance from fuel spills or release of oil during rig maintenance (rig fuel tank capacity <60 liter[1] or <5 liter oil stored for maintenance). Leaked/spilled materials and surface run-off could also infiltrate ground and potentially contaminate groundwater since the trails/golf course are unpaved. In terms of hazardous liquids at the worksite, diesel will be present for motor and pump operation, up to five (5) liters in volume stored at each rig location at any one time. Some hydraulic fluid and lubricants may also be required for general maintenance during operation; however the volume will be small (<5 liters) and stored in a dedicated locked hazardous material storage box. There will be no storage of fuel within the CCNR. In addition, as specified within *Table 2.7* and *Section 2.4.4*, refueling within the CCNR will involve the use of piston pumps and pipes fitted with flow control valves to limit drips.

During operation, the drilling rigs will require fresh water. Wastewater slurry, which consists of the water added during drilling and material generated during the drilling process, will therefore be generated. The volume of wastewater generated from the process will depend on the geology encountered during the drilling works. It is estimated however, a one 1,000 liter of wastewater will require removal from each drilling location daily. The FCT and tote tank will provide primary containment of this wastewater.

In summary, wastewater generation and impact of run-off to ground and surface water quality during operation activities of the rotary borehole and HDC rigs will be managed by 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,*

[1] Boart Longyear (2008) **DeltaBase 520.** Retrieved from http://www.premat.com.sg/dm/dm.boart.DB520.pdf

*2008*, *Public Utilities (Reservoir and Catchment Areas) Regulations, 2006* and LTA's *General Specifications, Appendix A, Safety, Health and Environment (for Rail Project) December 2014 Edition*. These include controls to protect impact to ground and surface water courses, such as prohibiting hazardous material release; provision of drip tray on site; limitations on release of suspended solids; measures controlling sanitary waste release; and best management practices. Detailed requirements are provided in *Volume I, Annex 1*;

- As mentioned in *Chapter 2*, wastewater generated during operation of the drilling rig will be contained within a FCT, pumped to an enclosed wastewater holding tank (ie 1,000 liter tote tank) and removed on a regular basis for disposal to a licensed third party waste management facility;
- The small amounts of maintenance oil will be stored in a dedicated locked steel container providing secondary containment;
- Adoption of Waste Management Plan including actions specified in *Section 2.4.4*;
- ECBs will be positioned within the CCNR during the set up phase beneath equipment at each unpaved worksite; and
- Vehicle and equipment maintenance checks will be undertaken prior to mobilization. Furthermore, rig maintenance will be undertaken at each worksite (if required) using drip trays to prevent impact to ground.

Although embedded controls will be in place to limit the potential for erosion, sediment runoff and/or potential contaminants (like the maintenance oil) reaching sensitive streams, high rainfall in Singapore combined with vehicle movement, will still weaken the integrity of the trails. Furthermore as some of the access routes (eg Sime trail) are in proximity to sensitive streams, impacts to water quality may occur. However, during normal operating conditions impacts are likely to be within ambient levels, are of a short-term nature and localized (the volume of contaminating liquid would be low). The magnitude of impact associated with reference to the criteria outlined in *Table 3.2*, is therefore considered to be *Small*.

Considering the *High* sensitivity of the water environment with the Alignment Option 1 study area, and *Small* magnitude, the impact to water quality from the rotary borehole and HDC boreholes is assessed as *Moderate*.

### *Mitigation Measures*

The following mitigation measures will be implemented to minimize the potential impact:

- During the Preliminary Investigation stage, prior to commencement of the SI works, the Contractor to survey, photograph and document the ground conditions of the mobilization/demobilization access routes. Survey to include noting where there are potential areas prone to flooding for the Contractor Environment Team (ET) to review when scheduling the works;
- In the event rotary borehole locations within the CCNR and golf courses need to be adjusted, boreholes should not be sited within 30 m of the surface water buffer zone and be subject to LTA and NParks' approval;

- Development and implementation of an earth control measures (ECM) plan for the final rotary borehole and HDC locations selected during the site reconnaissance phase of the Project;

- All survey equipment and rigs involved in the SI within the CCNR will undergo cleaning/washing prior to mobilization into the CCNR and upon exit from the CCNR. However, no equipment washing is to be undertaken within the CCNR;

- Strictly no storage of fuel within the CCNR;

- Employment of piston pumps and pipes fitted with flow control valves for refueling operations within the CCNR;

- Rainfall and Manual Transport of Rotary Borehole Ancillary Equipment. Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR and at BH02 - BH07, BH09, BH11, BH35 - BH37. Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed halted and as instructed by the Contract ET.

- Rainfall and Vehicle Movement Along Trails and within SICC Golf Course. No vehicle movement permitted along trails within CCNR and through SICC Golf Courses during rain. In the event of an unforeseen rainfall event while there is ancillary vehicle moving occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, at BH02 - BH07, BH09, BH11, BH35 - BH37 and within the SICC Golf Courses. Contractor ET to instruct when to recommence vehicle movement along trails and within SICC golf course following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further vehicle movement.

- Rainfall and Rotary Borehole Drilling Operations. Borehole drilling operations at each worksite within CCNR and at BH02 - BH07, BH09, BH11, BH35 - BH37 and in the SICC golf courses to be suspended during rainfall and all equipment to be covered with tarpaulin; FCT to be fitted with tight lid; closure of wastewater tote tank; storage of hazardous liquids/materials (eg maintenance oil, oily rags etc) within lockable enclosure to prevent generation of contaminated run-off and overflow. Contractor ET to instruct when to recommence rotary borehole drilling operations within CCNR following a rainfall event. As a minimum ET to wait until rain has fully stopped prior to instructing rig operator to remove FCT lid and tarpaulin before starting/recommence drilling.

- As a precautionary measure, Contractor ET to review weather forecast at end of each day and review schedule for mobilization/demobilization of ancillary vehicle and equipment within CCNR, around BH02 - BH07, BH09, BH11, BH35 - BH37 and in the SICC golf courses to avoid periods of rainfall. Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule during daily progress call (refer to *Chapter 7* for further details on the project implementation environmental management procedures) with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report;

- Contractor staff outside CCNR to monitor NEA rainfall forecasts and to update Contractor teams on site of any forecast rainfall events. Contractor teams to be equipped with walkie-talkies to allow for communication with staff outside the CCNR and to check in prior to any vehicle movements along trail.
- The FCT that will contain slurry is to be used at all times during operation of rotary and HDC rigs;
- The FCT is to be positioned on absorbent mats or within secondary containment;
- Wastewater from the FCT will be pumped into a small tank and be removed offsite by a small vehicle approved by NParks or LTA to a licensed third party waste management facility;
- The pump hose connecting the FCT to the water/wastewater tote tank is to be secured to avoid spillage from loose hoses;
- ECBs should be inspected and maintained throughout rotary borehole and HDC works;
- Restrict speed limits during mobilization and demobilization to 3 km / hr whilst within the CCNR and golf courses;
- Strictly no stockpiling of spoil material generated during drilling works. Waste material will be bagged and removed daily from each worksite location by licensed third party waste contractor;
- Spill kits will be available and absorbent pads are to be provided at each worksite;
- Following completion of permeability testing, all groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs; and
- Following completion of the SI works, prior to reopening of the trails to the public and golf courses, Contractor to cross check ground status and reinstate any damage to the trails/access routes. Equipment and material details required along with a schedule for any reinstatement works to be provided to NParks and SICC for approval prior to completing the works. A post-reinstatement survey should be completed, documented and submitted to LTA, including photographs.

### *Residual Impact Assessment*

Following implementation of the aforementioned mitigation measures, the impact magnitude of impact to the water quality is likely to be reduced to *Negligible.* The significance of water quality during rotary and HDC drilling works will therefore revert to *Negligible*.

***Table 3.3: Impact Assessment Summary***

| Criterion | Rating | Comment |
|---|---|---|
| **Impacts to Water Quality During Rotary and HDC Drilling Works** | | |
| Nature | Negative | Change to surface water and groundwater qualities due to sediment loading, contaminated run-off and/ or generation of wastewater. |
| Type | Indirect | Wastewater and sediment run-off required to flow over land or via surface soils before reaching water courses. |
| Duration | Temporary | Rotary drilling approximately two weeks at each borehole location and HDC approximately two years; the volume of wastewater and sediment run-off likely to reach water resources is minimal; and recharge of water resources is plentiful. |
| Extent | Local | Streams down topographic gradient of SI works and vehicle mobilization/demobilization routes such as streams Ha, Hd, I and Ma groundwater underlying the worksite. |
| Scale | - | Slight change of water quality in the watercourses affected. |
| Frequency | Intermittent | Wastewater transport required every day during the drilling operations and rainfall events are regular in the Study Area. |
| Magnitude | Small | Rainfall prevalent in Singapore, borehole worksites outside 30 m stream buffer zone, however some access trails will be via streams (eg along Sime track). Volume of wastewater and sediment run-off will be small therefore potential impact would be localized. Embedded controls and mitigation measures such as ECB, stop works during rainfall events, spill kits, ECM plan will be in place. |
| Receptor Sensitivity | High | Endangered species are found in the streams down gradient of SI works, and the streams feed into MacRitchie Reservoir.<br>Groundwater is not abstracted for use; however it is likely to interact with the surface water bodies within the Study Area. |
| Significance | Moderate | Moderate adverse impact to surface water and groundwater due to sediment loading, contaminated run-off and/or generation of wastewater during the rotary and HDC rig operation. |
| Residual Impact Magnitude | Negligible | Conducting drilling works during dry weather within CCNR and restricting speed limit will reduce potential for trails to be eroded during mobilization and demobilization. Borehole distance from streams > 30 m and ECM plan development and implementation will reduce potential erosion and stormwater loading to impact watercourses to negligible. Spill kits to contain any localized spills of hazardous liquids to ground. |
| Residual Impact Significance | Negligible | Sensitivity of the water environment in the Study Area remains high, while the mitigation measures will reduce impact magnitude to Negligible. |

### *3.5.2 Impacts to Water Quality during Geophysical Surveys and Mackintosh Probe*

Geophysical surveys consist of seismic refraction, seismic reflection, electrical resistivity and gravity surveys which will be undertaken at areas immediately above and in the vicinity of the tunnel alignment location. These include off trail areas, streams, and areas classified as *wetland* (as defined in *Volume II, Chapter 3*). Similarly, the proposed MP locations will be off trail within the wetland. Numerous MPs will be positioned within the buffer zone in close proximity to streams I and Hd. These surface waterbodies have distinct ecological value as discussed under *Section 3.5.1*, and are also sources that replenish the MacRitchie Reservoir along with groundwater. The overall sensitivity is therefore deemed as *High*.

Geophysical surveys will be conducted in stages over a total duration of approximately 205 days, assuming that gravity survey, electrical resistivity and seismic surveys are carried out sequentially. The

key activities of these surveys will involve 3 to 5 personnel accessing the survey locations, laying a string line along the survey lines, and mobilizing and demobilizing of equipment. As the survey lines will pass through off trail areas, surveyors might be required to use handheld tools such as parangs to cut their way through densely vegetated areas. This might lead to increased exposure of soil to erosion during rainfall, resulting in increased sediment loading at nearby streams. Personnel access to the off trail areas especially walking through streams and wetlands, could also give rise to impact to surface water bodies.

MPs will be carried out by two personnel using lightweight and manually portable equipment at nine locations as illustrated in *Figure 2.1*. Depending on the soil condition, each MP is estimated to take from a few hours to one day to complete or up to five days to complete all borings. The probe with a diameter of 27 mm will be driven to 15 m bgs, producing a small volume of drilling slurry (groundwater mixed with sediment, ie approximately 0.03 $m^3$) caused by hydraulic pressure. Slurry spread around the probe locations will be very localized. Hand augering at the probe locations will be undertaken to reduce friction on the rods. Disturbed soils equivalent to the size of the sampler (ie diameter of 0.1 m and length 0.6 m) will be collected for investigation of soil type and moisture content. Upon completion, the probe locations will be backfilled.

Impacts to the streams could arise as a result of sediment loading due to increased soil erosion following personnel access to geophysical survey locations; slurry which comes to the surface (in particular if the MP location is within a wetland area); and human disturbance to soils and sediments when the field personnel cross streams and wetlands during access to each MP worksite and geophysical survey location. The aforementioned situations will worsen if the works are undertaken during rainfall events.

However, where the off trail area is densely vegetated, field personnel may need to remove branches or stems of understory plants to gain access to the geophysical survey locations. No uprooting and removal of plants or trees will be required; no major exposure of ground is therefore anticipated. Furthermore, assuming that gravity and seismic/electrical resistivity surveys are scheduled sequentially for each string line, a maximum of 5 personnel will be present at each string line for not more than 5 days throughout the entire survey period. In addition, MP operations and associated mobilization and demobilization will be carried out consecutively for up to five days and the amount of sediment that will be generated from MPs and the associated mobilization and demobilization is expected to be very small. Consequently, any impact on the water quality of streams is likely to be well within the ambient levels and the water quality is expected to return to equilibrium conditions within a short timeframe (eg hours or days at most). Therefore the impact magnitude is evaluated to be *Small*.

Combining the overall sensitivity of *High* with the impact magnitude of *Small*, the impact to water quality from MP is deemed as *Moderate.*

### *Mitigation Measures*

The following mitigation measures will be implemented to alleviate the potential impact to surface water bodies within the CCNR:

- Prohibit damage to vegetation including the removal of the branches or stems of understory plants, shrubs and climbers;
- Restrict geophysical surveys to drier periods;
- Utilize the existing trails as much as possible to reduce the need for walking off trail;

- Restrict the locations of access routes to areas outside the wetland Buffer Zones;
- Arrange geophysical surveys such that works at similar locations will be conducted within the same period and following the same access route;
- Personnel are prohibited from walking through streams and areas where surface water pooling/flooding are observed;
- Relocate the MPs so field personnel can avoid traversing through streams or wetlands to access the MP locations. Three locations have been identified where probing can be undertaken within the stream while the personnel operate the equipment from a bridge. These MP locations are presented in *Figure 3.1*;
- Schedule the works such that probes at similar location could be carried out within the same visit to reduce the impacts from accessing the site; and
- Exercise due care during the probing by ensuring that probes are lowered into position slowly, in particular when beginning to probe through the streambed.

Following implementation of the abovementioned mitigation measures, there will be no impacts to surface water quality due to trampling effects through streams or wetland areas during personnel access to the MP locations. Furthermore, no hand augering or backfilling will be required for MP locations within the stream; the extent of sediments generated from the probes will therefore be very localized and small in scale.

The impact associated with geophysical surveys will also be reduced. In particular as vegetation clearance will be restricted, this will reduce the amount of sediments generated from exposed ground. There will also be no human disturbance to streams since the access routes will be restricted to dry patch (ie areas outside of streams and wetland areas).

Given the above, the significance of impact to water quality associated with MP works and geophysical surveys will therefore be reduced to *Negligible*. The magnitude of residual impacts to surface water quality is therefore assessed to be *Negligible.*

### *Table 3.4: Impact Assessment Summary*

| Criterion | Rating | Comment |
|---|---|---|
| **Impacts to Water Quality During MP Works** | | |
| Nature | Negative | An increase of sediment loading in surface water quality. |
| Type | | Slurry and sediment run-off needed to flow over land or via surface soils before reaching water courses. |
| Duration | Temporary | Geophysical surveys will last for 205 days but the surveys will be conducted in stages based on string line and each string line will take at most up to four days. MP operation including set up and decommissioning will likely be less than a day for each MP location (total duration of 5 days is estimated for completion of nine locations). |
| Extent | Local | Streams Fa, Ha, Hd and I. |
| Scale | - | Slight change of water quality in the watercourses affected. |
| Frequency | Intermittent | Slurry could be generated during probing. Removal of stems/branches might reduce the tree cover so that the ground is more exposed to erosion during rainfall. Topsoil of the ground could be exposed due to probing and hand auguring during MP. These are accompanied by frequent rainfall events in the Study Area. |
| Magnitude | Small | Geophysical surveys include off trail locations where vegetation clearance and traversing streams could be required and MPs will be located in close proximity to streams I and Hd. However the amount of slurry and sediment run-off that will is expected to be small. Therefore the impact will be localized and short-term. |
| Receptor Sensitivity | High | Streams Fa, Ha, Hd and I have distinct ecological value and are sources that replenish MacRitchie reservoir. |
| Significance | Moderate | Moderate adverse impact to surface water due to sediment loading during geophysical surveys and MP works |
| Residual Impact Magnitude | Negligible | Geophysical surveys will be restricted to areas that are accessible without the need for removal of stems, branches, shrubs and climbers as well as crossing streams.<br><br>The MPs will be relocated as per *Figure 3.1*. There will be no disturbance to the streams and wetland areas as the field personnel will not need to traverse through these areas to access the new MP locations. |
| Residual Impact Significance | Negligible | Sensitivity of the water environment in the Study Area is high. Implementation of the mitigation measures will reduce the magnitude of impact to Negligible. |

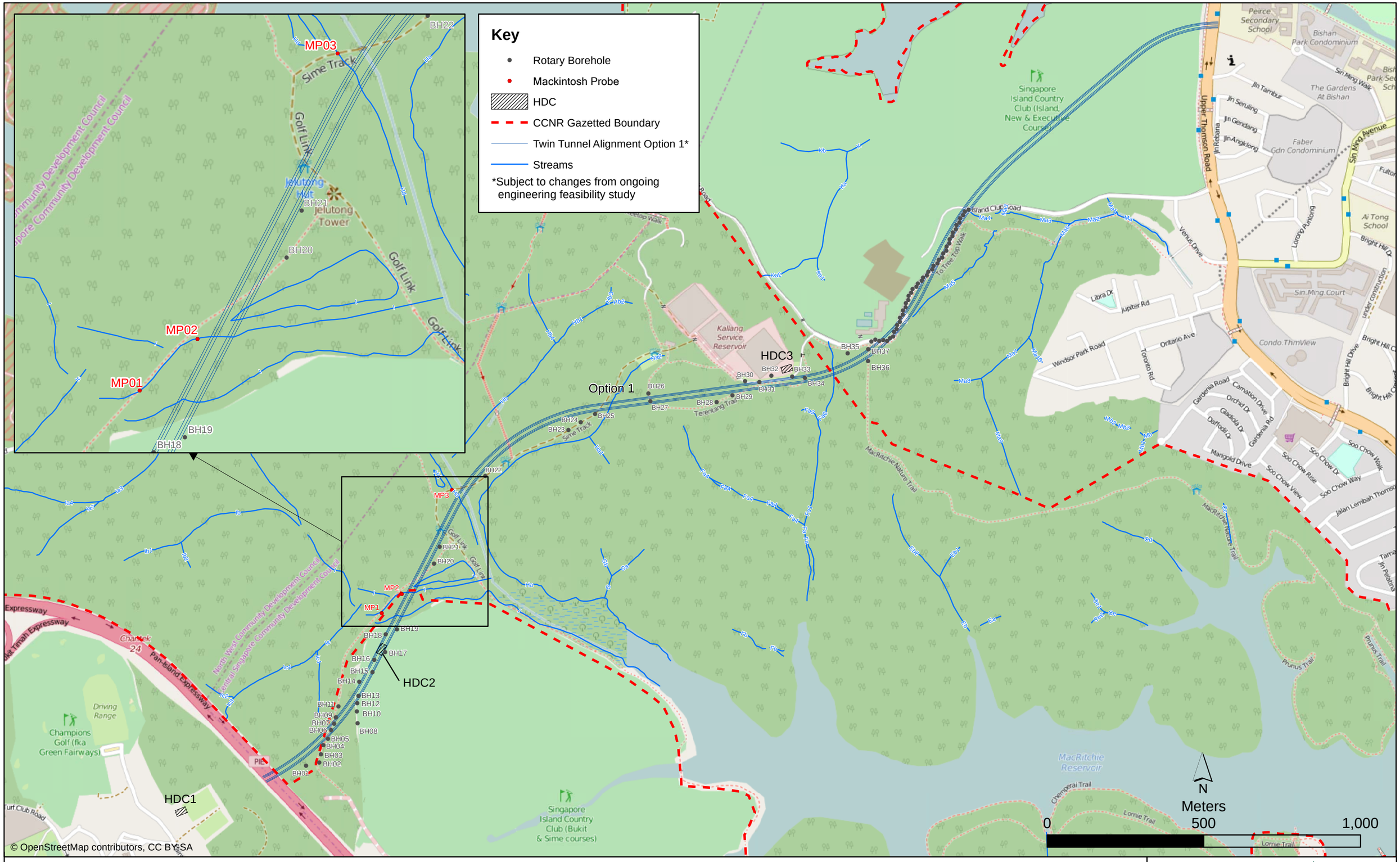



Figure 3.1 MP Locations After Mitigation

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Date: 15/12/2015

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### 3.5.3 Cumulative Impacts

The sensitivities of surface water features and groundwater within the AOI of Alignment Option 1 have been evaluated in *Section 3.5.1*, and are deemed as *High*.

In terms of other developments that will likely be underway at the time of the SI for Alignment Option 1, the Windsor Nature Park development will be underway (*Volume II, Chapter 2*). This development is in the vicinity of the CCNR stream system (in particular, steam Ma). Details of the Windsor Nature Park construction and schedule were not available to inform this study, however it is assumed that some of the works will involve generation of wastewater and the use of some hazardous material during normal operations that may interact with the surface water system (Ma). However it is assumed the volume of wastewater and hazardous material associated with the construction work would be small and managed in accordance with regulatory and best practice. The cumulative impacts from the construction of Windsor Nature Park and SI works of Alignment Option 1 during normal operations are therefore assessed to be of *Negligible* significance.

***Table 3.5: 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 construction site of Windsor Nature Park. |
| Type | Indirect | Wastewater and run-off required to flow over land or via surface soils before reaching water courses. |
| Duration | Temporary | Temporary when the construction of Windsor Nature Park and SI works occur at the same time |
| Extent | Local | The impacts will be limited to Stream Ma and groundwater in the area common to the SI works and the construction site of Windsor Nature Park. |
| Scale | - | Slight change of water quality. |
| Frequency | Rare | There is a potential that the construction of Windsor Nature Park and the SI works to be undertaken at the same time. |
| Magnitude | Negligible | Volume of potential contaminative material (ie wastewater and hazardous liquids) associated with Windsor Nature Park and the SI works will be small. Further both works will be undertaken in line with local regulatory requirements. |
| Receptor Sensitivity | High | Endangered species are found in the streams down gradient of SI works, and the streams are fed into MacRitchie Reservoir.<br>Groundwater is not abstracted for use; however it is likely to interact with the surface water bodies within the Study Area. |
| Significance | Negligible | Impact magnitude Negligible, while receptor sensitivity Medium to High. |

# 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 the proposed SI works for Alignment Option 1.

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* provides an overview of the impact assessment approach;
- *Section 4.5* provides an assessment of the potential impacts;
- *Section 4.6* presents mitigation measures required for the residual impact assessment; and
- *Section 4.7* presents a summary of the findings.

## 4.2 SCOPE OF THE 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* 7.

The scoping exercise identified several activities that may give rise to noise and vibration during the SI works. These activities were reviewed against the project description as outlined in *Chapter 2*, and the environmental baseline of the Study Area. The potential interactions were subsequently refined and the acoustics impacts carried forward for assessment are as follows:

- Use of accelerated drop weight during seismic reflection and refraction geophysical surveys at off-trail locations within the CCNR;
- Operation of rotary drilling rig(s) for intrusive soil investigation using rotary boreholes along existing trails within the CCNR;
- Use of vehicles for transportation of ancillary equipment during rig mobilization and demobilization, as well as for daily transportation of water to and from worksites during drilling works; and
- Operation of HDC rigs for intrusive soil investigation using inclined boreholes drilled from outside (but within close proximity to the boundary) of the CCNR.

Installation of MPs within the CCNR will generate metal-on-metal noise and vibration during the operation of a 4 kg drop weight from a freefall height of 300 mm, until the probe has reached a penetration depth of 15 m. Elevated noise levels will be generated over a short-term duration (9 MPs

will be completed over 5 days and take a few hours each). Vibration generated from the drop weight will likely be localized in nature and brief in duration, as the drop weight used will have a mass of approximately 4 kg, and the 12 mm diameter rods will be driven into soil. Noise and vibration impacts due to the use of MP have therefore been screened out of this assessment.

HDC operations will generate vibration during underground deployment of the drill bit. As the drill bit radius is small, vibration is likely to be attenuated within a few meters of the source. As the profile of the drill bit is largely vertical in the initial stages, before levelling out at depths of more than 30 m, vibration levels at nearby trails and golf courses are unlikely to be significant. Vibration impacts due to HDC works have therefore also been screened out of this assessment.

## 4.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

Key elements of the environmental baseline pertinent to the noise and vibration levels within the Study Area are summarized in the following sections.

### 4.3.1 Ambient Noise

Long-term, short-term and supplementary short-term noise measurements were undertaken over one week from 24 November to 26 December 2014 (ie Round 1, representative of the tail end of the inter-monsoon/ start of the Northeast monsoon), and over one week from 16 January to 9 February 2015 (ie Round 2, representative of the Northeast monsoon). Monitoring locations were selected to obtain representative baseline values at potential noise sensitive receptors identified within the Study Area (see *Table 5.2*, *Volume II Chapter 5*). General trends observed from measurements undertaken at these locations include:

- **NL101, along western perimeter of CCNR and SICC Bukit golf course:** Vehicular traffic plying the PIE (approximately 100 m from the measurement location), as well as wildlife vocalizations and wind-blown vegetation, comprise the predominant background noise levels. Hourly measurements indicated that peak traffic conditions occur between 10.00 and 5 pm (extending up to 8 pm on some days), whereas low traffic conditions typically occur between 23.00 to 06.00 on weekdays. Similarly, low traffic conditions were observed during the same period on weekends. Peak noise levels were observed from 4 pm to 5 pm, and between 7pm and 8 pm during weekends in December in Round 1 of monitoring. These peaks were not observable in measurements taken during January in Round 2 of monitoring. This could be attributed to the movement of public and other users and over the weekends.

- **NL102, along Sime Track within the CCNR:** Members of the public using the CCNR for recreational purposes and other personnel using the Sime track, contribute to infrequent peaks in measured baseline noise levels at this location. Hourly measurements indicated that low activity along this track occurs between 4 am and 8 am. Peak activity occurs between 9 and 11am; 12 pm and 2 pm; and 4 pm and 5 pm during the weekends. During the weekday, peak periods along the Sime track were slightly different during Round 1 and Round 2 periods of monitoring. In general, peaks occurred from 09.00 to 12.00, and 14.00 to 18.00 during Round 1; and between 09.00 to 10.00, and 14.00 to 16.00 during Round 2 of monitoring. Another peak in noise levels was observed at 19.00 on both weekdays and weekends throughout the year, indicating possible contribution from vocalizations of nocturnal species.

- **NL103, 50 m off Terentang trail (within the CCNR forest):** Natural noises, eg wildlife vocalizations and rustling of leaves, were the main contributors to the baseline noise levels measured at this off-trail location. A comparison of significant peaks occurring between 3 and 4 pm on 26 November 2014, at both NL102 and NL103, indicates that anthropogenic noise (observed west of the CCNR), may contribute to the increased noise levels at NL103. A review of hourly measurements indicated that noise levels typically peak in the late morning or early afternoon, ie between 10.00 to 13.00; mid-afternoon from 15.00 – 18.00; and between 19.00 to 20.00.

- **NL104, along Island Club Road:** The predominant source of noise observed at this location was vehicular traffic along Island Club Road. Hourly measurements across the weekdays and weekends for both Round 1 and Round 2 of monitoring remained fairly constant between 60 to 65 dB(A) from 06.00 to 7pm, after which noise levels dropped and fluctuated between 45 – 50 dB(A). This corresponds to the opening hours of the SICC Island course, ie 6.30 am to 19.00, and indicates that most vehicular traffic along Island Country Club Road are accessing the club facilities. Other intermittent sources of noise include the operation of lawn mowers within the golf course, and noise from members of the public using the Island Club Road.

In general, daytime noise levels measured in Round 1 of monitoring were observed to be 7 – 10 dB higher than those measured during the corresponding periods in Round 2. On the other hand, noise levels measured in the evening and night times were generally similar in both seasons. In most instances, this trend is attributable to the occurrence of thunderstorms in the day, as observed through a review of hourly rainfall data from NEA's recording station located within the SICC (Island location). Other peaks in noise levels may be attributable to localized events within the CCNR during Round 1 of the noise survey, and potential movement and vocalization of animals in close proximity to the noise meters.

### *4.3.2 Vibration*

Vibration measurements were undertaken over a period of one day at each of the locations listed below in March 2015. Monitoring locations were selected to obtain representative baseline values at potential vibration sensitive receptors identified within the Study Area (see *Table 5.8*, *Volume II Chapter 5*). General trends observed from measurements undertaken at these locations include:

- **VL101, off trail location near Jelutong Tower within the CCNR:** Horizontal component of vibration (as PPV) ranged between 0.254 and 0.508 mm/s, while vertical vibration was recorded at 0.508 mm/s. PPV levels could be attributed to users, eg joggers, trekkers, soldiers utilizing the nearby trail around Jelutong Tower, as well as potential disturbance by fauna or humans, or due to falling branches.

- **VL102, grass verge along PUB service road:** Horizontal PPV ranged between 0.762 and 0.889 mm/s, while vertical PPV was recorded at 0.254 mm/s. Vibration sources observed included joggers and trekkers using the Venus Link and PUB service road, as well as vehicular traffic along the adjacent PUB service road and the nearby Island Club Road.

- **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 included vehicles along Venus Drive, as well as joggers or trekkers using the adjacent pathway.

- **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 included 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

No regulatory noise emission limits have been defined for construction work undertaken in ecological areas. However, the World Health Organization (WHO) provides guidelines for community noise in 'parkland and conservation areas' stating that "*existing noise levels should be preserved and the ratio of intruding noise to natural background sound kept low*"[1]. The relevant limits for recreational users of the CCNR are therefore determined in terms of the difference between the measured baseline noise levels, ie $L_{Aeq, T}$, as summarized in *Table 4.1*, and the predicted construction noise.

The criteria for assessment of the magnitude of noise impact due to SI works are presented in *Table 4.2*.

[1] World Health Organization (1999) **Guidelines for Community Noise.** Ed(s) Berglund B, Lindwall T & Schwela DH. Retrieved from http://www.who.int/docstore/peh/noise/guidelines2.html

***Table 4.1: Free-field Baseline Noise Levels within the CCNR***

| Monitoring Point ID | Location | Inter-Monsoon Period (Note 1) | | | | | Monsoon Period (Note 1) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Baseline Measurements (dB(A)) (Note 2) | | | | | Baseline Measurements (dB(A)) (Note 2) | | | | |
| | | Day $L_{Aeq, 12hr}$ | Day $L_{Aeq, 1hr}$ | Eve $L_{Aeq, 1 hr}$ | Day $L_{Aeq, 5min}$ | Eve $L_{Aeq, 5min}$ | Day $L_{Aeq, 12hr}$ | Day $L_{Aeq, 1hr}$ | Eve $L_{Aeq, 1 hr}$ | Day $L_{Aeq, 5min}$ | Eve $L_{Aeq, 5min}$ |
| NL101 | End of Sime Road, 100 m east of the PIE | **Min:** 61 **Max:** 65 | **Min:** 58 **Max:** 72 | **Min:** 59 **Max:** 66 | **Min:** 57 **Max:** 78 | **Min:** 59 **Max:** 69 | **Min:** 59 **Max:** 64 | **Min:** 56 **Max:** 71 | **Min:** 58 **Max:** 66 | **Min:** 54 **Max:** 77 | **Min:** 55 **Max:** 75 |
| NL102 | Petaling Hut, < 5m from the Sime Track within CCNR | **Min:** 55 **Max:** 72 | **Min:** 44 **Max:** 82 | **Min:** 50 **Max:** 67 | **Min:** 40 **Max:** 88 | **Min:** 47 **Max:** 75 | **Min:** 47 **Max:** 55 | **Min:** 42 **Max:** 65 | **Min:** 49 **Max:** 59 | **Min:** 38 **Max:** 74 | **Min:** 39 **Max:** 68 |
| NL103 | Off-trail, approximately 50 m from the Terentang Trail within CCNR | **Min:** 54 **Max:** 64 | **Min:** 39 **Max:** 73 | **Min:** 46 **Max:** 66 | **Min:** 34 **Max:** 79 | **Min:** 44 **Max:** 70 | **Min:** 46 **Max:** 53 | **Min:** 39 **Max:** 59 | **Min:** 43 **Max:** 59 | **Min:** 36 **Max:** 68 | **Min:** 38 **Max:** 68 |
| NL104 | Along Island Club Road, approximately 10 m from Windsor Interim Green | **Min:** 61 **Max:** 66 | **Min:** 57 **Max:** 71 | **Min:** 58 **Max:** 63 | **Min:** 53 **Max:** 74 | **Min:** 52 **Max:** 68 | **Min:** 62 **Max:** 65 | **Min:** 59 **Max:** 72 | **Min:** 55 **Max:** 66 | **Min:** 54 **Max:** 77 | **Min:** 48 **Max:** 70 |

*Notes*

(1) Measurements were undertaken over two weeks at each location, once (Round 1) in November/December 2014 and Round 2 in January/February 2015. Levels during the other seasonal periods may differ.

(2) The minimum and maximum noise levels as measured over 7 continuous days, over the periods where SI works will be undertaken, ie day and evening.

***Table 4.2: Impact Magnitude Criteria for Ambient Noise Impacts***

| Impact Magnitude | Definitions (Note 1). |
|---|---|
| **Negligible** | • Predicted noise levels are less than 3 dB(A) above the relevant limits / thresholds |
| **Small** | • Predicted noise levels are 3 to less than 5 dB(A) above the relevant limits / thresholds. |
| **Medium** | • Predicted noise levels are between 5 and 10 dB(A) above the relevant limits / thresholds |
| **Large** | • Predicted noise levels are more than 10 dB(A) above the relevant limits / thresholds. |

*Notes:*

(1) The measured minimum baseline noise levels ($L_{Aeq,T}$) as summarized in *Table 4.1*, in accordance with WHO guidelines for community noise in parkland and conservation areas.

According to the *Fundamentals of Acoustics* published by the WHO[2], 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. Based on this, it is assumed that noise levels up to 5 dB above the standards will be clearly noticeable to receptors and are classified as being of ***Medium*** impact magnitude, while any levels more than 10 dB(A) above the standards can cause impacts of ***Large*** magnitude to receptors.

The other significance factor that is taken into account while determining the impact magnitude 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 defined as shown in *Table 4.4*.

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

*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 |
| <3 dB(A) | Negligible | Negligible | Minor |
| 3-5 dB(A) | Minor | Minor | Moderate |
| 5-10 dB(A) | Minor | Moderate | Moderate |
| >10 dB(A) | Moderate | Major | Major |

### *Vibration*

Local regulations on vibration are focused on the prevention of structural damage due to pile installation. There is no legislation or guideline in Singapore that stipulates vibration limits for construction works for the avoidance of disturbance to human or ecological receptors. International standards such as BS 5228-2:2009[3] 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 were considered in developing the criteria for assessment of vibration impacts, which are presented in *Table 4.5*.

*Table 4.5: Impact Magnitude Criteria for Vibration Impacts on Humans*

| Impact Magnitude | Vibration Magnitude (PPV(Note 1)) | Effect(Note 2) |
|---|---|---|
| **Negligible** | 0.14 mm/s | Vibration barely perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration. |
| **Small** | 0.3 mm/s | Vibration might be just perceptible in residential environments. |
| **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. |
| **Large** | 10 mm/s | Vibration is likely to be intolerable for any more than a very brief exposure to this level. |

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

As the vibration criteria specified in *Table 4.5* take into account the sensitivity of the receptor, separate criteria for receptor sensitivity are not applicable and are therefore not presented. The corresponding impact significance rating is outlined in *Table 4.6*, which also accounts for the duration of exposure (defined with reference to *Table 4.3*).

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

*Table 4.6: Impact Significance Criteria for Vibration Impacts on Humans*

| Impact Magnitude | Duration | | |
|---|---|---|---|
| | < 1 month | 1 to 6 months | > 6 months |
| Negligible | Negligible | Negligible | Minor |
| Small | Minor | Minor | Moderate |
| Medium | Minor | Moderate | Moderate |
| Large | Moderate | Major | Major |

### 4.4.2 Noise & Vibration Sensitive Receptors

Walkers and joggers along the CCNR trails and golfers utilizing the Bukit, Sime and Island golf courses or the SICC Island clubhouse may be exposed to noise and vibration from the SI works.

### 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 drilling rig operations. 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. The model allows for soft ground to be taken into account during propagation as an additional correction, where appropriate, eg in forested areas. ISO 9613-2 predicts long-term average downwind noise levels in meteorological conditions favorable to propagation, including moderate inversions.

The purpose of the modeling was to determine noise levels generated from the Project SI worksites, to allow for an assessment of the potential noise impacts and the need for mitigation measures.

#### Scenarios

The modeled scenarios took into account the sources of potentially significant noise impact, ie A-frame rigs and/or DeltaBase 520 rigs, HDC rigs and ancillary vehicles; the proposed number of equipment that could be operated simultaneously; the proposed sequence and schedule of activities associated with the SI phase; and the location of noise sources relative to each other and relative to nearby receptors. The following scenarios were modeled:

**Operation of Drilling Rig(s)**

- **Scenario 1:** Operation of one crawler mounted A-frame rig and water recirculation pump on an existing trail within the CCNR (see *Table 2.4*);
- **Scenario 2:** Operation of one DeltaBase 520 rig on an existing trail within the CCNR (see *Table 2.4*);

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

- **Scenario 3:** Simultaneous operation of three standard A-frame rigs and three pumps within approximately 25 m of each other, located outside the CCNR but at close proximity to the CCNR boundary;

- **Scenario 4:** Simultaneous operation of four standard A-frame rigs and four pumps within approximately 25 m of each other, located outside the CCNR but at close proximity to the CCNR boundary;

- **Scenario 5:** Simultaneous operation of one crawler mounted A-frame rig within, and four standard A-frame rigs outside the CCNR;

- **Scenario 6:** Simultaneous operation of two crawler mounted A-frame rigs within the CCNR and one crawler mounted A-frame rig outside the CCNR; and

- **Scenario 7:** Simultaneous operation of three HDC rigs outside the CCNR but at close proximity to the CCNR.

**Operation of Ancillary Vehicles**

- **Scenario 8:** Use of a lorry crane for transportation of ancillary equipment, during mobilization and demobilization at borehole locations within the SICC Bukit Golf Course and at BH01 within the CCNR;

- **Scenario 9:** Use of a Cabstar lorry for transportation of ancillary equipment, during mobilization and demobilization at BH20 and BH21 within the CCNR;

- **Scenario 10:** Use of a S25A or equivalent for mobilization and demobilization of ancillary equipment during mobilization and demobilization at borehole locations within the CCNR (proposed for BH22, with reference to the drilling sequence outlined in *Chapter 2*); and

- **Scenario 11:** Use of a S25A or equivalent for daily transportation of water/wastewater to and from each worksite within the CCNR.

The rationale behind the modelling of Scenarios 1 and 2 is to generate noise contours at one location, which can then be extrapolated to represent the propagation of noise at each borehole within the CCNR. Scenarios 3 and 4 enabled the assessment of potential impacts to users from noise generated by SI works undertaken outside but within close proximity to the CCNR boundary. Scenarios 5 and 6 represent the worst-case situations for the rotary borehole drilling in terms of number of operational rigs operating simultaneously and in terms of rig location. The SI works will be undertaken in phases, such that rotary borehole drilling and HDC drilling will not be undertaken simultaneously - Scenario 7 represents the HDC drilling phase. Scenarios 8 to 10 were used to assess potential impacts arising from the usage of ancillary vehicles for transportation of equipment during mobilization and demobilization. Finally, Scenario 11 was to represent the usage of ancillary vehicles for daily transportation of water/wastewater within the CCNR during drilling works.

### *Model Assumptions*

The following general assumptions were made in undertaking the noise modelling:

- The positioning of rigs refers to the borehole locations proposed by ARUP in their Site Investigation Strategy Report[5] and subsequent updates provided by the LTA (see *Figure 2.1*), as well as available topographical information provided by NParks and SICC;
- The rigs and ancillary vehicles will operate during the daytime, ie between 09.00 and 17.00;
- The effect of Singapore's mean relative humidity (84%) and mean temperature (27˚C) on noise propagation was factored into the model;
- Shielding effects due to the presence of structures near the noise sources was not accounted for, although a correction factor was applied to account for noise attenuation through the heavily forested area in the model; and
- Sound power level inputs for modeled equipment were calculated from empirical sound level data listed in BS 5228-1:2009[3], with the exception of the standard and crawler mounted A-frame rigs. Sound level data for the standard and crawler mounted A-frame rigs were obtained from empirical measurements of noise generated during operation of similar rigs in Singapore.

## 4.5 ASSESSMENT OF NOISE IMPACTS

This section presents the results of an assessment of impacts from:

- Noise from SPT activities;
- Noise from geophysical survey activities;
- Noise during intrusive investigations, ie drilling of rotary boreholes (Scenarios 1 to 5);
- Noise due to operation of HDC rig (Scenario 6); and
- Noise due to operation of a small vehicle for during mobilization and demobilization, as well as for daily transportation of water/wastewater during SI works (Scenarios 7 to 10).

### 4.5.1 Impacts due to SPTs

SPT testing will be undertaken for every 2 m drill depth during the rotary drilling of rotary boreholes. The actual test will involve the repeated dropping of a 63.5 kg weight onto an anvil, until the sample casing has been driven a fixed distanced into the ground. It is estimated that up to 17 tests will be undertaken at each borehole, with each test lasting between 15 to 30 min, depending on the resistivity of the ground. It is noted that impulsive sounds are generally perceived to be less acceptable than continuous noise emissions[6].

Noise measurements were taken during SPT testing using an A-Frame rig at another location in Singapore. During the measurements, SPT testing was underway at 3 m and 5 m depths. Due to the

[5] 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.

[6] British Standards Institution (2008) **Code of practice for noise and vibration control on construction and open sites – Part 1: Noise (BS 5228-1: 2009).**

configuration of the worksite, measurements could only be taken at a horizontal distance of 3 m from the rig. The sound level 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 occurred over periods of less than 10 minutes, only $L_{Aeq,5min}$ levels were obtained. The $L_{Aeq,5min}$ from SPT testing was measured at 90.1 dB(A).

The predicted noise levels at identified NSRs were calculated using *Equation 1* for sound propagation over distances. As trails will be closed during drilling operations, noise levels were predicted using the shortest and the longest distances between a worksite and the nearest open trail, ie 10 m between BH37 and Venus Link; and 765 m between BH02 and Golf Link.

***Equation 1: Sound Propagation over Distance***

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

Using the equation above, the predicted noise levels will range from 80 dB(A) at a distance of 10 m to 42 dB(A) at 765 m. Noise levels will therefore exceed the baseline levels by 4 to 42 dB(A) at different locations within the CCNR and along Island Club Road. This corresponds to a *Medium to Large* impact magnitude based on *Table 4.2*. Considering the short duration of 5 to 20 minutes for each SPT test, the impact significance is assessed to be *Minor to Moderate*.

### *Mitigation Measures*

The following mitigation measures are required during SPT testing along Alignment Option 1:

- SPT testing to be scheduled to be undertaken during daylight hours (09.00 to 17.00) on weekdays;
- Schedule works to avoid peak visitation periods, ie weekends and events, eg marathons within CCNR or golf tournaments at SICC locations;
- Where there are no space constraints, erect portable acoustic screens between worksite and nearby receptors, eg at BH08, BH10, BH12 – 19, BH30 - BH33 and boreholes east of BH35;
- A notice describing the proposed SI activities and their duration within the CCNR shall be posted on signboards at the MacRitchie Visitor Centre and Ranger Station for the duration of the SI Program; and
- Provide SICC management with the schedule of the proposed SI activities within the golf courses and promptly notify them of any schedule changes, to facilitate management of golfing activities in proximity to the worksites. Trials have reportedly been undertaken by the LTA in previous projects to mitigate the noise at the source. For example, noise absorbent material has been used to line the inside of the drop weight mechanism, and resilient material to pad the anvil to reduce metal on metal contact, however it is understood that this did not result in much attenuation. Furthermore, it was observed that the addition of noise adsorbent material could lead to skewed SPT test results due to the added weight to the drop weight mechanism. Further engineering to mitigate noise generated from SPT testing was therefore deemed to be unfeasible.

### *Residual Impact Assessment*

It is assessed that the implementation of the mitigation measures listed above will reduce the impact magnitude to ALARP, although noise levels are still expected to exceed current baseline levels by more than 10 dB(A). The advance notification of recreational users, in addition to the temporary closure of trails, is expected to reduce exposure by enabling potential receptors to take alternative routes to avoid areas of SI activities. The residual impact is therefore assessed to be of *Minor* significance.

***Table 4.7: Impact Assessment Summary for SPT Testing***

| Criterion | Rating | Comment |
|---|---|---|
| Impact – Increased noise levels from SPT testing at A-frame standard drill rigs | | |
| Nature | Negative | The Project will result in incremental noise levels at some NSRs that are predicted to exceed baseline noise levels by 4 to 42 dB(A). |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Temporary | Exposure duration of receptors will be temporary, ie up to 10 minutes per test. |
| Extent | Local | Effects will be on ground level receptors within a radius of approximately 500 m from the worksites. |
| Scale | Medium to Large | Human receptors utilizing open trails may be directly exposed to levels between 42 to 80 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 (17 times over an 11 to 18 day drilling period for each borehole). |
| Magnitude | Medium to Large | The predicted impacts exceed the baseline levels by 4 dB(A) (*Medium*) to 42 dB(A) (*Large*). |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Minor to Moderate | Minor impacts to human receptors near the Golf Link from noise levels that exceed baseline levels by 4 dB(A) over a short duration of <1 month.<br><br>Moderate impacts to human receptors located within 10 m of the boreholes are expected from unmitigated noise levels that exceed the baseline levels by up to 42 dB(A) ($L_{Aeq,5\ min}$) for a short duration, ie <1 month. |
| Residual Impact Magnitude | Small | The implementation of mitigation measures will enable human receptors to avoid worksites, and thereby avoid or minimize exposure. |
| Residual Impact Significance | Minor | Minor adverse impact to human receptors due to implementation of mitigation measures. |

## *4.5.2 Impacts due to Seismic Reflection & Refraction Surveys*

As part of the geophysical surveys, seismic reflection and refraction surveys will be undertaken along the proposed tunnel alignment, as depicted in *Figure 2.2*. As described in *Chapter 2*, *Section 2.3.1*, a handheld accelerated drop weight of approximately 15 kg will be deployed five or six times each at five locations along each survey line (of length 200 m) for the refraction survey. For the reflection survey, the weight will be deployed five or six times at each of the 40 geophone locations along each survey line. It is further noted that the deployment of the drop weight at each geophone could be repeated at the discretion of the seismographer, subject to the quality of the seismic readings. It is estimated that the reflection survey and the refraction survey could take up to 4 days for each survey line (200 m). It is assumed that a large portion of that survey period would involve navigation through off-trail locations

to lay the survey line and geophones. Deployment of the handheld drop weight could be completed in a maximum duration of half a day once the survey line (geophones and cable) are laid out. It is therefore conservatively estimated that the accelerated drop weight will be deployed for less than 1 minute every 5 minutes, for a half-day day every 3 days over a total survey period of 108 days.

As noted with respect to noise generated during SPT tests (see *Section 4.5.1*), impulsive sounds, such as the metal-on-metal pinging that will be generated by the accelerated drop weight, are generally deemed to be less acceptable than continuous noise emissions[7]. A conservative approach was therefore employed for this assessment, by assuming that the deployment of an accelerated drop weight of 15 kg would generate sound levels similar to that generated during an SPT test, ie $L_{Aeq,5min}$ 90.1 dB(A) (see *Section 4.5.1*). As geophysical surveys will be carried out concurrently with SI works, it is likely that seismic reflection and refraction surveys may be undertaken in close proximity to trails that have not been temporarily closed for SI drilling works. It is therefore possible that users of the open trails within the CCNR could come within less than 5 m of a geophone location, at which distance the noise generated would be up to 86 dB(A). This is 48 dB(A) above the baseline levels, and therefore corresponds to a *Large* impact magnitude based on *Table 4.2*. Considering the short duration of exposure for each receptor ie up to a few hours recreational activity in the vicinity of the CCNR trails, the impact significance is assessed to be *Moderate*.

### *Mitigation Measures*

Engineering to mitigate noise at the source, such as padding of the steel plate and hammer might inhibit the propagation of seismic sound waves. In addition, as most of the survey will be undertaken at off-trail locations, the use of acoustic enclosures would be intrusive and not considered appropriate within the CCNR. In view of this, the following administrative measures are required to mitigate noise impacts during seismic reflection and refraction surveys along Alignment Option 1:

- Schedule the surveys at locations in close proximity to ongoing SI works, to ensure that CCNR trails closest to the survey lines are temporarily closed to public access. Temporary closure of trails should also apply to trails which transect the proposed survey line, eg Golf Link, Petaling Trail and Venus Link.

- Deployment of handheld accelerated drop weights to be scheduled on weekdays during the stipulated daytime hours of 09.00 to 17.00;

- A notice describing the proposed SI activities and their duration within the CCNR shall be posted on signboards at the MacRitchie Visitor Centre and Ranger Station for the duration of the SI Program; and

- Provide SICC management with the schedule of the proposed geophysical survey works within the Bukit Golf Courses and promptly notify them of any schedule changes, to facilitate management of golfing activities in proximity to the survey worksites.

[7] British Standards Institution (2008) **Code of practice for noise and vibration control on construction and open sites – Part 1: Noise (BS 5228-1: 2009).**

#### *Residual Impact Assessment*

It is assessed that the implementation of the mitigation measures listed above will reduce the impact magnitude to ALARP, although noise levels are still expected to exceed current baseline levels by more than 10 dB(A). The advance notification of recreational users is however expected to reduce exposure by enabling potential receptors to take alternative routes to avoid areas of geophysical survey activities. Implementation of the above mitigation measures will therefore minimize the number of people exposed to nuisance impacts due to impulsive noise generated during seismic reflection and refraction surveys. The residual impact is therefore assessed to be of *Minor* significance.

***Table 4.8: Impact Assessment Summary for Geophysical Survey Activities***

| Criterion | Rating | Comment |
|---|---|---|
| Impact – Increased noise from deployment of accelerated drop weight during seismic reflection and refraction surveys | | |
| Nature | Negative | The Project will result in incremental noise levels at some NSRs that are predicted to exceed baseline noise levels by up to 48 dB(A), leading to potential nuisance impacts. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short-term | Exposure duration of receptors will be short-term, ie up to 1 minute per deployment, at 5 minute intervals over half a day per survey line. |
| Extent | Local | Effects will be on ground level receptors within a radius of approximately 500 m from the worksites. |
| Scale | Large | Human receptors within 5 m of the geophysical survey locations may be directly exposed to levels up to 86 dB(A) ($L_{Aeq,5\ min}$). |
| Frequency | Intermittent | Deployment of accelerated drop weight will be undertaken over 1 min periods, at 5 minute intervals over half a day per survey line. |
| Magnitude | Large | Predicted noise levels are more than 10 dB(A) above the baseline levels. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate adverse impacts to human receptors are expected from impulsive noise that exceed the baseline levels by up to 48 dB(A) ($L_{Aeq,5\ min}$) for a short duration of up to a few hours. |
| Residual Impact Magnitude | Small to Medium | The implementation of mitigation measures will enable human receptors to avoid worksites, and thereby avoid or minimize exposure. |
| Residual Impact Significance | Minor | Minor adverse impact to human receptors due to implementation of mitigation measures. |

### *4.5.3 Impacts due to Intrusive Investigations (Rotary Boreholes)*

#### *Scenario 1 – One Crawler Mounted A-frame Rig within the CCNR*

This scenario takes into account the proposed operation of one crawler mounted A-frame rig along the existing trails in CCNR, and scheduling of works during the day (09.00 – 17.00) and usage of an enclosure around the rig power pack as embedded controls. The trail will also be temporarily closed to the public during operation of the rig.

The predicted noise generated from the operation of one crawler mounted A-frame rig and water pump during rotary borehole drilling, as modelled at BH22 (see *Figure 2.1*), is presented in *Figure 4.1*. As shown in *Figure 4.1*, noise levels above the baseline ie 47 dB(A) (the minimum daytime $L_{Aeq,12hr}$ value measured at NL102), will be generated at a distance of up to 170 m from the rig. With the operation of the rig, daytime noise levels at NL102 and similar on-trail locations is predicted to increase to up to 65

dB(A) at the nearest open CCNR trail, ie 15 dB(A) in exceedance of baseline levels. This corresponds to a *Large* impact magnitude as defined in *Table 4.2*.

It is noted that the rig could be in operation for up to 18 days at each proposed borehole location. Human receptors in the area will be exposed to heightened noise levels for a short duration, ie likely to be in the range of less than 10 minutes a day. In addition, it is noted that receptors along the CCNR trails are currently exposed to elevated noise levels. Hourly baseline noise levels at NL102, which is representative of locations on and in proximity to existing trails within the CCNR, range from 42 to 65 dB(A), with peak hourly noise levels reaching 81.5 dB(A).

The impact magnitude is therefore assessed to be of *Moderate* impact significance to human receptors within the CCNR.

### *Mitigation Measures*

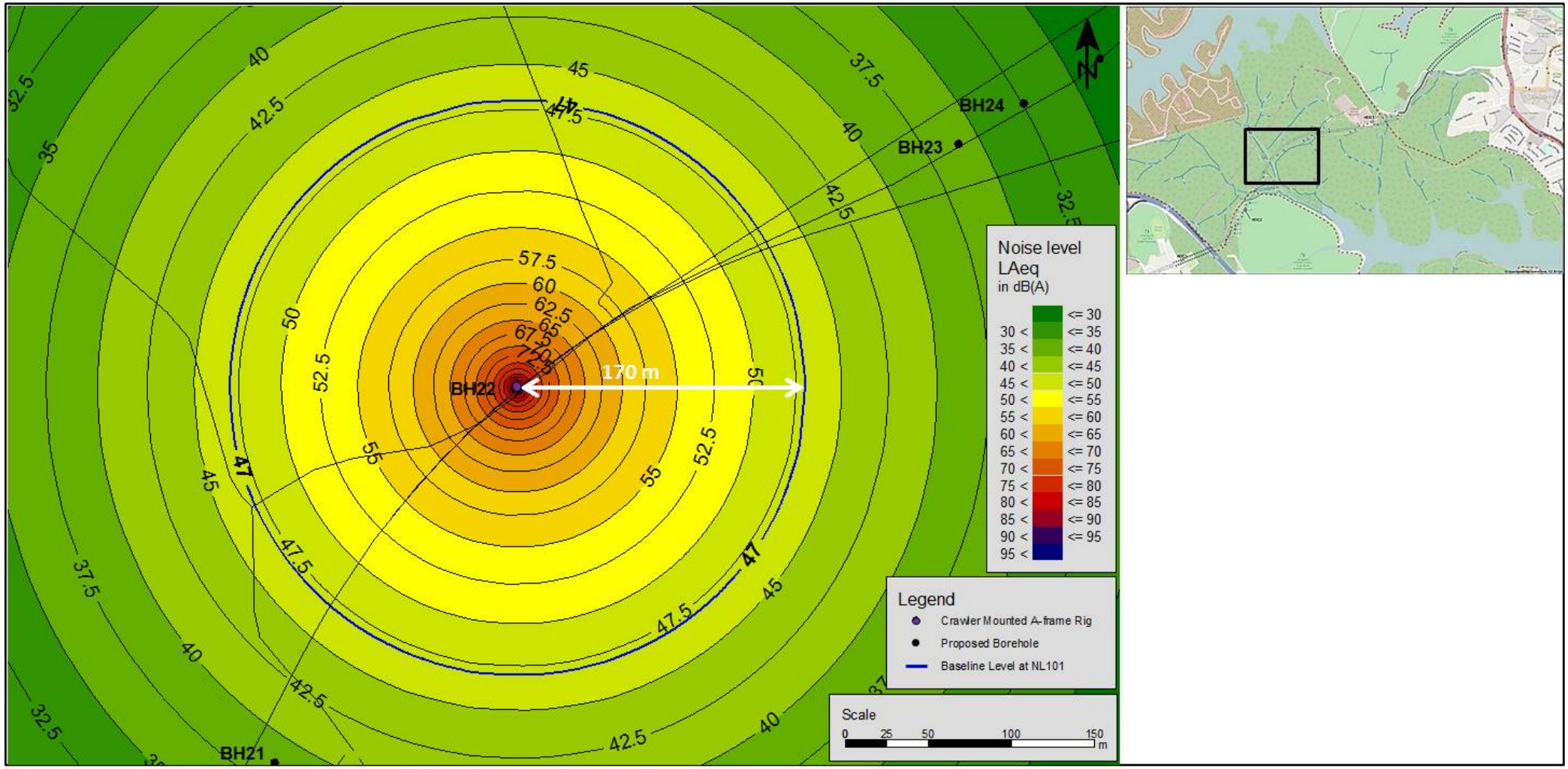
In addition to the embedded controls, the following mitigation measures are required during operation of the one crawler mounted A-frame rig;

- All rig operators to attend a pre-works tool box talk on equipment handling or noise minimization measures;
- Schedule works to avoid peak visitation periods in golf courses, ie weekends and events;
- A notice describing the proposed SI activities and their duration within the CCNR shall be posted on signboards at the MacRitchie Visitor Centre and Ranger Station for the duration of the SI Program;
- Rig and equipment used should have sound power specifications lower than (i) 105 dB(A) for rotary borehole drilling rigs before enclosure and 101 dB(A) after use of wooden enclosure for rig power source, and (ii) 96 dB(A) for diesel operated water pumps;
- All rigs and equipment to have the noise emission levels of (i) engine noise, and (ii) operational noise under normal conditions clearly indicated on a weather proof sticker pasted on the sides of these equipment to support equipment inspections;
- Rigs and equipment in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works; and
- All groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs to remove the piezometers from each location.

Where access permits, for example at BH01, BH20 and BH21, the use of quieter drilling equipment should be explored. The noise attenuation from the use of a DeltaBase 520 rig or similar is demonstrated in Scenario 2.

Due to space constraints along the trail, and in consideration of the need to minimize physical intrusion into the surrounding vegetation, the use of noise barriers to shield trail users from worksites was deemed unfeasible for borehole locations within the CCNR.

*Figure 4.1: Noise Contours for Scenario 1 ($L_{Aeq,5min}$) – Operation of One Crawler-Mounted A-frame Rig within the CCNR*



### *Residual Impact Assessment*

Following the implementation of the abovementioned mitigation measures, the impact magnitude (scale and extent) is likely to be reduced to ALARP. Nevertheless, predicted emissions are still expected to exceed current baseline levels by more than 10 dB(A) at open trails within 80 m of the nearest worksite; and by more than 3 dB(A) at open trails within 140 m of the nearest worksite. This corresponds to a *Small* to *Large* residual impact, depending on the distance of an open trail from the nearest worksite. Advance notification of recreational users would enable them to take alternative routes to avoid areas of SI activities, reducing their exposure and therefore the nuisance experienced by them. The residual impact is therefore assessed to be of *Minor to Moderate* impact significance.

***Table 4.9: Impact Assessment Summary for Scenario 1***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to operation of one crawler mounted A-frame rig for intrusive soil investigation using rotary boreholes along existing trails within the CCNR** | | |
| Nature | Negative | The Project will result in ambient noise levels that are predicted to exceed current baseline levels by up to 45 dB. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be short term, eg 10 minutes. |
| Extent | Local | Effects will be on recreational users within a radius of up to approximately 170 m from the worksites. |
| Scale | Large | Human receptors coming in close proximity to the rig may be directly exposed to levels up to 92 dB(A). |
| Frequency | Continuous | Borehole drilling rigs will be moved from location to location over a course of approximately six months, and be in continuous operation in the daytime. |
| Magnitude | Large | Predicted noise levels are more than 10 dB(A) above the baseline levels. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to short-term exposure to elevated ambient noise levels within the CCNR. |
| Residual Impact Magnitude | Large | The implementation of mitigation measures will reduce the magnitude to ALARP; however the noise levels are still expected to exceed the baseline levels by more than 10 dB(A). |
| Residual Impact Significance | Minor to Moderate | *Minor* impacts may occur where human receptors along open trails located within 140 m from the worksite, are exposed to noise levels more than 3 dB(A) above the baseline for a short duration of up to 10 minutes.<br><br>*Moderate* impacts may occur where human receptors along open trails within 80 m of the nearest worksite, are exposed to noise levels more than 10 dB(A) above the baseline for a short duration of up to 10 minutes. |

### *Scenario 2 – One DeltaBase 520 Rig within the CCNR*

This scenario explores the use of an alternative drilling rig, eg DeltaBase 520 or similar models, that has quieter noise specifications than the crawler mounted A-frame rig, within the CCNR. As the alternative rig is typically wider than the crawler mounted A-frame rig, the scenario considered the usage of the rig at BH01. This scenario is therefore representative of other similar borehole locations which can be

accessed by trails wider than 2.2 m, eg BH20 and BH21. Embedded controls such as the scheduling of the drilling works during the day, and temporary closure of the CCNR trail, were considered in this scenario.

The predicted noise generated from the DeltaBase 520 rig, is presented in *Figure 4.2*. As shown in *Figure 4.2*, the operation of the DeltaBase 520 rig will generate noise levels above the baseline, ie 59 dB(A) for BH01 (the minimum $L_{Aeq,12hr}$ value measured at NL101), at a distance of up to 35 m from the rig. Noise levels above the baseline ie 47 dB(A) as measured at the off-trail location NL102 were generated at a distance of up to 100 m from the rig. During drilling at BH01, human receptors using the nearest open trail, ie Golf Link, would not be exposed to elevated noise levels. During drilling at BH20 and BH21 which is 30 and 80 m respectively from the nearest open trail, ie Golf Link, human receptors would be exposed to levels up to 60 dB(A) and 50 dB(A), ie 13 dB(A) and 3 dB(A) above baseline noise levels. This corresponds to a *Negligible* impact magnitude at BH01, and a *Large* and *Small* impact magnitude for receptors along Golf Link during operations at BH20 and BH21 respectively.

Due to the faster rate of drilling as compared with the A-frame standard rig, it is estimated that the DeltaBase 520 rig will operate for approximately 11 days at each borehole location. Instantaneous baseline noise levels at NL101 and NL102, which are representative of CCNR locations close to and sheltered from the nearby PIE, peak at 72 and 82 dB(A) respectively (see *Table 4.1*).

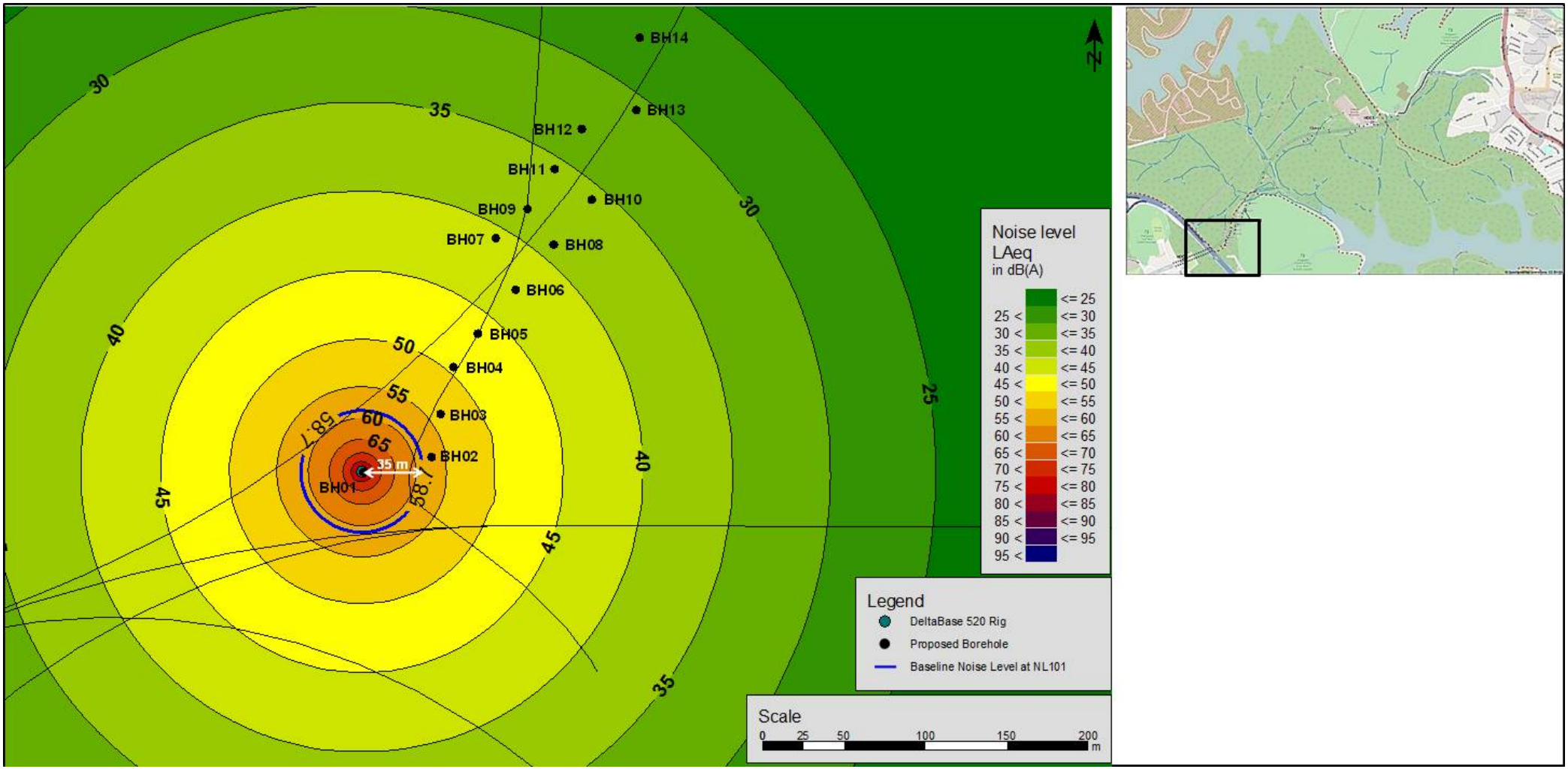
Similar to Scenario 1, the duration of exposure of human receptors passing by the worksite is anticipated to be short, ie likely to be in the range of less than 10 minutes a day. In addition, human receptors are currently exposed to elevated noise levels. The impact is therefore assessed to be of *Moderate* impact significance to human receptors within the CCNR.

### *Mitigation Measures*

In addition to the embedded controls, the following mitigation measures are required during operation of one DeltaBase 520 rig at BH20 and BH21:

- Signage to be posted at the worksite and along the trail in proximity to the worksite, to highlight that trail users are approaching a high noise working area;
- All rig operators to attend a pre-works tool box talk on equipment handling or noise minimization measures;
- Schedule works to avoid peak visitation periods in golf courses, ie weekends and events;
- A notice describing the proposed SI activities and their duration within the CCNR shall be posted on signboards at the MacRitchie Visitor Centre and Ranger Station for the duration of the SI Program;
- All rigs and equipment to have the noise emission levels of (i) engine noise, and (ii) operational noise under normal conditions clearly indicated on a weather proof sticker pasted on the sides of these equipment to support equipment inspections;
- Rigs in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works; and

*Figure 4.2: Noise Contours for Scenario 2 ($L_{Aeq,5min}$) – Operation of One DeltaBase 520 Rig within the CCNR*



- All groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs.

Due to space constraints along the trail, and in consideration of the need to minimize physical intrusion into the surrounding vegetation, the use of noise barriers to shield trail users from worksites was deemed unfeasible for borehole locations within the CCNR.

### *Residual Impact Assessment*

Following the implementation of the abovementioned mitigation measures, the impact magnitude (duration of exposure) is likely to be reduced to ALARP. Advance notification of recreational users would enable them to take alternative routes to avoid areas of SI activities, reducing their exposure and therefore the nuisance experienced by them. The residual impact is therefore assessed to be of *Minor to Moderate* significance.

***Table 4.10: Impact Assessment Summary for Scenario 2***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to operation of one DeltaBase520 rig or similar for intrusive soil investigation using rotary boreholes at BH01, BH20 and BH21** | | |
| Nature | Negative | The Project will result in ambient noise levels that are predicted to exceed current baseline levels by 26 dB(A) at BH01 and 38 dB(A) at BH20 and BH21. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be short term, eg 10 minutes. |
| Extent | Local | Effects will be on recreational users within a radius of up to approximately 35 m from the worksites. |
| Scale | Large | Human receptors coming in close proximity to the rig may be directly exposed to levels up to 85 dB(A). |
| Frequency | Continuous | Borehole drilling rigs will be moved from location to location over a course of approximately six months, and be in continuous operation in the daytime. |
| Magnitude | Negligible to Large | Negligible – Human receptors along the nearest open trail, ie Golf Link, will not be exposed to noise levels during operation of DB520 at BH01.<br><br>Small - Human receptors along the nearest open trail, ie Golf Link, will be exposed to noise levels up to 3 dB(A) above baseline during operation of DB520 at BH20.<br><br>Large - Human receptors along the nearest open trail, ie Golf Link, will be exposed to noise levels up to 13 dB(A) above baseline during operation of DB520 at BH21. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Negligible to Moderate | Negligible disturbance to human receptors along Golf Link during operation of DB520 at BH01.<br><br>Minor and Moderate disturbance to human receptors along Golf Link can be expected due to short-term exposure to noise levels during operation of DB520 at BH20 and BH21 respectively. |

| Criterion | Rating | Comment |
|---|---|---|
| Residual Impact Magnitude | Small to Large | The implementation of mitigation measures will reduce the magnitude to ALARP. Advance notification and scheduling will enable human receptors to avoid worksites, and thereby avoid or minimize exposure during operation of DB520 at BH20 and BH21. |
| Residual Impact Significance | Minor to Moderate | *Minor* impacts may occur where human receptors along Golf Link are exposed to noise levels up to 3 dB(A) above the baseline for a short duration of up to 10 minutes, during operation of DB520 at BH20.<br><br>*Moderate* impacts may occur where human receptors along Golf Link are exposed to noise levels up to 13 dB(A) above the baseline for a short duration of up to 10 minutes, during operation of DB520 at BH21. |

### *Scenarios 3 & 4 –Standard A-frame Rigs Outside the CCNR / Windsor Interim Green*

Standard A-frame rigs will be used for borehole locations outside the boundary of the CCNR and Windsor Interim Green, ie at BH02 – BH19, BH30 – BH33 and boreholes east of BH37. To shorten the overall duration of works at these locations, the simultaneous operation of three rigs (Scenario 3) and four rigs (Scenario 4) are considered. Due to the proximity of these locations to ecological receptors in the CCNR and the Island golf course, works would be restricted to the day (09.00 – 17.00). For operation of rigs on unpaved areas, eg within the SICC Bukit and Island Golf Courses, the worksite areas will be temporarily closed to public access in view of safety concerns. Human receptors will comprise of golfers and users of nearby CCNR trails.

The predicted noise generated from the simultaneous operation of three and four standard A-frame rigs for areas outside, but in close proximity to the CCNR boundary, are presented in *Figure 4.3* and *Figure 4.4* respectively. As shown in *Figure 4.3* and *Figure 4.4*, the simultaneous operation of three and four standard A-frame rigs will generate noise levels above the baseline at distances of up to 110 m and 125 m from the worksites, before attaining current baseline noise levels, ie minimum $L_{Aeq,12hr}$ 59 dB(A) as measured at NL101. It is noted that the baseline noise level at NL101, which is representative of the CCNR areas < 100 m from the PIE, will fluctuate in proportion to the traffic volume. Hourly baseline noise levels are shown to range between 56 and 72 dB(A) during the day (see *Table 4.1*). Recreational users of the Bukit Golf Course may already be exposed to short durations of elevated baseline noise levels due to passing traffic.

It is noted that during operations at BH02 –BH07, and BH09, the trail will be closed to public access. As shown in *Figure 4.3* and *Figure 4.4*, noise generated from the standard A-frame rigs would be attenuated to below baseline noise levels for human receptors at the nearest open trail, ie Golf Link. Golfers at the nearby fairways approximately 70 – 120 m away would be exposed to levels between 58 and 65 dB(A) for Scenario 3; and between 60 and 65 dB(A) for Scenario 4.

During operations at other locations outside CCNR, ie BH08, BH10 – BH19 in the Bukit Golf Course, BH30 – BH33 next to Kalang Service Reservoir, it is assumed as a worst-case scenario that the nearest CCNR trail would be open to recreational users. Human receptors would therefore comprise recreational users along the nearest trails located between 10 to 90 m from the worksites, and golfers less than 10 m from the worksites. These receptors would be exposed to noise levels between 63 and 80 dB(A) for both Scenarios 3 and 4. As the baseline levels are predicted to be exceeded by up to 21 dB(A), the impact magnitude is assessed to be *Large*.

***Figure 4.3: Noise Contours for Scenario 3 ($L_{Aeq,5min}$) – Operation of Three Standard A-Frame Rigs Outside the CCNR***

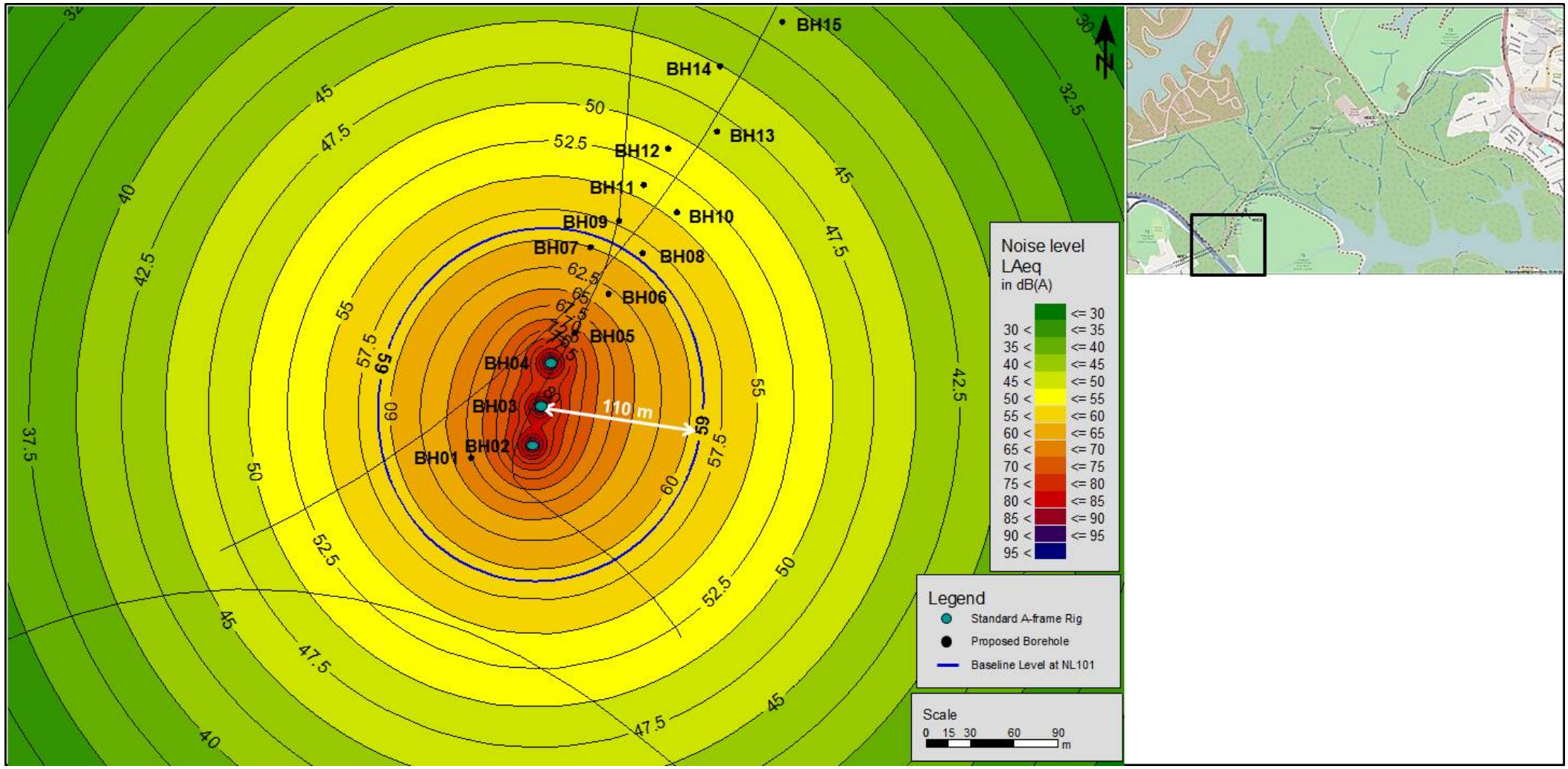
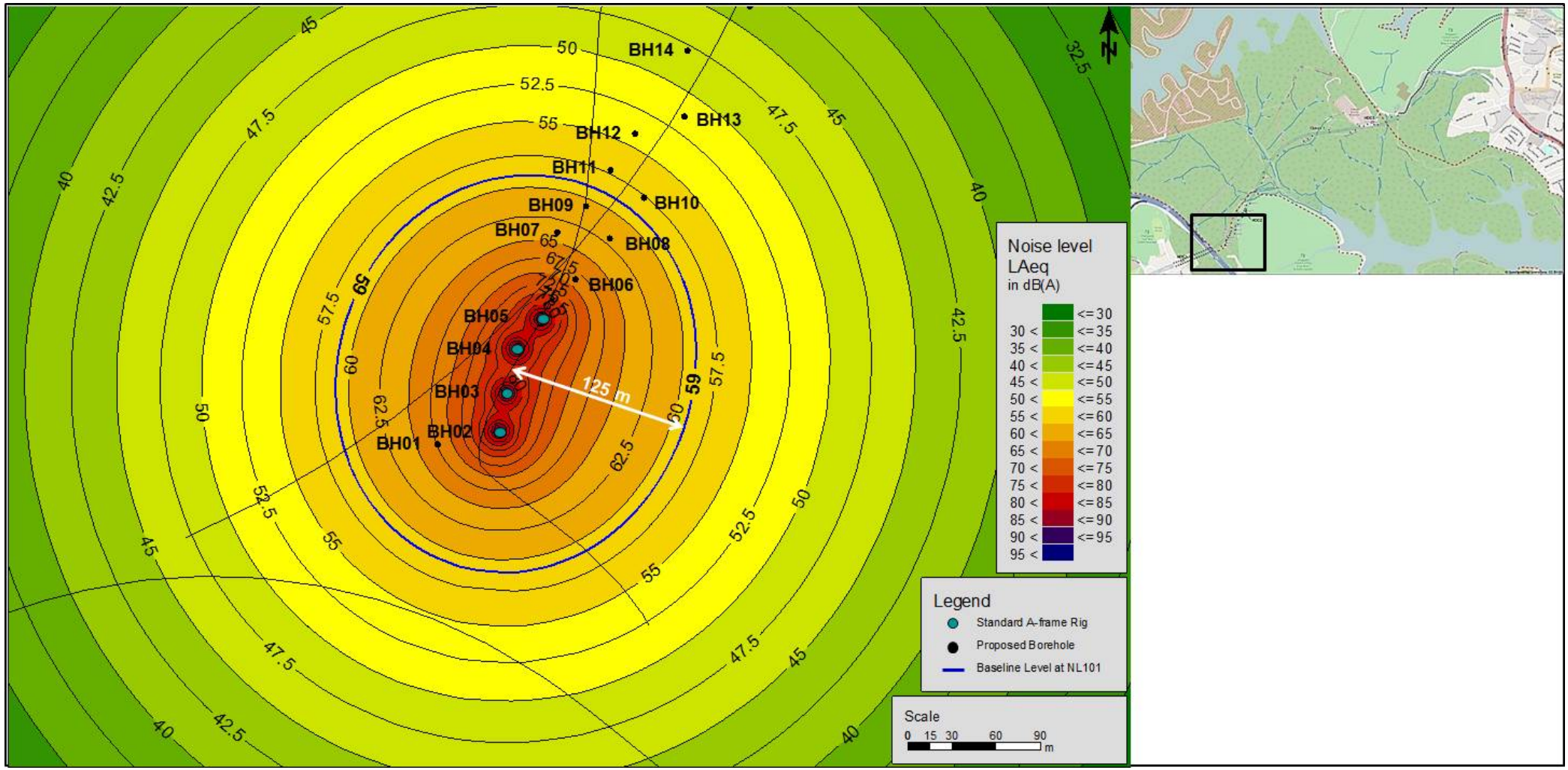


*Figure 4.4: Noise Contours for Scenario 4 ($L_{Aeq,5min}$) – Operation of Four Standard A-Frame Rigs Outside the CCNR*



It is estimated that the rigs will be in operation (including mobilization and demobilization) for up to 18 days at each proposed borehole location, ie SI works within the Island and Bukit Golf Courses might take up between 3 months (for Scenario 4) and 3.5 months (for Scenario 3) to complete. This might be shortened at sites outside the CCNR due to the use of motorized vehicles and accessibility of the worksite via an asphalt-covered track, compared with access via unpaved trails within the CCNR. It is anticipated however that direct exposure of human receptors such as users of nearby trails and golfers at the Island and Bukit Golf Courses would be short-term, ie 10 minutes for trail users and up to a few hours for golfers (worst case assumption). Considering the short duration of exposure, the impact is assessed to be of *Moderate* significance.

### *Mitigation Measures*

In addition to restricting rig operation to the day, the following mitigation measures are required during operation of standard A-frame rigs outside the boundary of CCNR and Windsor Interim Green:

- Use enclosures for all rig power pack to achieve sound power levels similar to the crawler rig, ie 101 dB(A);
- Where there are no space constraints, erect portable acoustic screens that are at least 2 m high, between worksite and nearby receptors, eg at BH08 – BH19, BH30 – BH33 and boreholes east of BH37;
- Maintain closure of Sime Trail during operation of drill rigs at BH02 – BH11;
- All rig operators to attend a pre-works tool box talk on equipment handling or noise minimization measures;
- Schedule works to avoid peak visitation periods in golf courses, ie weekends and events;
- Provide SICC management with the schedule of the proposed SI activities within the golf courses and promptly notify them of any schedule changes, to facilitate management of golfing activities in proximity to the worksites;
- Rig and equipment used should have sound power specifications lesser than (i) 105 dB(A) for rotary borehole drilling rigs before enclosure and 101 dB(A) after use of wooden enclosure for rig power source, and (ii) 96 dB(A) for diesel operated water pumps;
- All rigs and equipment to have the noise emission levels of (i) engine noise, and (ii) operational noise under normal conditions clearly indicated on a weather proof sticker pasted on the sides of these equipment to support equipment inspections;
- Rigs in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works; and
- Should there be an exceedance of the permissible noise limits during continuous noise monitoring at noise sensitive receptors, ie the golf clubhouses, temporarily suspend works and notify the LTA. LTA to then engage SICC and NEA, and undertake a review of the schedule of works to avoid impacts to human receptors as well as exceedance of the construction noise limits.

### *Residual Impact Assessment for Scenarios 3 & 4*

The usage of A-frame rigs with enclosed power packs, as well as portable acoustic screens at selected locations, was modelled to determine the noise benefit from implementation of these mitigation measures. The noise contours generated for operation of three and four crawler mounted A-frame rigs, where spatial constraints prevent the use of portable acoustic screens, are presented in *Figure 4.5* and *Figure 4.6* respectively. *Figure 4.5* indicates that while noise levels at 1 m from each rig remains high at $L_{Aeq,5min}$ 94 dB(A), noise levels above the baseline are generated up to 100 m from the rig instead of 110 m from the use of standard A-Frame rigs. *Figure 4.6* indicates that the operation of a fourth rig would cancel out the overall noise benefit from using enclosures for the rig power pack. The residual impact magnitude at these location is therefore *Large* as predicted levels after use of enclosures remain more than 10 dB(A) above the baseline.

The usage of crawler mounted rigs and portable acoustic screens, was further explored at suitable locations where there are no spatial constraints, eg BH13 – BH19. The noise contours generated for the simultaneous operation of three and four modified rigs are presented in *Figure 4.7* and *Figure 4.8* respectively. Both figures indicate that noise levels experienced by human receptors outside the worksite screens would be reduced from 63 – 80 dB(A) to 45 – 63 dB(A). This corresponds to a *Small* residual impact magnitude for receptors located within 75 m of the worksites where portable acoustic screens can be installed.

Following the implementation of the abovementioned mitigation measures, the impact magnitude (scale and extent) is likely to be reduced to ALARP at most worksites. Where there are constraints in implementing mitigation measures, eg portable acoustic screens for BH02 – BH07, BH09 and BH11), advance notification of golfers and trail users would enable them to schedule activities to avoid or minimize their exposure to high noise levels. Given the proximity to CCNR and aggregate noise level if four rigs operate concurrently side by side, schedule for one rig to operate at a time at the following worksites outside CCNR BH02-BH19, BH35 – BH37. The residual impact is therefore assessed to be *of Minor to Moderate* impact significance.

### *Table 4.11: Impact Assessment Summary for Scenarios 3 & 4*

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to operation of multiple standard A-frame rigs for intrusive soil investigation using rotary boreholes outside the boundary of CCNR and Windsor Interim Green** | | |
| Nature | Negative | The Project will result in ambient noise levels that are predicted to exceed current baseline levels by up to 21 dB(A). |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be short term, eg 10 min to a few hours. |
| Extent | Local | Effects will be on recreational users within a radius of 110 - 125 m from the worksites. |
| Scale | Large | Human receptors coming in close proximity to the rig may be directly exposed to levels up to 80 dB(A). |
| Frequency | Continuous | Borehole drilling rigs will be moved from location to location over a course of approximately six months, and be in continuous operation in the daytime. |
| Magnitude | Large | The predicted noise levels are more than 10 dB(A) above the baseline levels. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to short-term exposure to elevated ambient noise levels within the CCNR and within the golf courses. |
| Residual Impact Magnitude | Small to Large | Small - The implementation of mitigation measures will reduce the scale and extent of noise generated at receptors within 75 m of the worksites where portable acoustic screens can be installed, to within 5 dB(A) of baseline levels, ie Small residual impact magnitude.<br>Large - At locations where portable acoustic screens cannot be used, the predicted noise levels will be reduced by the use of enclosures; however noise levels will remain more than 10 dB(A) above the baseline. |
| Residual Impact Significance | Minor to Moderate | Minor adverse impact to human receptors within 75 m of worksites where there are no spatial constraints, ie where portable acoustic screens can be installed.<br>Moderate impacts to human receptors within 100 m of the worksites with spatial constraints, considering that advance notification will enable scheduling of activities to avoid or minimize human exposure to high noise levels. |

*Figure 4.5: Noise Contours for Scenario 3 ($L_{Aeq,5min}$) After Mitigation – Operation of Three Crawler Mounted A-Frame Rigs Outside the CCNR*

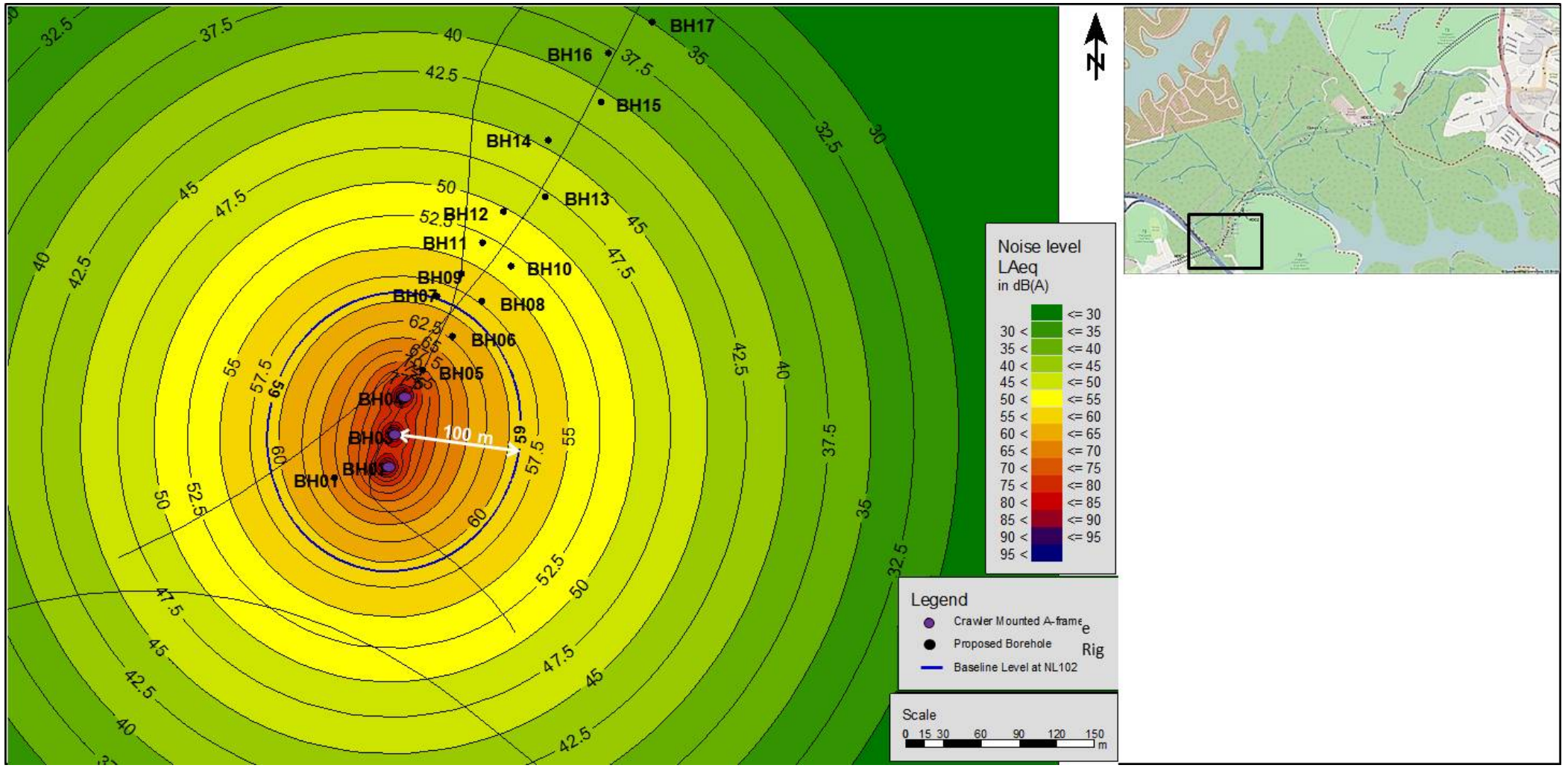


*Figure 4.6: Noise Contours for Scenario 4 ($L_{Aeq,5min}$) After Mitigation – Operation of Four Crawler Mounted A-Frame Rigs Outside the CCNR*

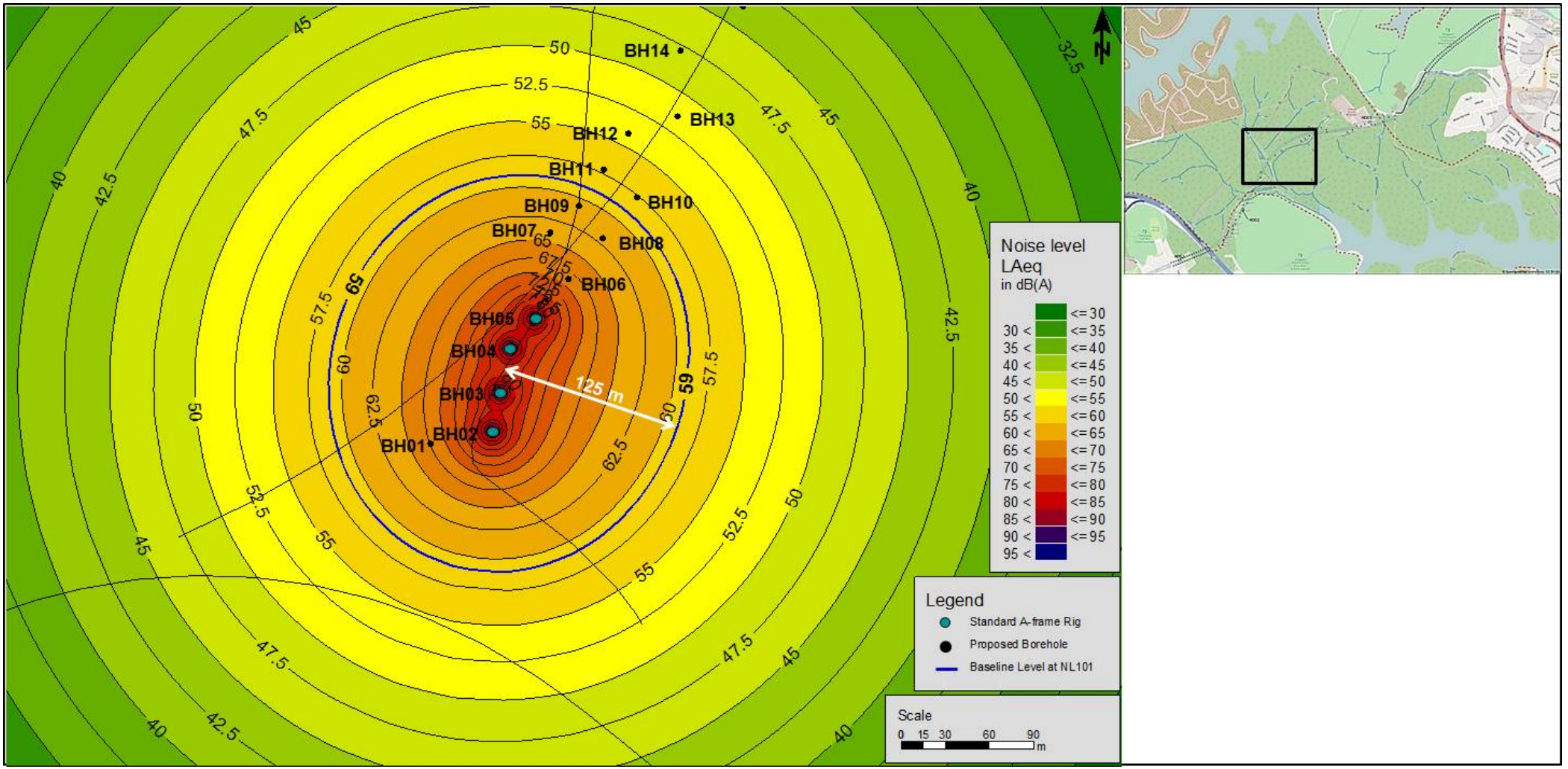


***Figure 4.7: Noise Contours for Scenario 3 ($L_{Aeq,5min}$) After Mitigation – Operation of Three Crawler-Mounted A-Frame Rigs Outside the CCNR, with Portable Acoustic Screens***

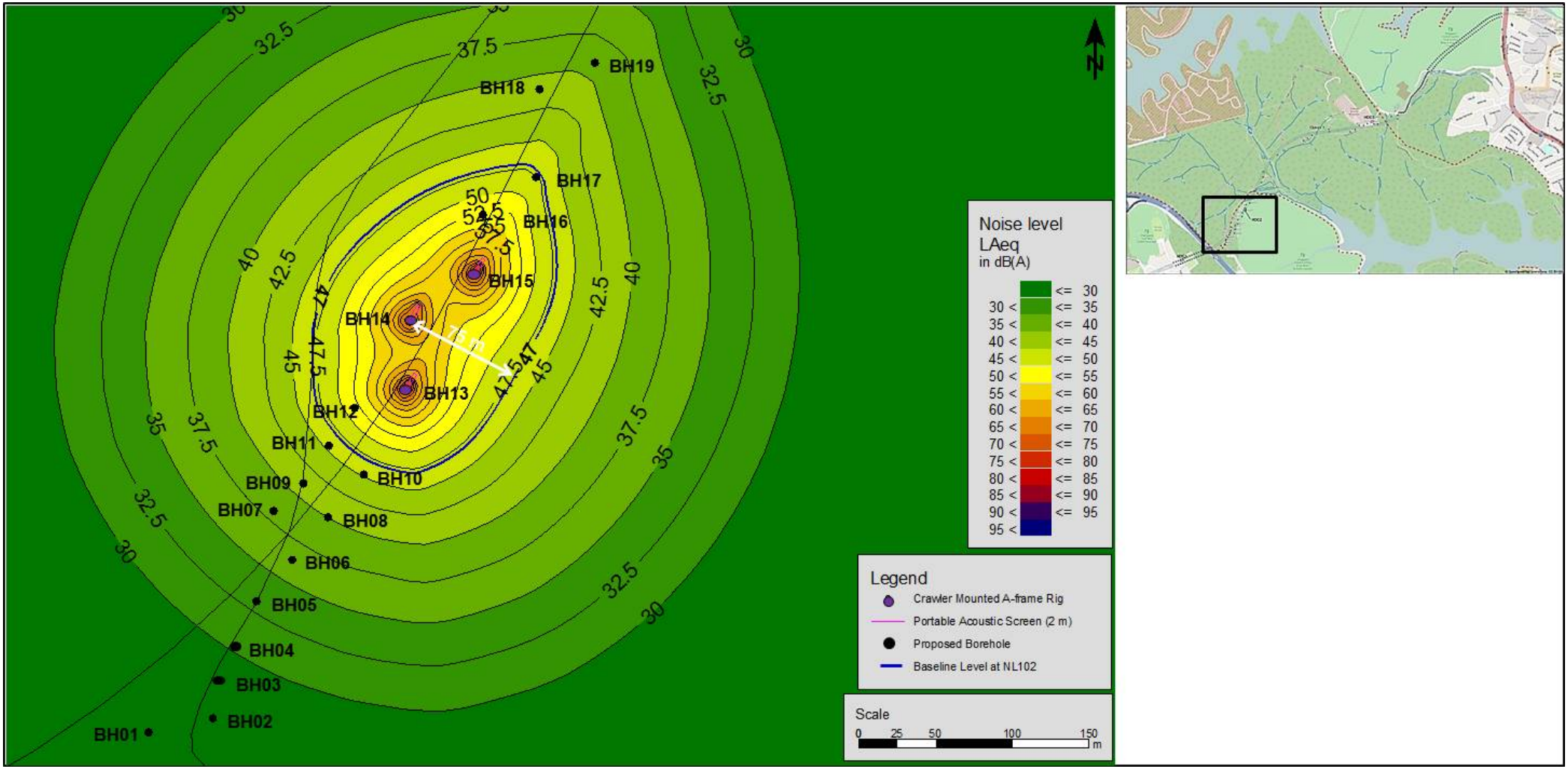
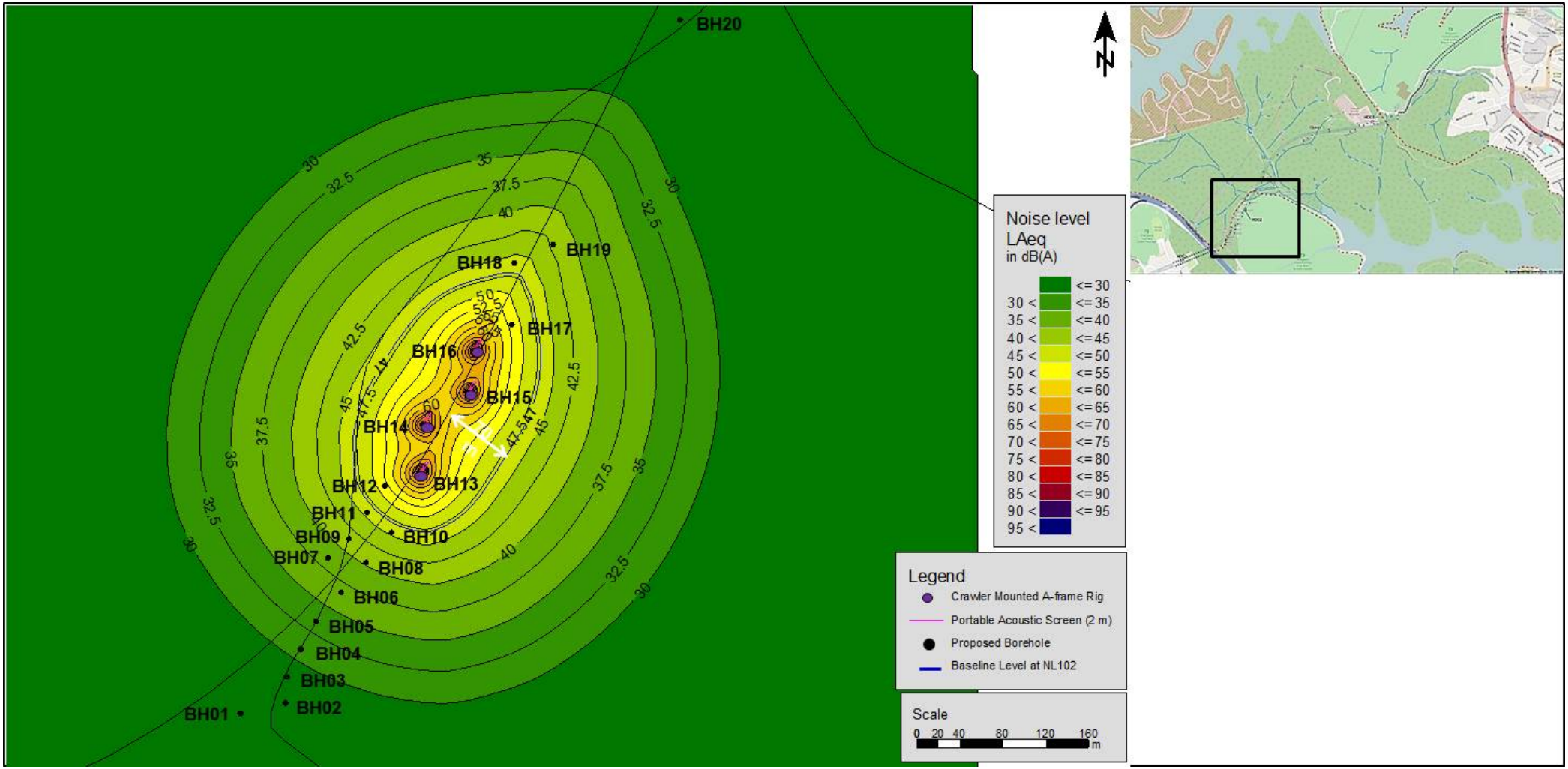


***Figure 4.8: Noise Contours for Scenario 4 ($L_{Aeq,5min}$) After Mitigation – Operation of Four Crawler-Mounted A-Frame Rigs Outside the CCNR, with Portable Acoustic Screens***



### *Scenario 5 –One Crawler Mounted & Four Standard A-frame Rigs*

The simultaneous operation of one crawler mounted A-frame rig and four standard A-frame rigs in areas in close proximity to the CCNR boundary, eg at BH01 to BH05, constitutes the worst-case scenario for SI works proposed for Alignment Option 1 in terms of the maximum number of rigs operating at the same time. This scenario considers the implementation of embedded controls such as restriction to daytime hours, use of enclosure for crawler mounted A-frame rig power pack and temporary closure of trails. The predicted noise generated from this scenario is presented in *Figure 4.9*.

As shown in *Figure 4.9*, noise levels above the baseline levels are predicted at distances of up to 170 m from the five worksites. Human receptors at the nearest open trail within the CCNR, ie Golf Link would not be exposed to noise from the worksites; however, golfers at the nearby fairway approximately 65 m away would be exposed to levels up to 73 dB(A). This corresponds to a *Large* impact magnitude for the golfers.

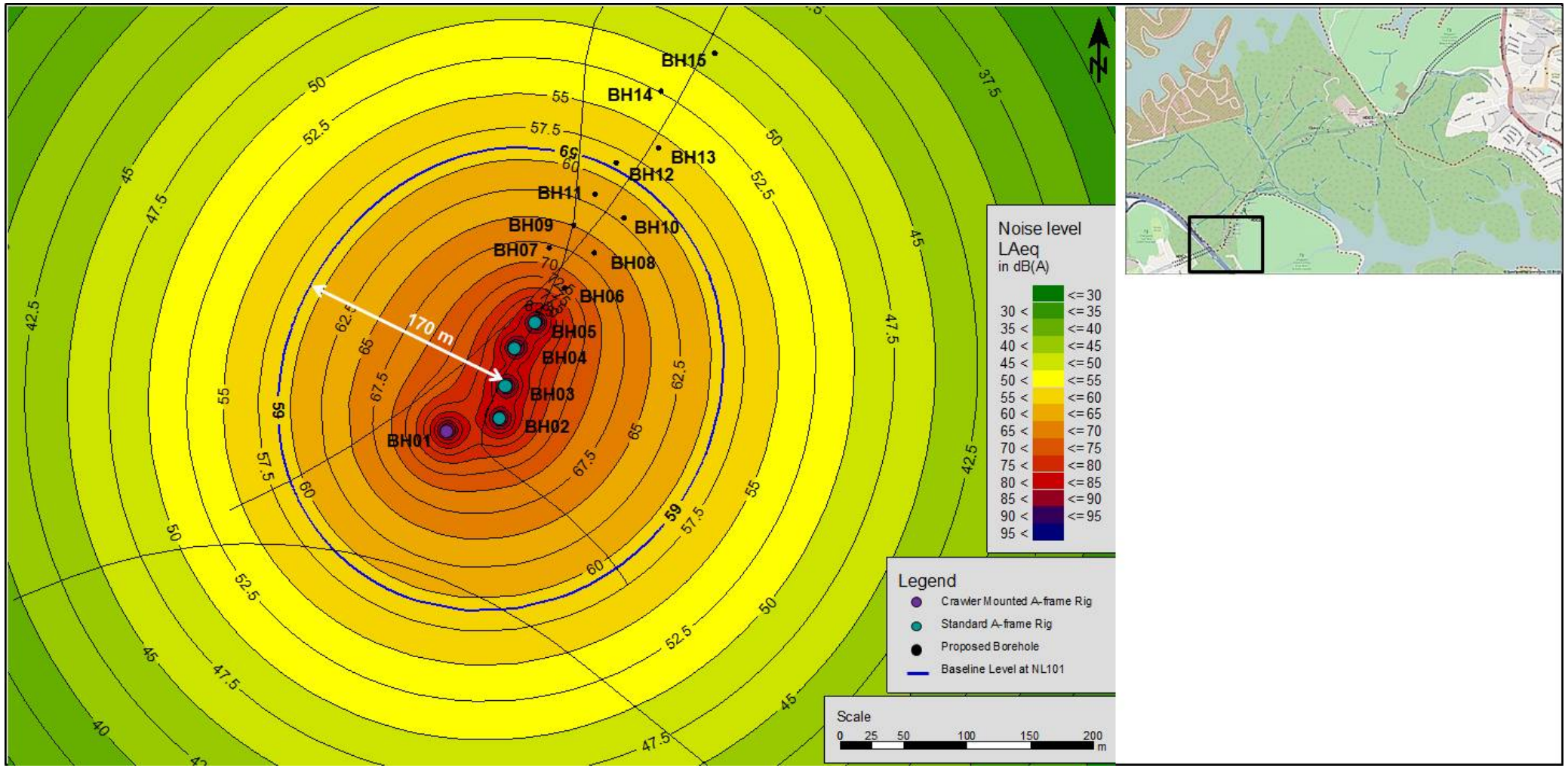
Although the rig will be in operation for up to 18 days at each proposed borehole location, the direct exposure of golfers at the Bukit Golf Course is anticipated to be short-term, ie up to a maximum of a few hours. In consideration of the short-term duration of exposure, the impact is assessed to be of *Moderate* significance.

### *Mitigation Measures for Scenario 5*

In addition to the embedded controls, the following mitigation measures are required during operation of a crawler mounted A-frame rig at BH01, and four standard A-frame rigs at BH02 to BH05:

- Use enclosures for all rig power pack to achieve sound power levels similar to the crawler rig, ie 101 dB(A);
- All rig operators to attend a pre-works tool box talk on equipment handling or noise minimization measures;
- Schedule works to avoid peak visitation periods in golf courses, ie weekends and events;
- Provide SICC management with the schedule of the proposed SI activities within the golf courses and promptly notify them of any schedule changes, to facilitate management of golfing activities in proximity to the worksites;
- Standard A-frame rig and equipment used should have sound power specifications lesser than (i) 105 dB(A) for rotary borehole drilling rigs before enclosure and 101 dB(A) after use of wooden enclosure for rig power source, and (ii) 96 dB(A) for diesel operated water pumps;
- All rigs and equipment to have the noise emission levels of (i) engine noise, and (ii) operational noise under normal conditions clearly indicated on a weather proof sticker pasted on the sides of these equipment to support equipment inspections; and
- Rigs in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works.

*Figure 4.9: Noise Contours for Scenario 5 ($L_{Aeq,5min}$) – Operation of One Crawler Mounted A-frame Rig Within & Four Standard A-frame Rigs Outside the CCNR*



### *Residual Impact Assessment for Scenario 5*

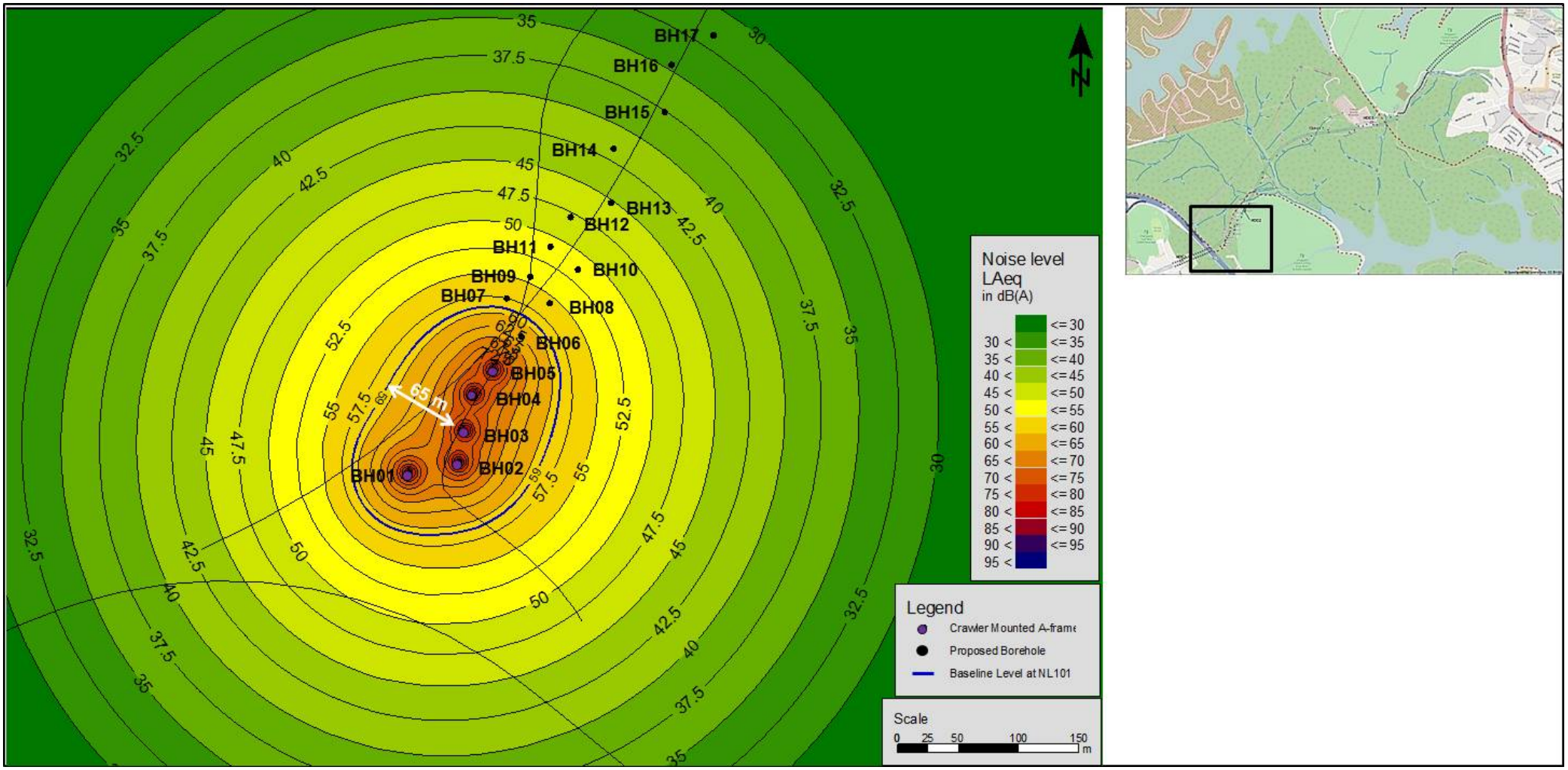
A crawler mounted A-frame rig equipped with an enclosure for the rig power pack was modelled instead of the standard A-frame rigs at BH02 – BH05 to determine the noise benefit from usage of enclosures. The noise contours are presented in *Figure 4.10*. *Figure 4.10* indicates that after mitigation, noise levels of up to 60 dB(A) are predicted for golfers located 65 m from the worksites. It was found that noise levels will attenuate to the background level over a shorter distance, ie 65 m instead of the 170 m when using a standard rig. This is an exceedance of up to 1 dB(A) above the baseline, which corresponds to a *Small* residual impact magnitude at the nearby fairway.

Advance notification of recreational users would enable them to take alternative routes to avoid areas of SI activities, reducing their exposure and therefore the nuisance experienced by recreational users of the CCNR. The residual impact is therefore assessed to be of *Minor* significance.

***Table 4.12: Impact Assessment Summary for Scenario 5***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to operation of one crawler mounted A-frame rig and four standard A-frame rigs for intrusive soil investigation using rotary boreholes along existing trails within and near the CCNR boundary.** | | |
| Nature | Negative | The Project will result in ambient noise levels that are predicted to exceed current baseline levels by up to 35 dB(A), for the scenarios considered. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be temporary, short term, eg 10 minutes to a few hours at a time. |
| Extent | Local | Effects will be on recreational users within a radius of up to approximately 170 m from the worksites. |
| Scale | Large | Human receptors coming in close proximity to the rig may be directly exposed to levels up to 73 dB(A). |
| Frequency | Continuous | Borehole drilling rigs will be moved from location to location over a course of approximately six months, and be in continuous operation in the daytime. |
| Magnitude | Large | Human receptors on the nearby fairway will be exposed to noise levels that are more than 10 dB(A) above the baseline. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to short-term exposure to elevated ambient noise levels within the Bukit Golf Course. |
| Residual Impact Magnitude | Small | The implementation of mitigation measures will reduce the exceedance to up to 1 dB(A). |
| Residual Impact Significance | Minor | Minor adverse impact to human receptors from the use of enclosed power packs as well as advance notification to enable human receptors to avoid worksites, thereby avoiding or minimizing exposure. |

*Figure 4.10: Noise Contours for Scenario 5 ($L_{Aeq,5min}$) After Mitigation – Operation of Crawler Mounted A-frame Rigs Within & Outside the CCNR*



### *Scenario 6 –Two Crawler Mounted A-frame Rigs Within & One Rig Near the CCNR Boundary*

The simultaneous operation of two crawler mounted A-frame rigs within the CCNR (eg BH25 and BH26) and one crawler mounted A-frame rig in close proximity to the CCNR boundary, eg at BH37, constitutes the worst-case scenario for SI works proposed for Alignment Option 1 in terms of the proximity of rigs to sensitive ecological and human receptors. This scenario considers the implementation of embedded controls such as restriction to daytime hours, use of enclosure for crawler mounted A-frame rig power pack and temporary closure of Sime and Terentang trails. It is noted that MacRitchie Nature Trail where BH37 will be located will not be closed during rig operation. This is in view of the need to maintain public accessibility to open trails and considering that the trail will be wide enough to allow safe passage of recreational users past the worksites. The predicted noise generated from this scenario is presented in *Figure 4.11*.

As shown in *Figure 4.11*, noise levels above the baseline levels are predicted at distances between 170 and 180 m from the rigs. Human receptors at the nearest open trail within the CCNR, ie the track to the Rangers Station, would be exposed to levels up to 50 dB(A); however, human receptors accessing the CCNR from MacRitchie Nature Trail and Island Club Road would be exposed to levels up to 92 dB(A). This corresponds to a *Small* impact magnitude for recreational users within the CCNR, and to a *Large* impact magnitude for the recreational users near the junction of MacRitchie Nature Trail and Island Club Road.

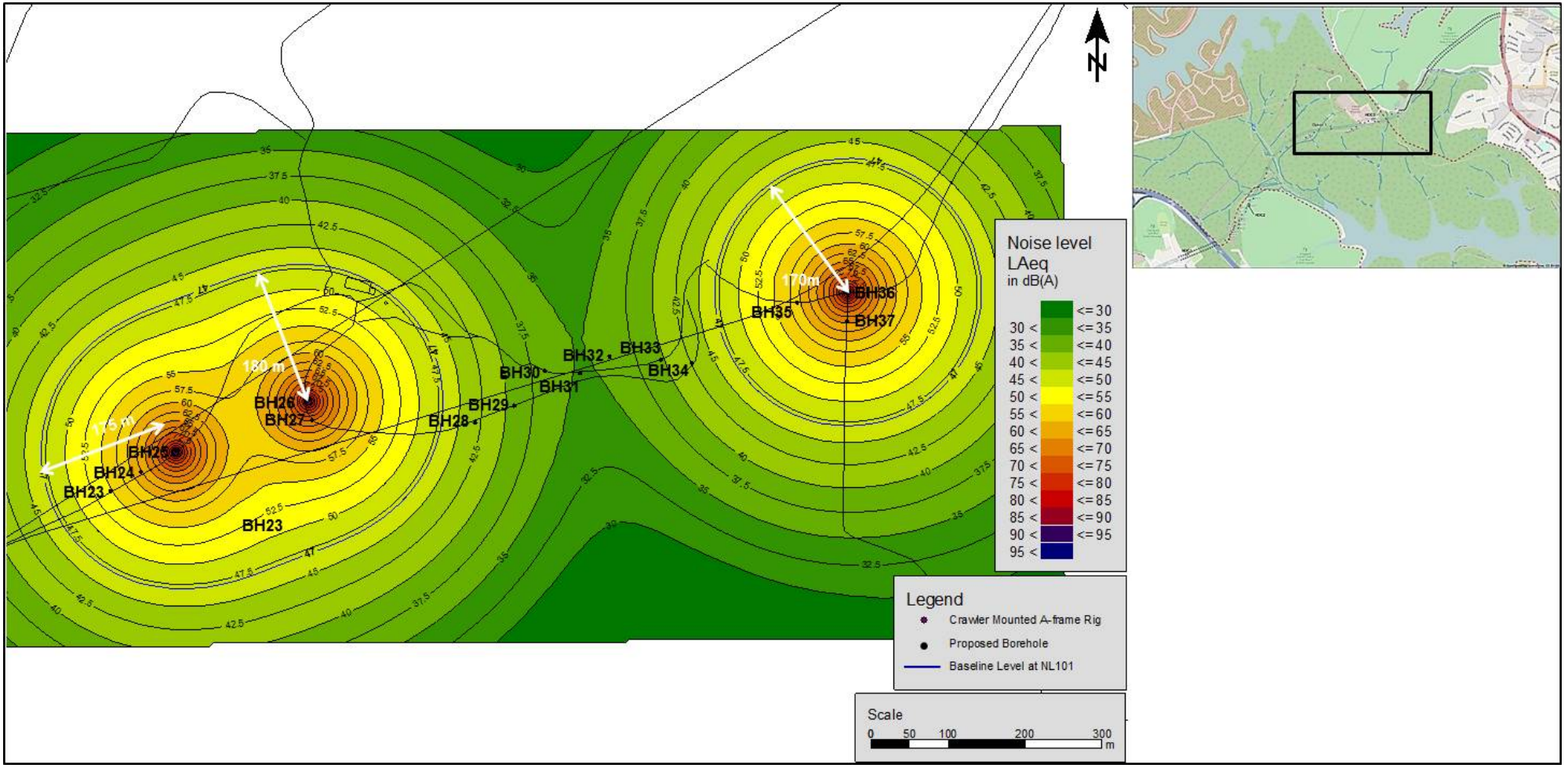
Although the rig will be in operation for up to 18 days at each proposed borehole location, the direct exposure of trail users is anticipated to be short-term, ie ranging between a few minutes for passersby and a few hours for users resting at the Rangers Station. In consideration of the short-term duration of exposure, the impact is assessed to be of *Moderate* significance.

### *Mitigation Measures for Scenario 6*

In addition to the embedded controls, the following mitigation measures are required during operation of two crawler mounted A-frame rigs within the CCNR, and one crawler mounted A-frame rig outside the CCNR:

- All rig operators to attend a pre-works tool box talk on equipment handling or noise minimization measures;
- Schedule works to avoid peak visitation periods in golf courses, ie weekends and events;
- A notice describing the proposed SI activities and their duration within the CCNR shall be posted on signboards at the MacRitchie Visitor Centre and Ranger Station for the duration of the SI Program;
- Rig and equipment used should have sound power specifications lower than (i) 105 dB(A) for rotary borehole drilling rigs before enclosure and 101 dB(A) after use of wooden enclosure for rig power source, and (ii) 96 dB(A) for diesel operated water pumps;
- All rigs and equipment to have the noise emission levels of (i) engine noise, and (ii) operational noise under normal conditions clearly indicated on a weather proof sticker pasted on the sides of these equipment to support equipment inspections;

*Figure 4.11: Noise Contours for Scenario 6 ($L_{Aeq,5min}$)– Operation of Crawler Mounted A-frame Rigs Within & Outside the CCNR*



- Rigs and equipment in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works; and
- All groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs.

Due to space constraints along the trail, and in consideration of the need to minimize physical intrusion into the surrounding vegetation, the use of noise barriers to shield trail users from worksites was deemed unfeasible for borehole locations along the CCNR trails.

### *Residual Impact Assessment for Scenario 6*

Following the implementation of the abovementioned mitigation measures, the impact magnitude (scale and extent) is likely to be reduced to ALARP. Nevertheless, predicted emissions are still expected to exceed current baseline levels by more than 10 dB(A) at open trails within 80 m of the nearest worksite; and by more than 3 dB(A) at open trails within 150 m of the nearest worksite. This corresponds to a *Small* to *Large* residual impact, depending on the distance of an open trail from the nearest worksite. Advance notification of recreational users would enable them to take alternative routes to avoid areas of SI activities, reducing their exposure and therefore the nuisance experienced by recreational users of the CCNR. The residual impact is therefore assessed to be of *Minor to Moderate* impact significance.

***Table 4.13: Impact Assessment Summary for Scenario 6***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to operation of two crawler mounted A-frame rigs within and one crawler mounted A-frame rig near the CCNR boundary for intrusive soil investigation using rotary boreholes.** | | |
| Nature | Negative | The Project will result in ambient noise levels that are predicted to exceed current baseline levels by up to 45 dB(A). |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be temporary, short term, eg 10 minutes to a few hours at a time. |
| Extent | Local | Effects will be on recreational users within a radius of up to approximately 180 m from the worksites. |
| Scale | Large | Human receptors coming in close proximity to the rig may be directly exposed to levels up to 92 dB(A). |
| Frequency | Continuous | Borehole drilling rigs will be moved from location to location over a course of approximately six months, and be in continuous operation in the daytime. |
| Magnitude | Large | Human receptors along the nearest open CCNR trail will be exposed to noise levels that are more than 10 dB(A) above the baseline. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to short-term exposure to elevated ambient noise levels, during utilization of open CCNR trails. |
| Residual Impact Magnitude | Small | The implementation of mitigation measures will reduce the magnitude to ALARP; however the noise levels are still expected to exceed the baseline levels by more than 10 dB(A). |

| Criterion | Rating | Comment |
|---|---|---|
| Residual Impact Significance | Minor to Moderate | *Minor* impacts may occur where human receptors along open trails located within 150 m from the worksite, are exposed to noise levels more than 3 dB(A) above the baseline for a short duration.<br><br>*Moderate* impacts may occur where human receptors along open trails within 80 m of the nearest worksite, are exposed to noise levels more than 10 dB(A) above the baseline for a short duration of up to 10 minutes. |

### 4.5.4 Impacts due to Horizontal Directional Coring

HDC works will be undertaken at three locations within the Project Area; however, the HDC worksites will be located outside the CCNR. The predicted noise generated from the simultaneous operation of the three HDC rigs boundary is presented in *Figure 4.12*. As shown in *Figure 4.12*, elevated noise levels are predicted to extend up to a radius of 135 m from each HDC rig before attaining baseline noise levels characteristic of the surrounding, eg PIE, Island Club Road. Long-term measurements undertaken at NL101 and NL104 indicate that minimum daytime $L_{Aeq,12hr}$ levels are 59 and 61 dB(A) respectively. It is noted that hourly baseline measurements at both these locations are predominantly influenced by passing traffic, and were observed to fluctuate between 56 and 72 dB(A) at NL101, and 57 to 72 dB(A) at NL104. Receptors are therefore already exposed to high noise levels due to passing vehicular traffic. Night-time criteria are not considered applicable in this scenario despite operation of HDC rigs during the night, as the surrounding areas are closed to recreational users at night.

It is estimated that the HDC rigs will be in continuous operation for up to 2 years, ie long-term duration. The human receptors directly exposed to noise levels associated with the HDC rigs are recreational users of the nearby trails and golfers utilizing the SICC Island and Bukit Golf Courses. The noise contours indicate that these human receptors will be exposed to levels of up to $L_{Aeq,12hr}$ 75 dB(A), ie 16 dB(A) above baseline $L_{Aeq,12hr}$ noise levels of 59 dB(A) at Bukit Golf Course; and 9 dB(A) above baseline $L_{Aeq,12hr}$ noise levels of 61 dB(A) at Island Club Road, ie *Large* impact magnitude.

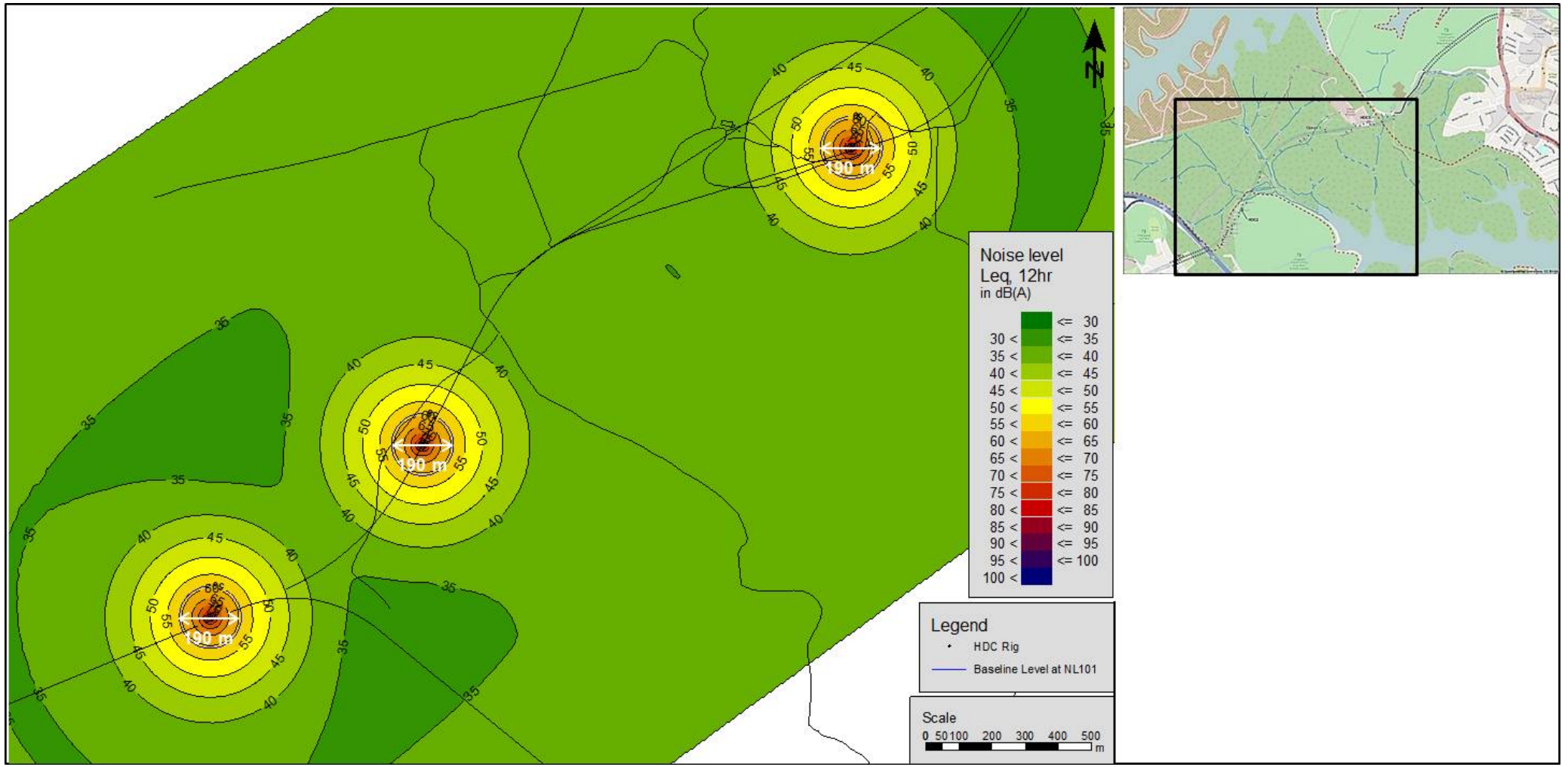
It is noted that trail users will likely be exposed to noise levels for a short duration, ie less than 10 minutes. Similarly, golfers are likely to be exposed for a short duration, ie up to a few hours per day. The impact is therefore assessed to be of *Moderate* impact significance.

#### Mitigation Measures for HDC Works (Scenario 7)

The following mitigation measures are required during operation of the three HDC rigs, especially at worksites located in close proximity to the CCNR boundary:

- Erect noise barriers (at least 3 m high) between the worksite and nearby receptors, ie golfers and recreational users within the CCNR;
- All rig operators to attend a pre-works tool box talk on equipment handling or noise minimization measures;
- All rigs and equipment to have the noise emission levels of (i) engine noise, and (ii) operational noise under normal conditions clearly indicated on a weather proof sticker pasted on the sides of these equipment to support equipment inspections;

***Figure 4.12: Noise Contours for Scenario 7 ($L_{Aeq,12hr}$) – Operation of Three HDC Rigs Outside the CCNR***



- Rigs in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works;

- Use low-noise generators[7] and/or engines, ie models which are at least 5 dB(A) quieter than 2 other equipment model types commonly used in Singapore;

- Locate the noise-generating equipment as far from nearby receptors as possible within the worksite, and

- Use acoustic enclosures for noise-generating equipment such as portable generator sets, water recirculation pumps etc. For the construction of machinery enclosures, a sheet material mass of at least 10 kg/m$^3$ is recommended[8]. 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 performance requirements for enclosures published by NEA under its *Guidelines on Quieter Construction Fund*[9].

### *Residual Impact Assessment for HDC Works (Scenario 7)*

Following the implementation of the abovementioned mitigation measures, the impact magnitude is likely to be reduced to ALARP, in particular for users of CCNR trails in close proximity to the HDC rig located within the SICC (Bukit location). As shown in *Figure 4.13*, after installation of 3 m high noise barriers, predicted emissions at CCNR trails adjacent to the HDC rig along Island Club Road are reduced to below current baseline levels. Golfers within the Bukit golf course within 25 m of the worksite would be exposed to levels up to 65 dB(A), ie *Medium* residual impact magnitude. Considering the short exposure duration of receptors, the residual impact due to operation of HDC rigs is assessed to be of *Minor* significance.

[8] British Standards Institution (2008) **Code of practice for noise and vibration control on construction and open sites – Part 1: Noise (BS 5228-1: 2009).**

[9] NEA (nd) **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

***Figure 4.13: Noise Contours for Scenario 7 ($L_{Aeq,12hr}$) – Operation of Three HDC Rigs Outside the CCNR (Post Mitigation)***

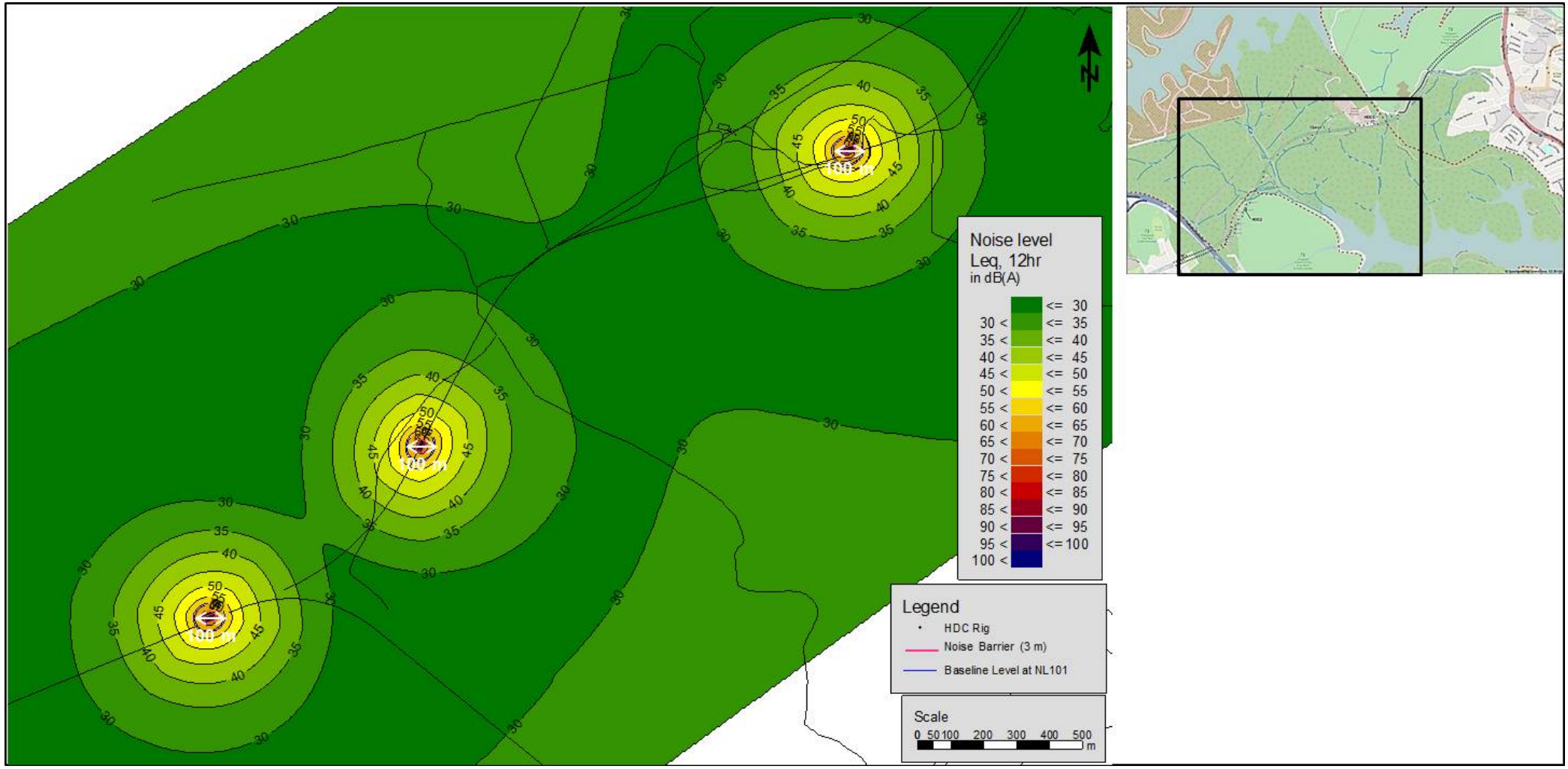


***Table 4.14: Impact Assessment Summary for Horizontal Directional Coring***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to operation of HDC rigs** | | |
| Nature | Negative | The Project will result in incremental ambient noise levels which will exceed current baseline levels by up to 16 dB(A). |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be short term, eg 10 minutes to a few hours at a time. |
| Extent | Local | Effects will be on recreational users within a radius of ~95 m from the worksites. |
| Scale | Large | Human receptors coming in close proximity to the rig can be directly exposed to levels up to 75 dB(A), which could lead to nuisance impacts. |
| Frequency | Continuous | HDC rigs will be in continuous operation for up to 2 years. |
| Magnitude | Large | The predicted noise levels are more than 10 dB(A) above the baseline. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to short-term exposure to elevated ambient noise levels within and/or in close proximity to the CCNR, and within the SICC Bukit Golf Course. |
| Residual Impact Magnitude | Negligible to Medium | Negligible - After mitigation, users of the nearest open CCNR trails adjacent to the HDC rig along Island Club Road will not be exposed to levels above the baseline.<br>Medium - Golfers within the Bukit golf course within 25 m of the worksite would be exposed to levels up to 6 dB(A) above the baseline. |
| Residual Impact Significance | Minor | Minor adverse impact to human receptors after implementation of mitigation measures, considering the short duration of exposure. |

### *4.5.5 Impacts due to Usage of Ancillary Vehicles*

Vehicles will be deployed during the mobilization and demobilization of worksites, to transport all ancillary equipment apart from the drilling rig eg drill rods, borehole casings etc. A variety of vehicles have been identified taking into consideration trail and/or road access widths and conditions. The usage of each of these vehicles, ie lorry crane, Cabstar lorry and S25A, has been simulated in Scenarios 7, 8 and 9. Smaller vehicles, such as S25A or equivalent, will also be used for transportation of water and wastewater during drilling works at locations within the CCNR. The use of this vehicle is simulated respectively in Scenario 10.

#### *Scenario 8 – Lorry Crane (Mobilization & Demobilization)*

A lorry crane will be deployed for mobilization and demobilization of equipment at BH30 to BH33 via Kalang Service Reservoir Road; boreholes along Island Club Road, via Island Club Road; and boreholes within the Island and Bukit golf courses. The current Sime Trail extending from Sime Road up to Jelutong Tower consists of a gravel path that has been adapted for use by vehicles. The lorry crane will therefore also be deployed to mobilize and demobilize equipment at BH01, located within the CCNR.

As Kalang Service Reservoir Road and Island Club Road are currently used by heavy vehicles and passenger cars accessing the Kalang Service Reservoir and the SICC Island golf course respectively, noise impacts due to deployment of a lorry crane along these roads was not deemed to be significant. In consideration of the usage of the CCNR and the neighboring golf courses for recreational uses,

deployment of the lorry crane to BH01 via the Sime Road and Sime Trail, and within the Island golf course was simulated to determine potential noise impacts. The model took into account deployment of the lorry crane for one round trip per mobilization and demobilization within the CCNR and at off-road locations within the golf course.

It is observed that due to safety concerns, public access to both the Sime Trail section would be temporarily closed during deployment of the lorry crane. It is therefore unlikely that joggers utilizing other open trails within the CCNR would be exposed to noise generated from the lorry crane. Golfers utilizing the putting greens in close proximity to the borehole locations at Island and Bukit golf courses might however be exposed to noise generated from the lorry crane.

Noise contours from these simulations are presented in *Figure 4.14* and *Figure 4.15* respectively. As shown in *Figure 4.14* and *Figure 4.15*, noise levels are predicted to exceed the baseline $L_{Aeq,5min}$ level of 54 dB(A) at distances up to 30 m from the haul route for BH01; and to exceed the baseline $L_{Aeq,5min}$ level of 53 dB(A) at distances up to 80 m from the haul route within the Island Golf Course. Noise levels of up to $L_{Aeq,5min}$ 69 dB(A) at 1 m from the haul route will be generated by the movement of the lorry crane. This is an exceedance of more than 10 dB(A), therefore corresponding to a *Large* magnitude.

In addition, the generation of noise from the lorry crane would be over a short duration of approximately 10 minutes. This is evident from the resultant $L_{Aeq,1hr}$ values, which was predicted at up to 59 dB(A) at 1 m from the haul route ie $L_{Aeq,1hr}$ levels are only 2 to 3 dB(A) above the baseline $L_{Aeq,1hr}$ values at BH01 (56 dB(A))and within the Island golf course (57 dB(A)). The frequency of the event is limited to two trips per borehole over the 11 to 18 day period, further reducing the number of receptors who may be exposed to elevated noise levels. The impact is therefore of *Minor* significance to golfers in close proximity to the borehole locations at Island golf course.

*Figure 4.14: Noise Contours for Scenario 8 ($L_{Aeq,5min}$) – Operation of Lorry within the CCNR (Mobilization / Demobilization at BH01)*

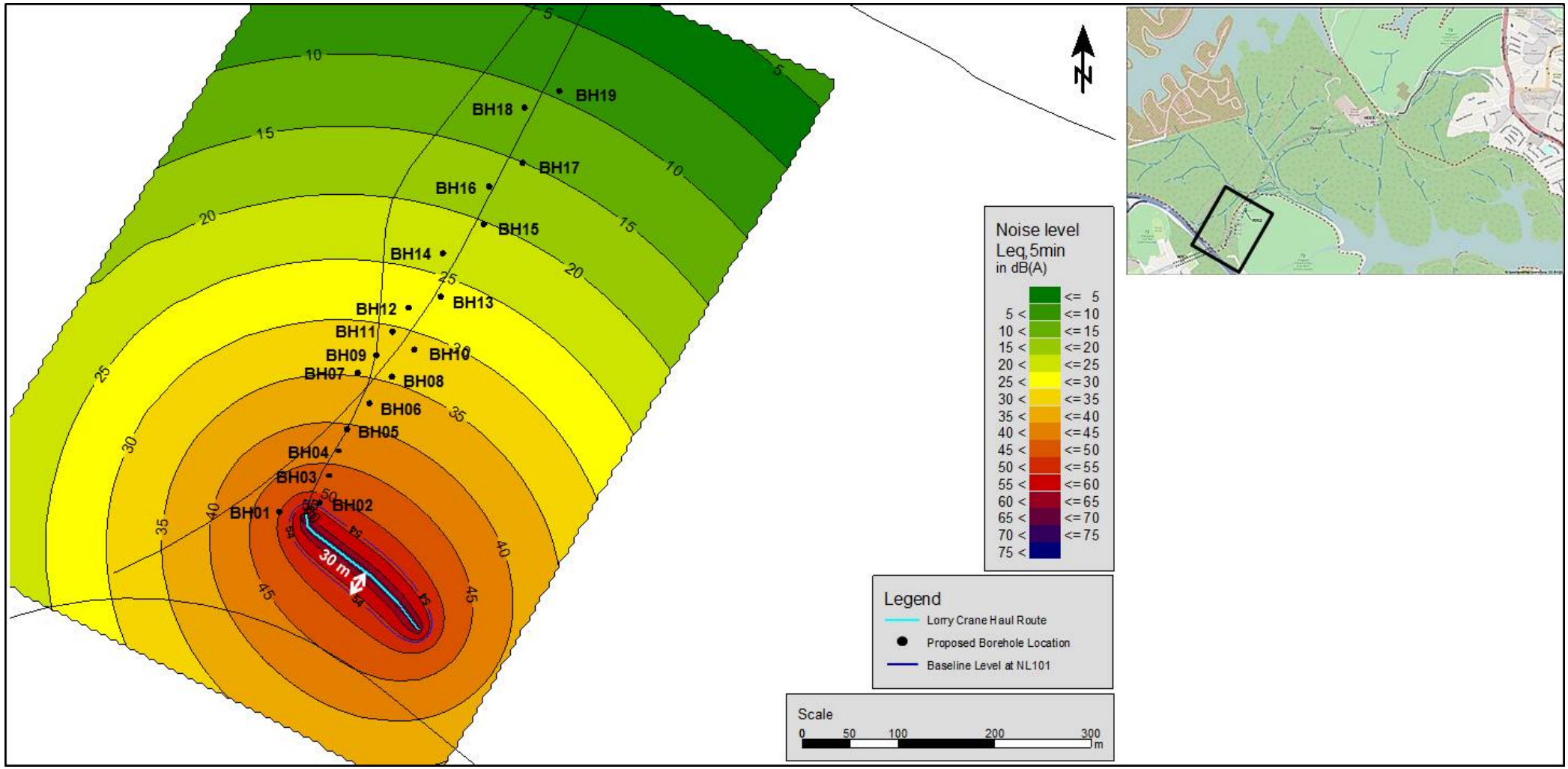


***Figure 4.15: Noise Contours for Scenario 8 ($L_{Aeq,5min}$) – Operation of Lorry within the Island Golf Club (Mobilization / Demobilization)***

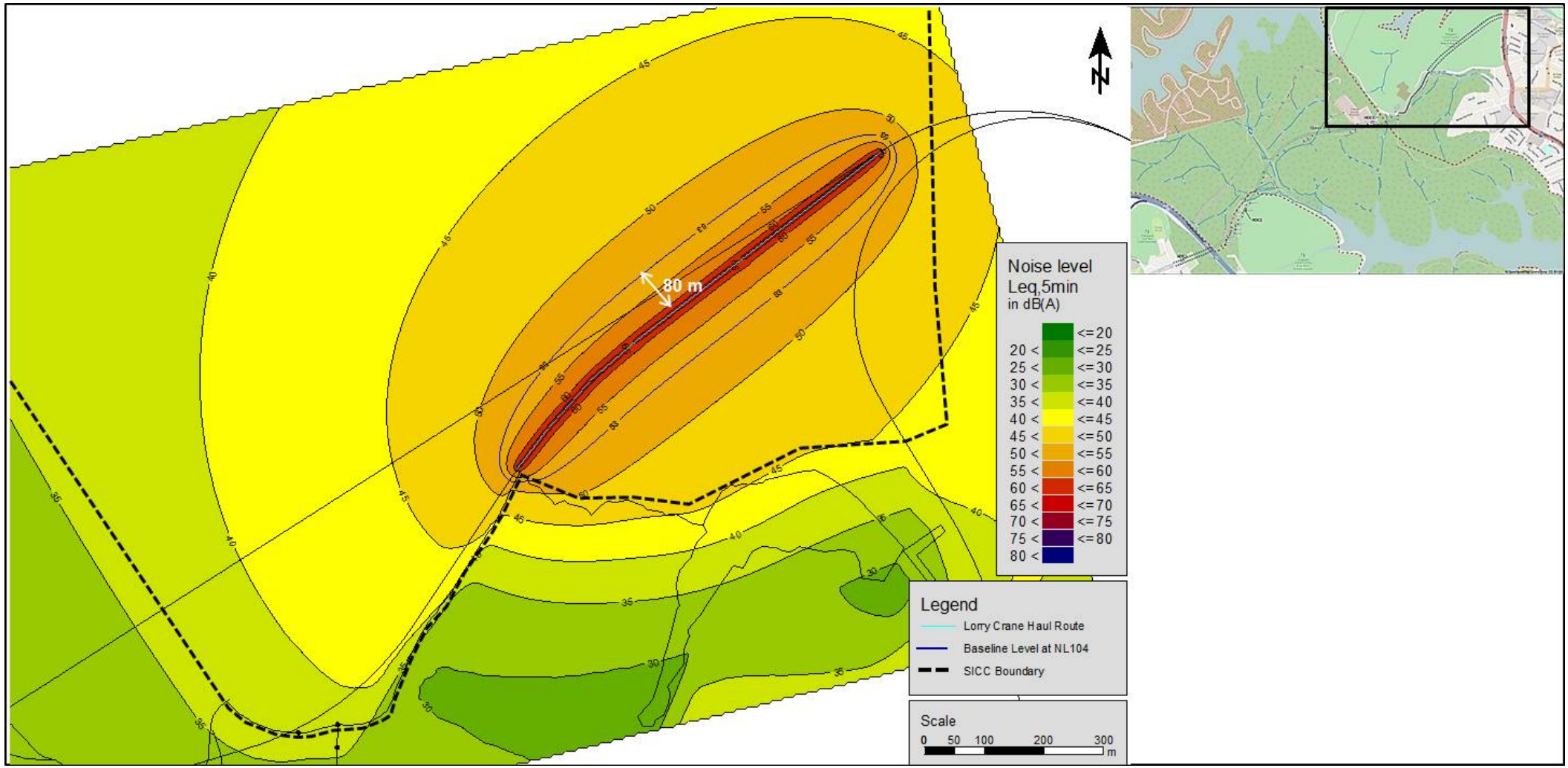


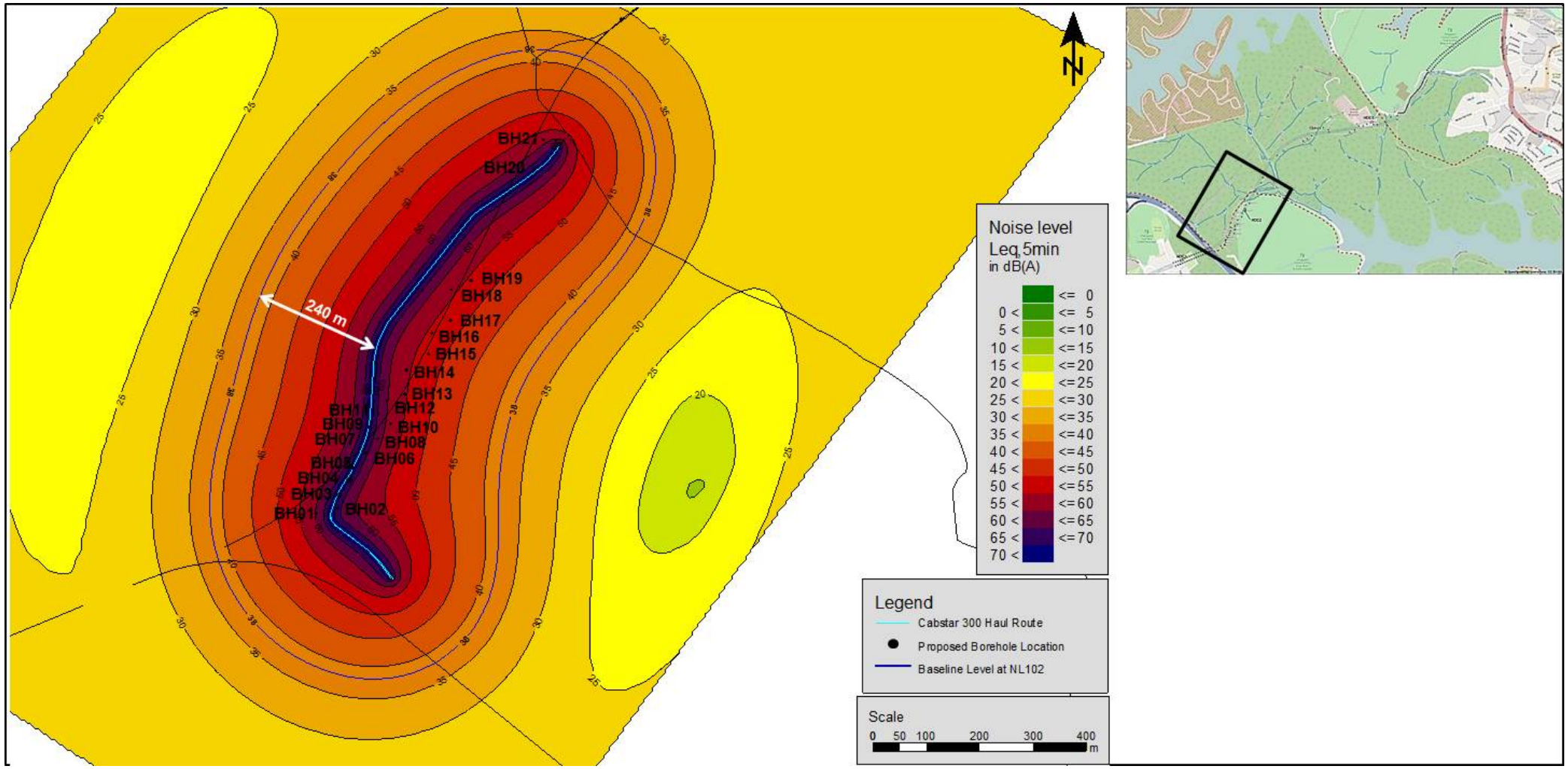
***Table 4.15: Impact Assessment Summary for Lorry Crane Deployment***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to deployment of lorry cranes during mobilization and demobilization** | | |
| Nature | Negative | The Project will result in incremental ambient noise levels which will exceed current $L_{Aeq,5min}$ baseline levels by 15 to 16 dB(A); and $L_{Aeq,1hr}$ baseline levels by 2 to 3 dB(A). |
| Type | Direct | Golfers within the Island and Bukit golf courses will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of golfers within the Island and Bukit golf courses will be temporary, eg 10 minutes during each trip. |
| Extent | Local | Effects will be on golfers within 30 m of the haul route to BH01; and within 80 m of the haul route within Island golf course. |
| Scale | Large | Human receptors in close proximity to the haul routes can be directly exposed to levels up to $L_{Aeq,5min}$ 69 dB(A), which could lead to nuisance impacts. |
| Frequency | Ad-hoc | The lorry crane will be deployed to undertake one round trip during mobilization, and one round trip during demobilization, ie 2 round trips over a period of 11 to 18 days. |
| Magnitude | Large | Noise levels that are more than 10 dB(A) above the baseline levels will be generated by the movement of the lorry crane. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Minor | Golfers would be exposed to noise levels more than 10 dB(A) above the baseline levels for a short period of up to 10 minutes, for deployment of the lorry crane twice at each borehole. |

### *Scenario 9 – Cabstar Lorry (Mobilization & Demobilization)*

A Cabstar lorry will be deployed for mobilization and demobilization of ancillary equipment at BH20 and BH21. The lorry will utilize the current Sime Trail which extends from Sime Road up to Jelutong Tower, and which consists of a gravel path that has been adapted for use by vehicles. The model took into account deployment of the Cabstar lorry for one round trip per mobilization / demobilization within the CCNR. Noise contours for Scenario 9 are presented in *Figure 4.16*.

*Figure 4.16: Noise Contours for Scenario 8 ($L_{Aeq,5min}$) – Operation of Cabstar Lorry for Mobilization / Demobilization at BH21*



Noise levels of up to $L_{Aeq,5min}$ 79 dB(A) at 1 m from the haul route will be generated by the movement of the Cabstar lorry. As shown in *Figure 4.16*, noise levels are predicted to exceed the baseline $L_{Aeq,5min}$ level (ie 38 dB(A)) for a distance of up to 240 m from the haul route.

It is observed however that due to safety concerns, the Sime Trail section extending from Sime Road to Jelutong Tower would be temporarily closed to public access during deployment of the Cabstar lorry. The nearest human receptors would be joggers utilizing the Golf Link, who would be exposed to $L_{Aeq,5min}$ levels of up to 55 dB(A) during Cabstar lorry deployment, ie 17 dB(A) in exceedance of current baseline $L_{Aeq,5min}$ levels at NL102. This corresponds to a *Large* magnitude as per *Table 4.2*. It is noted that current baseline $L_{Aeq,5min}$ levels at NL102, which is representative of locations on and in proximity to existing trails within the CCNR, range from 38 to 74 dB(A), with peak noise levels reaching 88 dB(A) (as measured during the inter-monsoon period).

In addition, the generation of noise from the Cabstar lorry would be over a short duration of not more than 15 minutes. This is evident from the resultant $L_{Aeq,1hr}$ values, which was predicted at 45 dB(A) at the Golf Link / Jelutong Tower, ie 3 dB(A) above the baseline $L_{Aeq,1hr}$ value of 42 dB(A). Further, this event will occur only 4 times over the period of SI works. The magnitude of impact to human receptors from the mobilization and demobilization at BH20 and BH21 is therefore assessed to be of *Minor* impact significance.

***Table 4.16: Impact Assessment Summary for Cabstar Lorry Deployment***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to deployment of Cabstar lorry during mobilization and demobilization at BH20 and BH21** | | |
| Nature | Negative | The Project will result in incremental ambient noise levels which will exceed current $L_{Aeq,5min}$ baseline levels by 17 dB(A); and $L_{Aeq,1hr}$ baseline levels by 3 dB(A) at the nearest open CCNR trail, ie Golf Link. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be temporary, eg not more than 15 minutes during each trip. |
| Extent | Local | Effects will be on recreational users along the Golf Link. |
| Scale | Large | Human receptors along Golf Link can be directly exposed to levels up to $L_{Aeq,5min}$ 55 dB(A), which could lead to nuisance impacts. |
| Frequency | Ad-hoc | The Cabstar lorry will be deployed to undertake one round trip during mobilization, and one round trip during demobilization, ie 2 round trips over a period of 11 to 18 days. |
| Magnitude | Large | Joggers utilizing the Golf Link will be exposed to levels up to 17 dB(A) above the baseline. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Minor | Minor disturbance to human receptors along Golf Link can be expected due to elevated ambient noise levels of up to $L_{Aeq,5min}$ 55 dB(A) over a short duration of up to 15 minutes. This will occur four times during the SI works. |

### *Scenario 10 – S25A or Equivalent (Mobilization & Demobilization)*

As an embedded control to minimize intrusive impacts to the CCNR, ancillary equipment at most borehole locations located on the unpaved trails within the CCNR will be transported manually. Where worksites are located at a great distance from each other however, a S25A or equivalent vehicle will be deployed to ensure the safety of workers. As described in *Table 2.4*, the S25A will be deployed for the following occasions:

- Transportation of ancillary equipment from BH11 worksite to BH20 worksite, via Sime Trail (approximate haulage distance of 650 m);
- Transportation of ancillary equipment from BH32 worksite to BH22 worksite, via Sime Trail (approximate haulage distance of 1.6 km);
- Transportation of equipment to BH24 worksite via Terentang Trail (approximate haulage distance of 1.3 km); and
- Transportation of equipment to BH26 worksite from BH24 worksite, via Sime Trail (approximate haulage distance of 550 m).

As the capacity of the S25A is smaller than that of the lorry crane and Cabstar lorry, a total of up to 11 round trips will be required for transportation of ancillary equipment (including water tote). As a worst-case scenario, the scenario with the longer haul route was modelled. This model has considered that the S25A would be able to make up to 1 round trip every hour. During the deployment of S25A along the haul route, it is assumed that the Terentang Trail, the Sime Track, the Tree Top Walk and Petaling Trail will be temporarily closed for the safety of trail users.

Predicted $L_{Aeq,5min}$, $L_{Aeq,1hr}$ and $L_{Aeq,12\ hr}$ levels at the nearest open trails within the CCNR are summarized in *Table 4.17*. The noise contours for deployment of S25A along the 1.6 km haulage route between BH32 and BH22 are presented in *Figure 4.17* to *Figure 4.19*.

***Table 4.17 Predicted Noise Levels due to Deployment of S25A during Mobilization & Demobilization***

| Nearest Receptor | Predicted Noise Levels (dB(A))[Note 1, Note 2] | | | Applicable Noise Limits (dB(A)) | | |
|---|---|---|---|---|---|---|
| | $L_{Aeq,5min}$ | $L_{Aeq,1hr}$ | $L_{Aeq,12hr}$ | $L_{Aeq,5min}$ | $L_{Aeq,1hr}$ | $L_{Aeq,12hr}$ |
| Users of Rifle Range Link | **60** | **50** | **<40** | 38[Note 3] | 42 | 47 |
| Users of Golf Link | **60** | **50** | **<40** | | | |
| Rangers and recreational users at Ranger Station | **90** | **80** | **70** | | | |
| Users of MacRitchie Nature Trail and Venus Link | **<65** | <55 | <45 | 53[Note 4] | 57 | 61 |

*Note:*

(1) Receptors along the full length of the nearest open CCNR trail would be exposed to a range of noise levels. The highest noise exposure is presented herein, with reference to the noise contours presented respectively in *Figure 4.15* to *Figure 4.17*.

(2) Values in bold indicate an exceedance of applicable noise limits.

(3) As per the assessment criteria, applicable noise limits at these trails are taken to be the minimum baseline levels measured at NL102 (representative of trails within the CCNR).

(4) As per the assessment criteria, applicable noise limits at these trails are taken to be the minimum baseline levels measured at NL104 (representative of trails near Island Club Road).

As shown in *Table 4.17*, users of the trails east of the haulage route ie MacRitchie Nature Trail and Venus Link would be exposed to levels up to $L_{Aeq,5min}$ 65 dB(A), which is up to 12 dB(A) above the minimum baseline $L_{Aeq,5min}$ levels measured at NL104. Users of trails west of the haul route, such as Rifle Range Link and Golf Link, are predicted to be exposed to levels up to $L_{Aeq,5min}$ 60 dB(A), which is up to 22 dB(A) above the minimum baseline $L_{Aeq,5min}$ levels measured at NL102. Rangers and recreational users at the Rangers Station, which is in close proximity to the haul route, may be exposed to $L_{Aeq,5min}$ levels of up to 90 dB(A). This therefore corresponds to a *Large* impact magnitude. It is noted however that receptors may already be exposed to intermittent noise generated from other non-recreational activities within the CCNR. Current baseline $L_{Aeq,5min}$ levels at NL102 range from 38 to 74 dB(A), with peak noise levels reaching 88 dB(A) (as measured during the inter-monsoon period).

In addition, the above scenario will occur four times during the project, and will last for up to two days each time, ie short-term duration. Depending on the recreational activity that receptors are engaged in, the typical exposure durations are expected to range from a few minutes (for joggers who are passing through the area), up to an hour (for users resting or using the facilities at the Ranger Station) and up to 8 hours for rangers working within the Ranger Station office. The impact to receptors is therefore assessed to be of *Moderate* significance.

### *Mitigation Measure for Deployment of S25A for Mobilization/Demobilization (Scenario 10)*

Deployment of the S25A or equivalent vehicles shall be scheduled to occur during weekdays, and during off-peak periods (mid-morning to early afternoon) to minimize the number of receptors likely to be exposed to elevated noise levels.

### *Residual Impact Assessment for Deployment of S25A for Mobilization/Demobilization (Scenario 10)*

To minimize the impacts due to deployment of S25A or equivalent vehicle, sequencing of drill rig operation within the CCNR has been undertaken to enable transportation of equipment by manual means for most of the worksites. Trails will also be temporarily closed to ensure the safety of recreational users of the CCNR. Taking into consideration further implementation of the abovementioned mitigation measure, it is assessed that residual noise impacts to receptors will be of *Minor* impact significance.

*Figure 4.17: Noise Contours for Scenario 10 ($L_{Aeq,5min}$) – Operation of S25A for Mobilization at BH22*

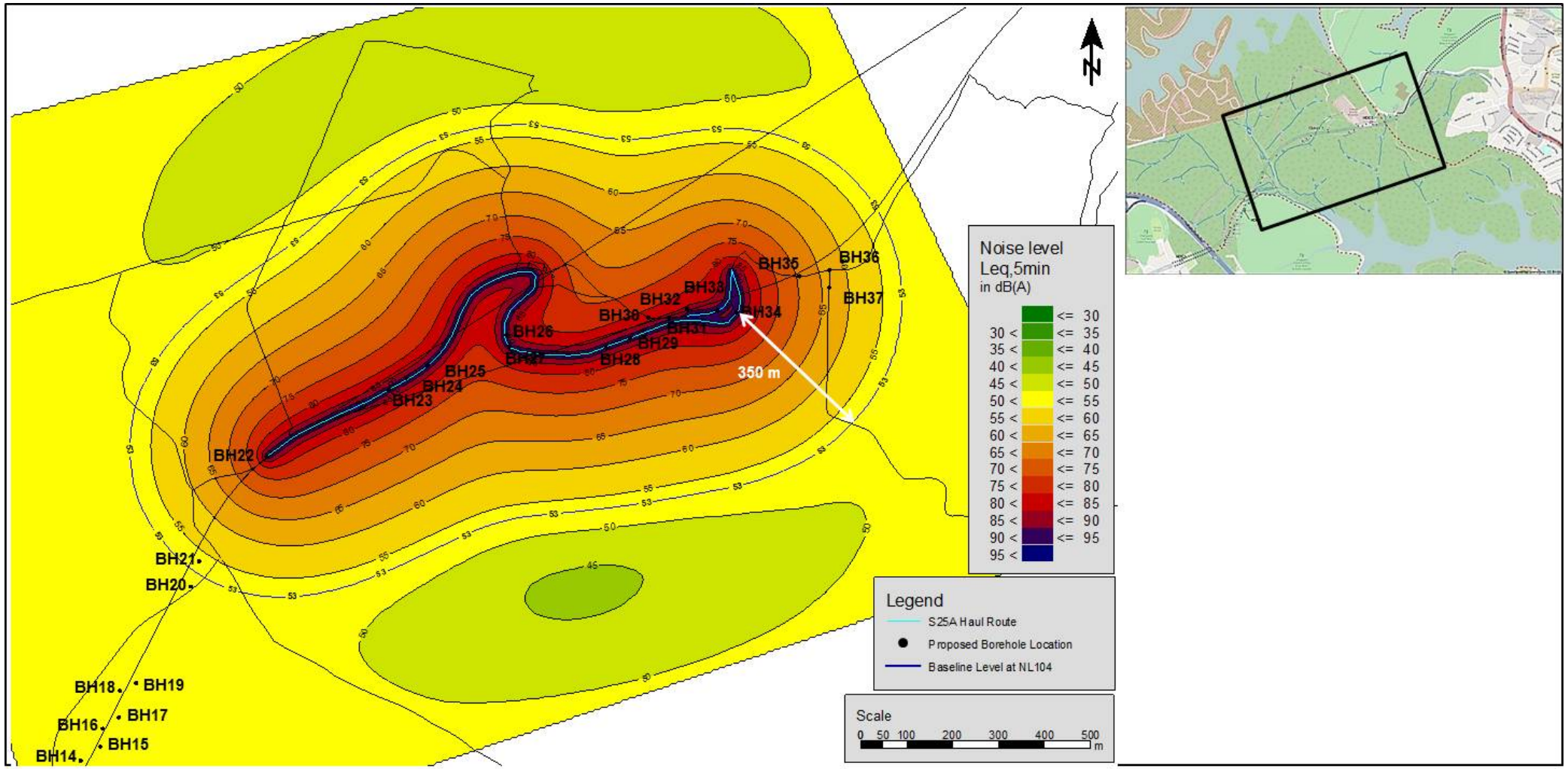


*Figure 4.18: Noise Contours for Scenario 10 ($L_{Aeq,1hr}$) – Operation of S25A for Mobilization at BH22*

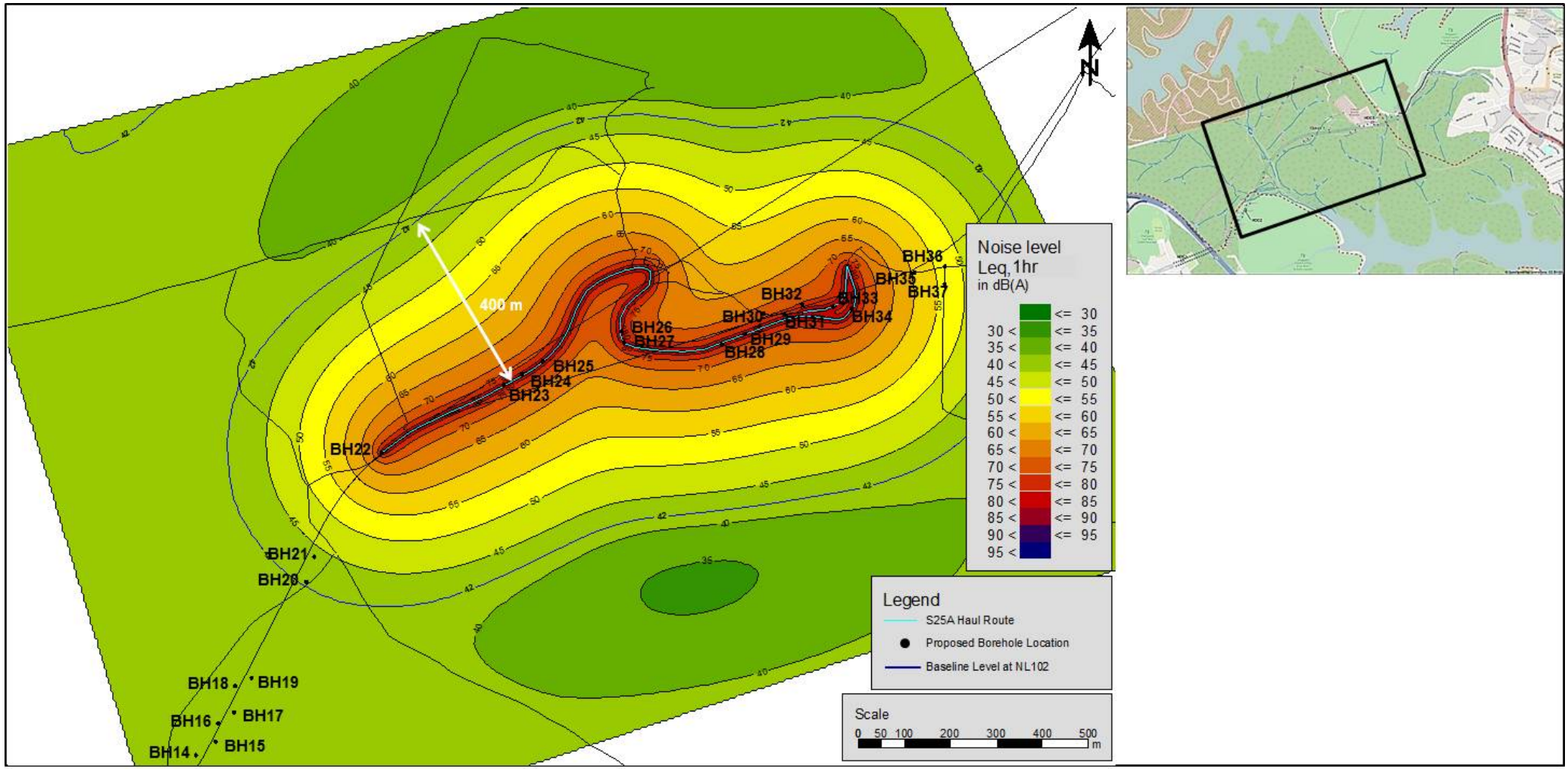


*Figure 4.19: Noise Contours for Scenario 10 ($L_{Aeq,12hr}$) – Operation of S25A for Mobilization at BH22*

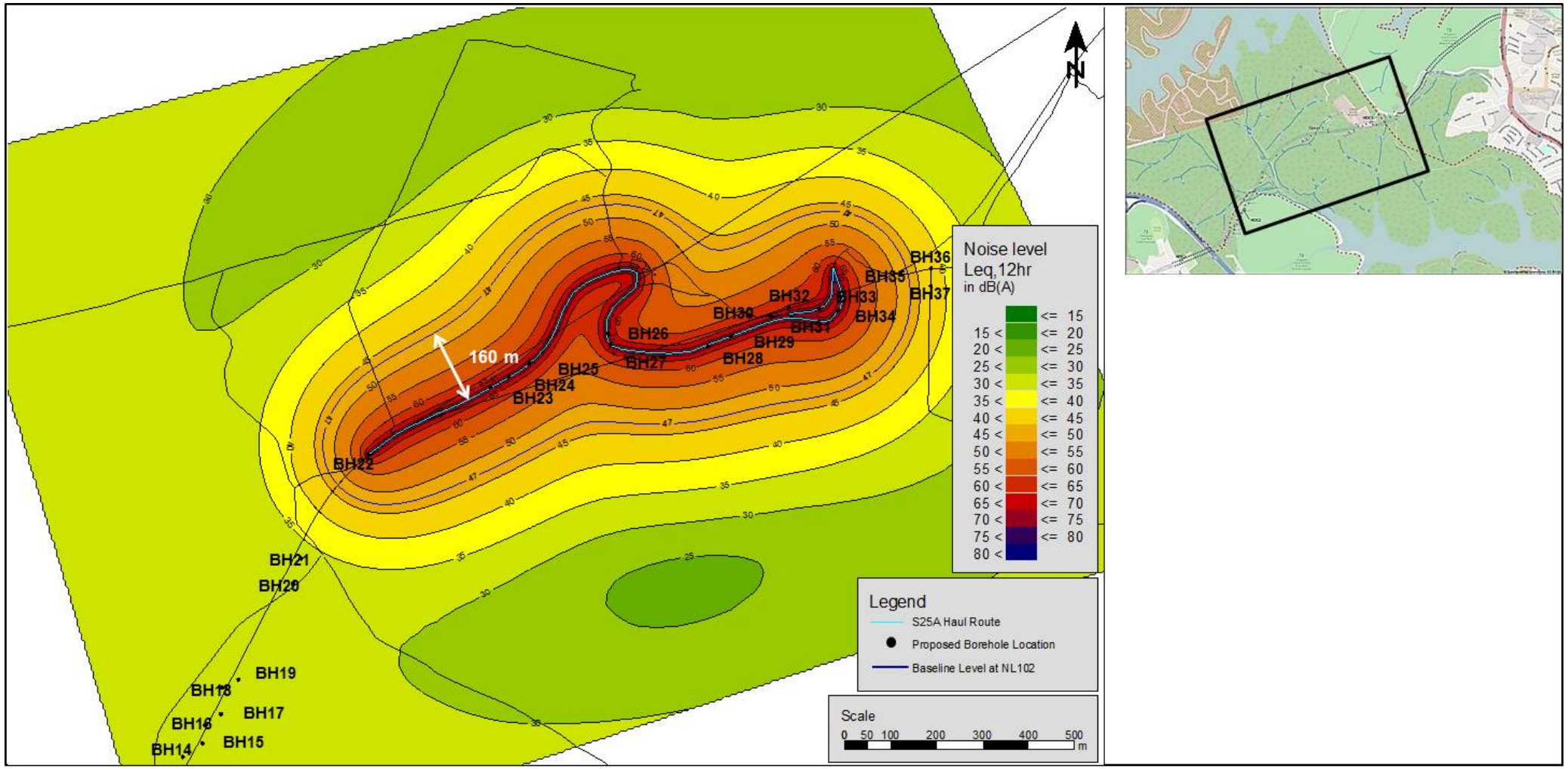


***Table 4.18: Impact Assessment Summary for S25A Deployment (Mobilization / Demobilization)***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to deployment of S25A or equivalent during mobilization and demobilization** | | |
| Nature | Negative | The Project will result in incremental ambient noise levels which will exceed current $L_{Aeq,5min}$ baseline levels by up to 52 dB(A) at the Ranger Station, and up to 22 dB(A) at the nearest CCNR trails, which could lead to nuisance impacts. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels. |
| Duration | Short | Exposure duration of recreational users will be up to an hour; and up to 8 hours for rangers working at Ranger Station. |
| Extent | Local | Effects will be on recreational users along the nearby CCNR trails and rangers at the Ranger Station. |
| Scale | Large | Human receptors can be directly exposed to levels exceeding current $L_{Aeq,5min}$ baseline levels by up to 52 dB(A) at the Ranger Station, and up to 22 dB(A) at the nearest CCNR trails. |
| Frequency | Low | The S25A or equivalent vehicle will be deployed to undertake up to 11 round trips during mobilization at BH22; and during demobilization of equipment at BH32 worksite. Each deployment would occur up to four times during the SI works. |
| Magnitude | Large | Rangers, recreational users at the Rangers Station and users of trails such as Rifle Range Link, Golf Link, MacRtichie Nature Trail and Venus Link may be exposed to levels that are more than 10 dB(A) above the baseline. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors at nearby CCNR trails can be expected due to elevated noise levels of more than 10 dB(A) above the baseline over a short-term duration, twice during the SI works. |
| Residual Impact Magnitude | Large | The implementation of mitigation measures will minimize the number of receptors exposed to predicted noise levels. However, scale and extent of predicted noise impacts will remain for exposed receptors. |
| Residual Impact Significance | Minor | Minor adverse impact to human receptors is predicted as deployment will be scheduled during off-peak hours to minimize the number of receptors. |

### *Scenario 11 – S25A (Drilling Works)*

A small vehicle, such as a S25A or equivalent may be used for transportation of water and wastewater during rotary borehole operations within the CCNR and boreholes BH02 to BH07, BH09, BH11 and BH35 to BH37 as per the schedule outlined in *Chapter 2*. As outlined in *Table 2.6* and the aforementioned schedule, a S25A is being proposed for the water and wastewater transportation due to various factors, most importantly as it does not require a turning radius to access the worksites along the trails. It is noted that it is used in other off-road environments in Singapore. It is estimated that up to two round trips will be required daily during drilling works. The usage of such a vehicle over one of the longer haul routes assumed within the CCNR, ie approximately 1.4 km between BH01 and BH21, has been considered in the model. Predicted noise levels are presented in *Figure 4.20*.

Noise levels of up to $L_{Aeq,5min}$ 95 dB(A) at 1 m from the haul route will be generated by the movement of the S25A, which is predicted to propagate over an approximate distance of between 470 and 560 m from the haul route before attaining the current baseline level measured along existing trails, ie minimum daytime $L_{Aeq,5min}$ 38 dB(A) as measured at NL102. It is noted that the necessary trails along

the haul route and for the worksites will be temporarily closed to public access. It is therefore anticipated that only recreational users of the nearest open CCNR trails will be exposed to noise emissions, ie up to $L_{Aeq,5min}$ 70 (along Golf Link) and up to $L_{Aeq,5min}$ 80 at the Rangers Station. This is more than 10 dB(A) above the baseline levels and is therefore classified as a *Large* impact magnitude.

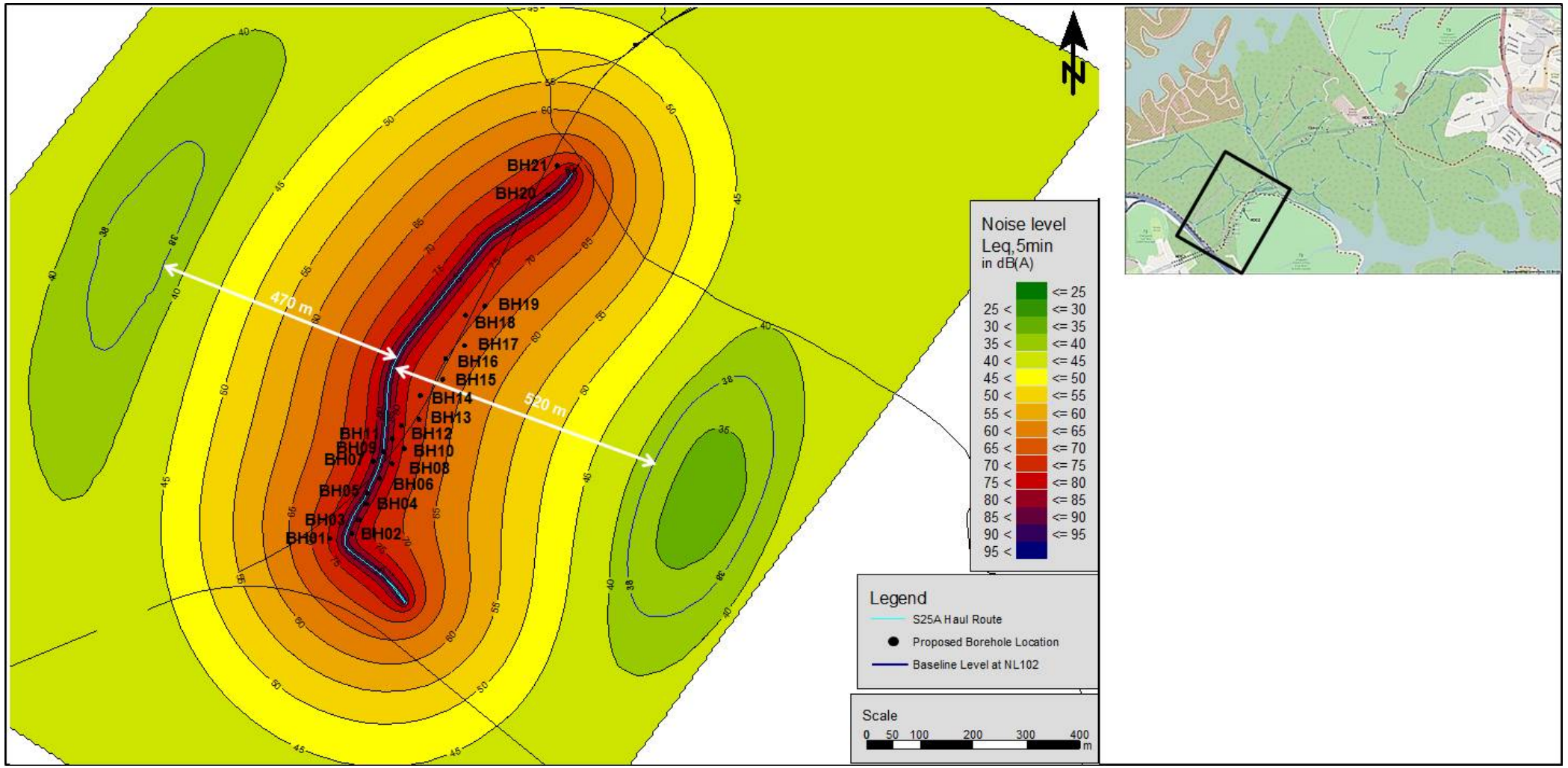
Receptors would however be exposed over a short duration, as each trip would last less than 20 minutes at a frequency of up to 4 trips per day between 09.00 and 17.00. The impact significance is therefore assessed to be *Moderate*.

### *Mitigation Measures for Deployment of S25A or Equivalent during Drilling Works (Scenario 11)*

The following mitigation measures are required during usage of the S25A or equivalent for transportation of water and removal of wastewater from worksites within the CCNR:

- Unless in an emergency, the ancillary vehicle shall not be used in peak visitation hours within the CCNR between 09.00 to 11.00 and 15.00 to 17.00 for weekends, and after 15.00 for weekdays *(NParks, personal communication, 2014)*;
- Plan logistics and resources such that a minimum number of trips is required;
- Operators to maintain suitable driving qualifications; and
- The vehicle engine shall be turned off when not in use, or throttled down to a minimum in the intervening periods.

*Figure 4.20: Noise Contours for Scenario 11 ($L_{Aeq,5min}$) – Operation of S25A or Equivalent for Water Transport during Drilling Works*



### *Residual Impact Assessment for Deployment of S25A or Equivalent during Drilling Works (Scenario 11)*

Given that no vehicles other than S25A are currently considered as practical to access the trails (due to the turning radius requirement), regardless of the mitigation outlined, the magnitude will remain *Large*. Scheduling of activities will reduce the number of receptors exposed; however, as the frequency and magnitude of impact remain unchanged, the residual impact is assessed to be of *Moderate* significance.

***Table 4.19: Impact Assessment Summary for Scenario 11***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Elevated ambient noise levels due to usage of S25A or equivalent during twice daily transportation of water within the CCNR** | | |
| Nature | Negative | The Project will result in incremental ambient noise levels which will exceed current baseline levels by up to 42 dB(A) along CCNR trails. |
| Type | Direct | Recreational users of the area will be directly exposed to elevated noise levels generated along open trails within the CCNR. |
| Duration | Short term | Exposure duration of recreational users will be short term, eg less than 20 minutes each trip. |
| Extent | Local | Effects will be on recreational users within 470 to 520 m from the haul route. |
| Scale | Large | Human receptors using the trails in the CCNR will be temporarily exposed to noise levels between 70 dB(A) and 80 dB(A). |
| Frequency | Ad-hoc | The S25A or equivalent will be deployed twice daily for transportation of water and used slurry to and from the worksites within the CCNR. |
| Magnitude | Large | Predicted noise levels are more than 10 dB(A) above the baseline. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to elevated ambient noise levels for a short duration along open trails within the CCNR. |
| Residual Impact Magnitude | Large | Predicted noise levels are more than 10 dB(A) above the baseline. |
| Residual Impact Significance | Moderate | Moderate disturbance to human receptors can be expected due to elevated ambient noise levels for a short duration along open trails within the CCNR. |

## 4.6 ASSESSMENT OF VIBRATION IMPACTS

The following activities are likely to cause vibration in the surrounding environment:

- SPTs for each borehole; and
- Drilling through soil and rock.

### 4.6.1 Impacts due to SPTs

Vibration is expected to be generated during the SPTs, in which a split-spoon sampler is driven through the soil by a 65 kg automatic hammer. 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 BS 5228-2:2009. 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 65 kg weight. A pile toe depth of 1 m was used in the equation.

At a horizontal distance of 2 m from the rig, a PPV of approximately 1.3 mm/s was predicted. With reference to the impact magnitude criteria for vibration impacts on humans defined in *Table 4.5*, this is a *Medium* impact magnitude. The exposure to vibration at this distance from the rig is expected to occur only to those passing by on the trail, and is therefore likely to be brief (ie in the range of 10 min or less). Longer duration exposure, for example for those engaged in research within the CCNR, may occur at for those located further away from the rig. For a horizontal distance of 10 m, the vibration magnitude drops to 0.18 mm/s, which corresponds to less than a Small impact magnitude in *Table 4.5*. Both predicted values are well below the PPV level of 10 mm/s that is intolerable over brief exposure durations. Further, SPT will only be carried out while drilling through the soil, which is estimated to take 1 day for the DeltaBase 520 rig and 2 days for an A-Frame standard rig per borehole.

In view of the low levels of vibration that will be generated from SPT and the short duration of both the activity and human exposure, the impact from vibration generated by this activity is assessed to be of *Minor* significance.

### *4.6.2 Impacts due to Drilling*

Drilling through the soil and rock will generate vibration over a period of approximately 17 days for each borehole drilled using an A-Frame standard rig and 11 days for drilling using the DeltaBase 520 rig or similar. The historical data reviewed for rotary rigs is based on vibration levels measured during bored piling, and shows peak particle velocities ranging from 0.4 mm/s at a horizontal distance of 10 m from the rig to 0.03 mm/s at 30 m. These values are for much larger rigs with a diameter of 500 mm, as compared to the 52 mm core diameter for the boreholes to be drilled along Alignment Option 1. Vibration measurements were therefore undertaken at a rotary borehole rig operating in an area within 100 m of the study area, and which thereby shared similar geological characteristics as the proposed borehole locations. The PPV levels at fixed distances from the operational rotary borehole rig were measured over a 5 minute interval, as summarized in *Table 4.20*. Detailed results are appended in *Volume II, Annex 5.0*.

***Table 4.20: 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 1) | 0.621 | 0.911 | 0.529 |
| F | 20 m | Grass (Note 1) | 0.515 | 0.896 | 0.820 |
| G (Note 2) | 5 m | Grass | 0.555 | 0.740 | 0.698 |

*Notes:*

(1) Grass verge was not in continuity with the grassy area on which the rotary borehole rig was operating.

(2) Measurements were undertaken when the rig was not operating, to establish baseline vibration levels due to extraneous sources.

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; 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, PPV due to the rotary borehole rig would likely be less than 1.0 mm/s, from distances at and greater than 3 m from the rotary borehole rig. At distances 2 m or less from the rotary borehole rig, PPV could exceed 1 mm/s. These values would therefore correspond to a *Medium* impact magnitude as defined in *Table 4.5*. It is noted that while trails would be temporarily closed to the public during drilling works, there is still a possibility that joggers or trekkers would continue to utilize areas within 2 m of the borehole rigs. Considering the brief duration of exposure of these human receptors, the impact of vibration from drilling operations is evaluated to be *Minor*.

***Table 4.21: Impact Assessment Summary***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Operation of drill rig(s) for intrusive soil investigation using rotary boreholes along existing trails within the CCNR** | | |
| Nature | Negative | The Project will result in vibration levels that are expected to exceed ambient levels |
| Type | Direct | Recreational users of the area will be directly exposed to elevated vibration levels. |
| Duration | Short Term | Exposure duration of recreational users will be temporary, short term, eg 10 minutes at a time. |
| Extent | Local | Effects will be on recreational users within a radius of ~10 m from the worksites. |
| Scale | Medium | Receptors within 2 m of the worksites eg recreational users of the CCNR trails would be exposed to levels exceeding 1.0 mm/s, though well below 10 mm/s. Receptors located more than 2 m from the worksites would experience levels below 1 mm/s. |
| Frequency | Continuous | Borehole drilling rigs will be moved from location to location over a course of approximately six months, and be in continuous operation in the daytime. |
| Magnitude | Medium | Vibration levels are predicted to be in excess of 1 mm/s though less than 10 mm/s at receptors within 2 m or less. Levels may still be above 0.3 mm/s for receptors further from the rig. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Minor | Human receptors within 2 m of the rigs would be directly exposed to vibration levels > 1.0 mm/s, though only for short-term durations ie 10 min. Human receptors located further away, eg golfers would be exposed to Small impact, for maximum duration of a few hours. |

## 4.7 CUMULATIVE IMPACTS

The Study Area is of high amenity value due to its largely natural environs and usage for recreational activities requiring low levels of man-made noise, eg nature treks, bird-watching, cross-country running, etc.

Other developments that are likely to coincide with the Project, and to be undertaken within or near the Study Area, comprise solely of the Windsor Nature Park development (*Volume II, Chapter 2*). Activities associated with the Windsor Nature Park development were reported to include the construction of 4.1 km of boardwalks to replace existing trails within the current Windsor Interim Green area (ie Venus Loop and Venus Link), habitat enhancement works such as wetland restoration and reforestation, and the construction of basic park facilities such as shelters and washroom(s).

The Windsor Nature Park development is scheduled to commence in mid-2015 and reach completion in end 2016, although further details on the breakdown and location of activities were not available to inform this study. Cumulative vibration impacts are not expected, given the rapid attenuation in manmade earthborne vibrations with distance[10]. It can be reasonably assumed however that there would be cumulative noise emissions due to the additional equipment, vehicles and workers associated with the Windsor Nature Park development, and aboveground construction works, but that these would

[10] California Department of Transportation (2002). Transportation Related Earthborne Vibrations. Retrieved from http://www.dot.ca.gov/hq/env/noise/pub/TRANSPORTATION_RELATED_EARTHBORNE_VIBRATIONS.pdf

likely be localized to the relevant worksites. It is not known at this stage if the activities would be planned or designed so as to enable continued public access to the Venus Link and Venus Loop trails, which connects the Venus Carpark to the CCNR trails. As a worst case scenario, it is assumed that receptors would be accessing the Venus Link and Venus Loop trails during other aboveground construction works, eg park facilities, and would therefore be directly exposed to cumulative noise over a short-term duration.

***Table 4.22: Impact Assessment Summary***

| Criterion | Rating | Comment |
|---|---|---|
| **Impact – Nuisance Effects Due to Cumulative Noise Emissions** | | |
| Nature | Negative | Contributions from the Windsor Nature Park development and Project activities will lead to cumulative noise impacts resulting in greater exceedance of baseline levels. |
| Type | Direct | Recreational users accessing CCNR through the Venus Loop and Venus Link, will be directly exposed to cumulative noise levels. |
| Duration | Short Term | Exposure duration of recreational users will be temporary, short term, eg less than 1 hour each time |
| Extent | Local | Effects on recreational users likely to be localized at worksites. |
| Scale | Large | Human receptors using the trails in the CCNR will be temporarily exposed to cumulative noise levels, ie noise levels at or higher than those predicted for Project activities. |
| Frequency | Continuous | It is conservatively assumed that noise emissions from the Windsor Nature Park development would be continuous during each development activity. |
| Magnitude | Large | Predicted noise levels from the Project are more than 10 dB(A) above the baseline for many scenarios. |
| Receptor Sensitivity | N/A | Receptor sensitivity is accounted for in the impact magnitude criteria. |
| Significance | Moderate | Moderate disturbance to human receptors can be expected due to short-term exposure to cumulative, elevated ambient noise levels within the easternmost portion of CCNR adjacent to the current Windsor Interim Green. |

# 5 CLIMATE AND AIR QUALITY

## 5.1 INTRODUCTION

This chapter presents an assessment of the impacts of activities associated with the SI works for alignment option 1 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* provides an assessment of the potential impacts.

## 5.2 SCOPE OF THE ASSESSMENT

SI activities identified in the scoping exercise to have significant interactions with ambient air quality were reviewed against the SI description presented in *Chapter 2*. The predicted sources of impacts to air quality are as follows:

- Dust generated from drilling operation and vehicle movements on exposed soil and unpaved ground; and
- Vehicular emissions from engines and generators.

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

Vehicular emissions will mainly arise from the use of diesel-fueled vehicles and equipment including S25A vehicle or similar for daily transportation of water and wastewater; engines of drilling rigs; and generators associated with pumps and the HDC. Given the small number of vehicles that will be operated at any one time (ie less than 5) and that emissions from all off-road engines including construction equipment are regulated under the *Environmental Protection and Management (off-Road Diesel Engine Emissions) Regulations 2012*, impacts due to emissions from operational vehicles are expected to be insignificant and have therefore been screened out from further assessment.

The scope of the assessment is therefore focused on impacts to human health from dust emissions. With regard to impacts on biodiversity, this chapter includes a screening assessment of impacts of

[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.

airborne pollution on the CCNR. Assessment of impacts to specific habitat, flora and fauna is discussed in further detail in *Chapter 6: Ecology and Biodiversity*.

## 5.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

The baseline ambient air quality conditions are described in *Volume II, Chapter 6*. Key findings are summarized as follows:

- The receptors that will be potentially sensitive to atmospheric emissions from SI activities associated with Alignment Option 1 are:
  - Ecological receptors within CCNR, Windsor Interim Green and the SICC golf courses; and
  - Users of the trails along the CCNR and the golf courses.
- The main existing sources of emissions to air in the Study Area are vehicular emissions along the roads on the boundary of the CCNR; namely Upper Thomson Road, Lornie Road and the PIE.
- Other sources of vehicular emissions include trucks, occasional emergency vehicles and NParks' maintenance vehicles operated on an ad-hoc basis within the CCNR, as well as lawn mowers operated within the golf courses bounding CCNR.
- A review of historical measurements of $PM_{10}$ and $PM_{2.5}$ by the NEA for the years between 2011 and 2013 indicates that over the long-term, the ambient concentrations of particulate matter in the vicinity of the study area were generally above the Singapore 2020 and long-term ambient air quality targets.
- Short-term measurements recorded at select locations along Alignment Option 1 from November 2014 to January 2015 (*Table 6.3* of *Volume II, Chapter 6)* indicate that ambient concentrations of $PM_{10}$ and $PM_{2.5}$ in the Study Area were generally within the Singapore ambient air quality targets, though levels in excess of the targets were recorded on some days of Round 1 of the survey.

## 5.4 ASSESSMENT METHODOLOGY

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 [1] of the source, thus the scale of impacts predicted are within this range and of a duration of up to 6 months. ERM has therefore used a qualitative risk-based approach for the assessment of impacts. 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 $m^2$;<br>• Soil type with large grain size (eg sand); and/or<br>• Total material moved < 5,000 tonnes. |
| **Small** | • Total site area 500 $m^2$ to 2,500 $m^2$;<br>• Soil type with large grain size (eg sand); and/or<br>• Total material moved 5,000 to 20,000 tonnes. |
| **Medium** | • Total site area 2,500 $m^2$ to 10,000 $m^2$;<br>• Moderately dusty soil type (eg silt); and/or<br>• Total material moved 20,000 tonnes to 100,000 tonnes. |
| **Large** | • Total site area > 10,000 $m^2$;<br>• potentially dusty soil type (eg clay, which will be prone to suspension when dry due to small particle size ); and<br>• Total material moved 100,000 tonnes. |

The sensitivity of human receptors to the health effects of dust follows the IAQM criteria for $PM_{10}$. For 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 this assessment are presented in *Table 5.2*.

***Table 5.2 Determination of Receptor Sensitivity***

| Sensitivity | Description |
|---|---|
| **Low** | *Human Receptors*<br>• Locations where human exposure is transient (Note 1)<br><br>*Nature Areas*<br>• Locally designated sites; and/or<br>• Areas of specific ecological interest, not subject to statutory protection |
| **Medium** | *Human Receptors*<br>• 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).<br><br>*Nature Areas*<br>• Nationally designated sites. |
| **High** | *Human Receptors*<br>• 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).<br><br>*Nature Areas*<br>• Internationally designated sites. |

| Sensitivity | Description |
|---|---|

*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 Rig Operation, Mobilization and Demobilization

For the purpose of the assessment it is assumed that two drilling rigs will be operational within the CCNR at any one time. Outside the CCNR boundary up to four boreholes will be drilled concurrently. The boreholes outside the CCNR will be located within the Bukit and Island Golf Courses, the Windsor Interim Green, and near the PIE as shown in *Figure 2.1*. After completion and interpretation of results from the other SI activities, three boreholes will also be completed using HDC drilling method at locations within the Kalang Service Reservoir compound and outside the CCNR as illustrated in *Figure 2.1.*

The main dust-generating activities will include mobilization and demobilization of drilling rigs and associated equipment for each of the boreholes. In addition, there will be daily vehicle trips (twice daily) along the CCNR trails to transport freshwater and remove wastewater from each rotary borehole worksite. Sensitive receptors that may be affected are visitors to the CCNR. Dust emissions from drilling activities will be minimal since the water used during as a drilling fluid will prevent significant mobilization of dust. Spoil removed from the boreholes will be bagged and removed on a daily basis. Minimal disturbance to the ground is expected due to the presence of the ECB at each worksite. It is further noted that as per LTA's *General Specifications, Appendix A, Safety, Health and Environment (for Rail Project) December 2014 Edition* vehicles leaving unpaved roads are required to go through wheel washing to prevent removal of dirt onto public paved roadways.

In summary, the drilling operation will adhere to administrative requirements outlined in *Volume I, Chapter 3*. The embedded control measures to minimize potential impact from dust generation include the following:

- Implementation of various measures outlined in *Chapter 4*, regarding noise minimization, will also be applicable to dust, such as the speed limit of 5 km / hr at all unpaved areas;
- Vehicles leaving unpaved roads will be required to go through wheel washing, as per the *General Specification, Appendix A, Safety, Health and Environment (for Rail Project) December 2014 Edition*; and
- Water will be used as a drilling fluid.

The footprint required for both types of drilling technique will be small, approximately 22 $m^2$ for A-frame crawler and 28.6 $m^2$ for DB 520s or similar rigs. Soil type of the surface layer within the CCNR

was not determined at the stage of writing, however based on observation it is assumed that the surface soil type is likely to be the earth soils comprised of a mixture of sand, silt and clay covered with gravel, as is typical in Singapore. The surface has been assumed to be moderately dusty with reference to *Table 5.1*. Hardstanding in areas outside the CCNR will require breaking and the underlying surface soils are anticipated to be fill material which is also considered to be moderately dusty when excavated. The maximum material removed from each borehole is estimated to be 0.15 $m^3$ considering a borehole diameter of 54 – 100 mm and an average depth of 70 m. The duration of activities at any one location will range from 11 to 18 days depending on the type of drilling rig used.

The extent of impacts for dust generated is predicted to be within 350 $m^1$ from the worksite. Further, it is expected that water injected during the drilling operations will minimize the generation of dust.

Based on the above, the magnitude of impact from rotary borehole drilling is evaluated to be *Negligible*. Within the CCNR, human exposure to dust will be transient, which corresponds to a *Low* sensitivity in *Table 5.2*. As the CCNR is a nationally designated protected area, its sensitivity to dust generated from SI works is considered to be *Medium*. The significance of impact to designated nature areas and human receptors due to changes in ambient air quality from dust emissions from rotary borehole drilling is therefore *Negligible*.

The footprint of a HDC worksite is estimated to be 700 $m^2$. Soil type within the areas that HDC will be carried out is assumed to be similar to the CCNR which is considered to be moderately dusty. The material that will be removed from each HDC borehole is approximately 1.39 $m^3$ assuming a diameter of 0.047 m and 800 m drill length. With reference to the criteria outlined in *Table 5.1*, the magnitude of impact from the HDC is considered *Small*. As the sensitive receptors located within 350 m from the HDC borehole sites include users of the golf courses and CCNR, and nature areas within the CCNR, the impacts is assessed as *Negligible* for human receptors and *Minor* for ecological receptors.

***Table 5.3: Impact Assessment Summary***

| Criterion | Rating | Comment |
|---|---|---|
| **Impacts Due to Dust Emissions from Borehole Drilling Rig Operation, Mobilization and Demobilization** | | |
| Nature | Negative | Generation of dust. |
| Type | Direct | Human / nature areas sensitive receivers directly exposed to dust |
| Duration | Short-term | Total duration is expected to be around 6 months for rotary drilling and 2 years for HDC. |
| 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 transportation of water and wastewater and during mobilization and demobilization of crawler rigs every few days for each borehole within the CCNR.<br>Daily during HDC at areas outside of the CCNR. |
| Magnitude | Negligible to Small | The footprint of the rotary drilling worksites is small with only minimal amount of soil to be removed. Embedded controls include dust suppression; bagging and removal of spoil; wheel washing; slow vehicle movement and ECB.<br>The footprint of the HDC worksite is 700$m^2$ each. The maximum amount of soil that will be removed is estimated to be 1.39 $m^3$ for one HDC borehole. |
| Receptor Sensitivity | Low to Medium | Human receptors include visitors of the CCNR and users of Island Golf Course. Sensitivity of human receptors is low since the impacts will be transient. The CCNR is a nationally designated protected area in terms of ecology and is therefore of |

| | | |
|---|---|---|
| | | *medium* sensitivity. |
| Significance | Negligible to Minor | Negligible adverse impacts can be expected as a result of generation of dust during drilling rig operation, mobilization and demobilization within the CCNR.<br>Negligible to Minor adverse impacts could arise during the HDC operation at areas outside of the CCNR. |

### *5.5.2 Cumulative Impacts*

Cumulative impacts to receptors within the CCNR may arise if the SI coincides with the construction of Windsor Nature Park. Cumulative impacts may arise in the areas of the golf course and CCNR that are closest to the Windsor Nature Park. Limited information[3] available at the time of writing revealed that the size of the Windsor Nature Park will be 750,000 $m^2$; however it is assumed that there will be minimal excavation works since the development is primarily an enhancement of the existing park that will include minor construction incorporating the building of small structures, such as boardwalks, expansion of existing trail and small-scale reforestation. The impacts to air associated with the construction of this development will likely be similar to the SI works in terms of source and scale. Further, it is assumed that the construction activities will be conducted in accordance with regulatory requirements and any mitigation measures recommended within the Windsor Nature Park EIA. Taking this into consideration along with the *Small* magnitude of impact from the SI works, the magnitude of the cumulative impact is also assessed to be *Negligible*.

The receptors of the cumulative impacts are similar to ones identified for the SI works and the overall sensitivity was assessed as *Medium* as discussed in Section 5.5.1. The cumulative impacts from the construction of Windsor Nature Park and SI works are therefore evaluated to be of *Negligible Significance.* As a precautionary measure, it is recommended that the schedule of SI works near the Windsor Nature Park to be reviewed in conjunction with the schedule of construction for Windsor Nature Park to ensure activities are not undertaken concurrently.

[3] Channel News Asia (14 Feb 2015) **New Nature Park at Upper Thomson to be Ready by End 2016**

### *Table 5.4: Impact Assessment Summary*

| Criterion | Rating | Comment |
|---|---|---|
| **Cumulative Impacts Due to the Overlap Construction Period Between Windsor Nature Park and the SI works** | | |
| Nature | Negative | Generation of dust |
| Type | Direct | Human / nature areas sensitive receivers directly exposed to dust |
| Duration | Temporary | Temporary when the construction of Windsor Nature Park and SI works occur at the same time |
| Extent | Local | Effects will be on human receptors within 350 m from the worksite |
| Scale | - | Slight elevated concentrations of $PM_{10}$ |
| Frequency | Frequent | Not determined at this stage |
| Magnitude | Negligible | The construction of Windsor Nature Park is small in scale. Excavation and other ground disturbance works are anticipated be minimal. Further, it is assumed that the construction activities will be conducted in line with local regulatory requirements and mitigation measures recommended within the EIA. |
| Receptor Sensitivity | Medium | Sensitivity of human receptors is low since the impacts will be transient, but the CCNR is a nationally designated protected area in terms of ecology. |
| Significance | Negligible | *Negligible* adverse impacts as a result of the cumulative impacts arise during the overlap period between the SI and construction activities of Windsor Nature Park. |

# 6 ECOLOGY & BIODIVERSITY

## 6.1 INTRODUCTION

This chapter presents an assessment of the potential impacts on the ecological resources of the Project Study Area, as a result of SI works associated with Alignment Option 1.

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.

## 6.2 SCOPE OF THE ASSESSMENT

### 6.2.1 Project SI Works

This assessment of impacts to ecological resources 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 1 in *Volume III, Chapter 2* and include a number of embedded controls. These embedded controls includes measures to avoid causing significant impacts such as the limits on the number of boreholes (BHs) as well as their location through the imposition of buffer areas for BHs near streams. This has reduced the number of boreholes to 16 within the CCNR that have been supplemented with geophysical investigations.

The core 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*, and include:

- Preliminary Investigations;
- Geophysical Investigations including seismic refraction and reflection surveys, electrical resistivity surveys and gravity surveys;
- Mackintosh Probes;
- Rotary Boreholes; and
- Horizontal Directional Coring

The key impacts on ecological resources that are associated with each of these activities are described and assessed in *Section 6.5.*

The baseline information regarding ecological resources and their value draws upon a number of existing data sources. These include studies and reports that have been organized and commissioned

on the ecology and biodiversity of the Study Area both in the past (secondary data) and from recent surveys (primary data from October 2014 to November 2015.

The review of secondary data included available publications from:

- NParks;
- Independent bodies (eg *Cross Island Line Working Group Report* (05 January 2014)[1], hereafter referred to as the 'CRL WG Report');
- Government (eg PUB, LTA, MINDEF, *etc*); and
- Private sector literature; academic studies; scientific journals; vegetation maps and land use maps, including from institutions such as National University of Singapore (NUS), Raffles Museum of Biodiversity Research of the NUS, Nanyang Technological University (NTU) and Nature Society Singapore (NSS).

Secondary information was gathered and reviewed to characterize the existing condition within the Study Area and to identify habitats and species of potential importance in the area. It should be noted that, among the reviewed information, the publically available NSS's *Cross-Island Line Discussion and Position Paper* (2013) and CRL WG Report are two comprehensive documents which summarize the existing key ecological information of the MacRitchie zone within the CCNR. Overall, there is extensive existing ecological baseline information available within CCNR, considered to be enough to evaluate the overall ecological sensitivity and significance of the majority of the Study Area for the purpose of ecological impact assessment. However, there was not necessarily adequate information for the potentially directly affected areas, in particular the indicative location for the SI works within the CCNR, which would enable detailed ecological impact assessment. As a consequence, detailed ecological surveys within the Study Areas, in particular focusing within the CCNR along the Alignment Option 1 route, were undertaken. Given the ecological sensitivity of the CCNR and the availability of certain credible ecological information, non-intrusive and non-harmful baseline survey techniques were adopted as a first choice so that unnecessary disturbance to the area was avoided. In addition, all surveys were for the most part restricted to the observations from or in close proximity, to the existing trails within the CCNR (For full details on the collection of data, refer to *Volume II, Annex 7.0*).

### *6.2.2 Resources and Receptors*

For this assessment of impacts on ecological values, 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;

[1] 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**

- butterflies (generally considered as a good indicator of forest quality);
- odonates (generally considered as a good indicator of wetland/ stream habitat quality); and

- Freshwater fauna and flora identified in the baseline.

The selection of these resources and taxa groups of the purpose of the impact assessment has been based on review of 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.

### 6.2.3 Study Area

The Study Area used for the purpose of ecology and biodiversity is shown in *Figure 6.1,* and comprised of two key parts – the area falling within a small southern section of the CCNR and along the NParks managed area to Venus Drive (generally termed the MacRitchie area), and the area falling outside the CCNR, ie along Island Club Road through SICC Island Golf Course in the east to Upper Thomson Road and 0.4 km from the CCNR boundary to the west

## 6.3 SUMMARY OF RELEVANT BASELINE CONDITIONS

Review of available secondary data indicate that the MacRitchie area is a key area for biodiversity within Singapore. Tailored ecological surveys set out to confirm findings of the secondary data review as well as fill any key information gaps, particularly gathering information at those areas that could potentially be directly affected by the Project SI works. Field surveys focused on the MacRitchie NParks managed area of the CCNR, investigating habitats and vegetation, birds, mammals, herpetofauna, butterflies, odonates and aquatic fauna and recording the presence or absence of floral and faunal species of conservation interest, or the extent of faunal roosting/ foraging/ breeding.

Available literature concerning the Project's Study Area as well as the recent field survey works (October 2014 to November 2015), suggest that the majority of the Study Area, particularly the MacRitchie area including areas within the geophysical survey corridor (refer to *Figure 6.1*), is of important ecological value to Singapore, with high biodiversity and a large number of species considered of conservation value. Species of conservation interest have been defined as those that are listed as:

- CR, CR/D, EN, EN/D or VU, VU/D in the *Singapore Red Data Book* (2008) (*Singapore RDB,* 2008); and/or

- VU, EN or CR on the *IUCN Red List of Threatened Species* (IUCN 2015.01); and/or

- in Appendix I or II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

Species of conservation interest have been located within the Study Area for each of the taxa studied. For example, the secondary data and findings from recent field surveys have recorded: over 240 plant/tree; and over 30 bird; 18 mammal; 39 herpetofauna; 14 butterfly and 22 odonate species of conservation interest as well as at least 10 freshwater fish species of conservation interest.

Overall the evidence also shows that the whole MacRitchie area of the Study Area is generally of high ecological value; all Study Area habitats falling within the CCNR boundary including the streams, are considered highly sensitive ecological resources, with the exception of the Bukit Kalang Service Reservoir compound and surrounding road which are considered '*Development Area'* of medium sensitivity.

Outside the CCNR boundary, while most habitats within the Study Area are of medium ecological and biodiversity value, there are some exceptions. The *Developed Area* to the west of CCNR is considered of low value and while areas falling just outside the CCNR (but which form part of NParks Managed Areas and are continuous with habitats within the CCNR) have high ecological value. These include the *Wetland Forest* inside SICC Bukit Golf Club, the *Regeneration Forest A*[1] near Venus Drive, and the very small area of *Regeneration Forest A* near SICC Bukit Golf Club to the west of the trail that is under NParks management but not within the CCNR gazetted boundary. *Figure 6.1* illustrates the location of the various habitats within the Study Area, while *Figure 6.1a* and *Figure 6.1b* show where various species of conservation interest have been recorded.

It is recognized that the CCNR is a highly fragmented habitat. In its entirety, the CCNR encompasses the forested watersheds of four inland reservoirs (MacRitchie, Upper Peirce, Lower Peirce and Upper Seletar) as well as the Nee Soon Swamp Forest (NSSF), as illustrated in *Vol II, Figure 7.1*. These reservoirs, together with fenced areas within the CCNR and even public trails and unofficial off trail routes, act as barriers limiting wildlife movement as they serve to break up the continuity of habitats. The CCNR is also separated from the BTNR and other forested areas by major roads such as Mandai Road and Mandai Lake Road to the North, the Bukit-Timah Expressway to the west, and Old Upper Thomson Road to the east. In addition, it is noted that the forest mix in the CCNR is varied such that the lack of a contiguous forest type may limit the movement of animals that are highly sensitive to changes in habitat. Fragmentation is understood to have deleterious impacts on species populations and diversity, as evidenced by studies conducted on birds[2], mammals[3], amphibians[4] and invertebrates[5, 6]. In light of this, the highly fragmented nature of the CCNR has been a key consideration in the impact assessment.

On top of fragmentation effects, the CCNR also experiences several internal stressors throughout its entirety, from human use (eg human use including night entry, illegal uses including mountain biking and poaching etc), developmental (eg pipe jacking, construction, urban developments in close proximity) and environmental pressures (eg release of domestic pets, invasion of exotic species, fire and storm damage). Although the impacts of individual pressures are localized, the stress exerted on the CCNR by all these pressures may have a cumulative effect. NParks has sought to relieve some of the pressures around the CCNR by creating buffer zones in the form of nature parks (ie Springleaf Nature Park, Windsor Nature Park, Chestnut Nature Park) to relieve visitor pressure on the CCNR and provide

[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.

[2] Turner IM (1996) Species Loss in Fragments of Tropical Rainforest: A Review of the Evidence. Journal of Applied Ecology. 33. 200-209.

[3] Turner IM (1996) Species Loss in Fragments of Tropical Rainforest: A Review of the Evidence. Journal of Applied Ecology. 33. 200-209.

[4] Bickford D, Ng TH, Q Lan, Kudavidanage EP, & Bradshaw CJA (2010) Forest Fragment And Breeding Habitat Characteristics Explain Frog Diversity and Abundance in Singapore

[5] Ye MS & Li D (nd) The Effects of Forest Fragmentation on Arthropod Diversity. Department of Biological Sciences, The National University of Singapore.

[6] Koh LP & Sodhi N (2004) Importance of Reserves, Fragments and Parks for Butterfly Conservation in a Tropical Urban Landscape. Ecological Applications, Vol 14, 6. 1695, 1708.

additional green spaces for species to seek refuge in. In addition, in 2013, the eco-link wildlife crossing between BTNR and CCNR was completed to reconnect these two fragmented forests.

The Study Area only falls on the MacRitchie area of the CCNR. This forest area is fragmented due to the presence of forest trails and the MacRitchie reservoir which cuts off the Lornie forest from the MacRitchie core nature area. The Singapore Island Country Club's golf courses to the north and south of the forest also present barriers to animal dispersal to other parts of the CCNR and adjacent forests. The MacRitchie area also faces current and future pressures in the form of cross-country marathons, water supply projects and siltation to its streams from earthworks.

Given the isolation of CCNR, highly fragmented nature of the habitats and the existing stresses from human use, developmental and environmental pressures, the overall wildlife population within the CCNR, particularly those listed as CR or EN or VU in the Singapore RDB, is expected to be limited. For example, Malayan Colugo was estimated of 1,074±209 individuals existing within BTNR and CCNR (density estimate of 0.535 individuals per ha)[1] and the population of Slow Loris is also estimated to be small[2]. Any additional stresses or threats, if significant enough, may affect the individuals and hence the health of the future generation, as well as genetic variability of small populations.

There is considerable literature regarding the biodiversity of the whole CCNR, with some studies focusing specifically on the Study Area around the MacRitchie Reservoir, which is considered to be enough to evaluate the overall ecological sensitivity and significance of the area, both are essential for ecological impact assessment. However, it is considered that there is still lack of detailed information to allow an assessment of total population sizes and territorial extent of species, particularly those that are CR or EN or VU in the Singapore RDB where any change in population may reduce genetic variability (such as the Banded Leaf Monkey[3]). Such information is important to the evaluation of magnitude as well as the significance of impacts for this C1001 EIA as the potential impacts may affect small populations of species listed as CR or EN or VU in the Singapore RDB within the unique and fragile CCNR.

[1] Lim NT and Ng PKL (2010) Population Assessment Methods for the Sunda Colugo *Galeopterus variegatus* (Mammalia: Dermoptera) in Tropical Forests and their Viability in Singapore. The Raffles Bulletin of Zoology 58(1): 157-164. National University of Singapore. Available at https://lkcnhm.nus.edu.sg/nus/pdf/PUBLICATION/Raffles%20Bulletin%20of%20Zoology/Past%20Volumes/RBZ%2058(1)/58rbz157-164.pdf

[2] Fam SD, Lee BPY and Shekelle M (2014) The conservation status of slow lorises *Nycticebus* spp. in Singapore. Endangered Species Research, 25, 69–77.

[3] Ang A, Srivasthan A, Md-Zain BM, Ismail MRB, and Meier R (2012) Low Genetic Variability in the Recovering Banded Leaf Monkey Population of Singapore. The Raffles Bulletin of Zoology. 60 (2). 589-594. National University of Singapore.

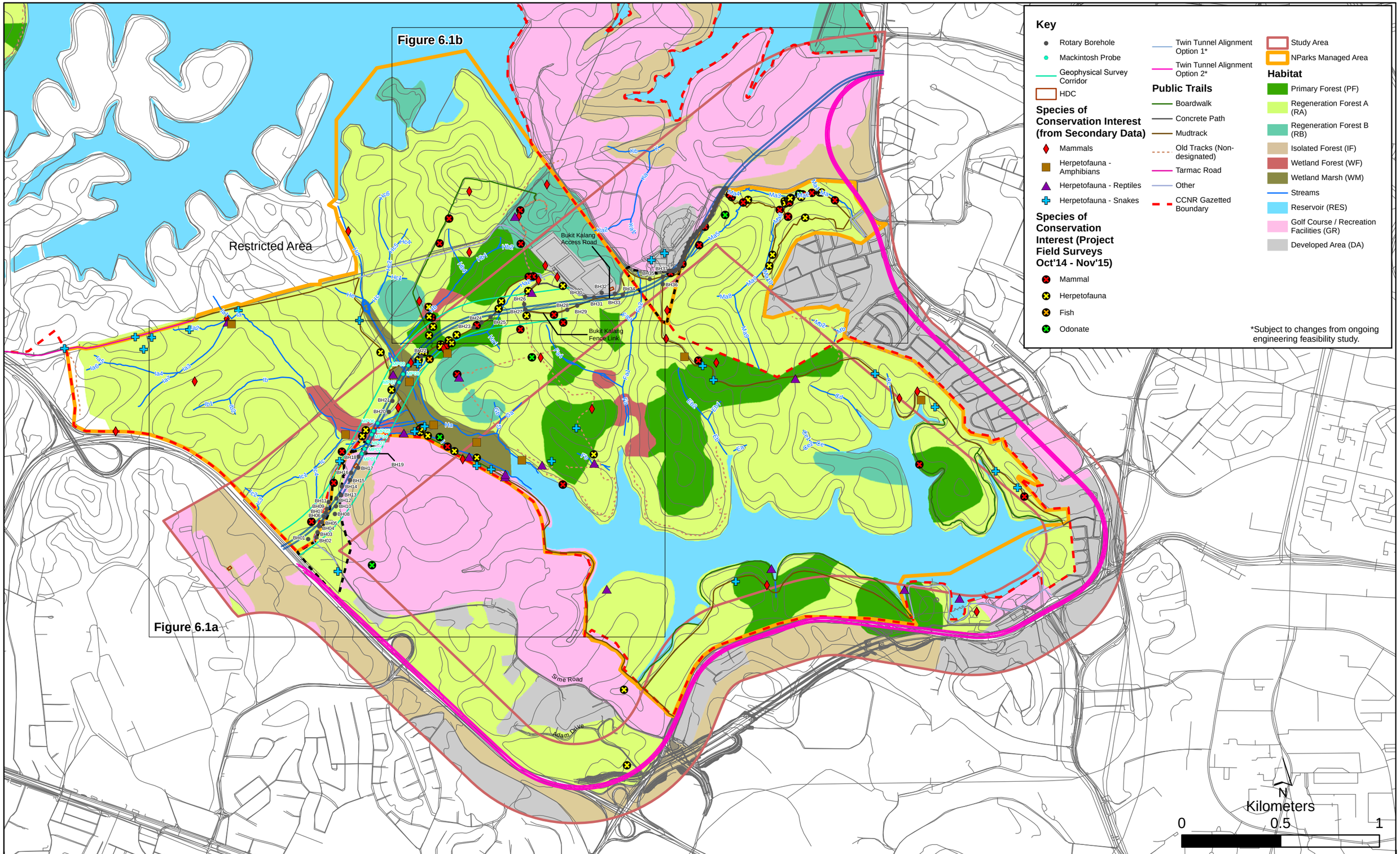



Figure 6.1 Study Area and Habitat Map showing SI Locations (Rotary Boreholes, Mackintosh Probes, Horizontal Directional Coring) and Species of Conservation Interest - Alignment Option 1

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Date: 17/12/2015

Environmental Resources Management

ERM

**Key**

- Rotary Borehole
- Mackintosh Probe
- HDC
- Geophysical Survey Corridor

**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
- Odonate

- Twin Tunnel Alignment Option 1*
- Twin Tunnel Alignment Option 2*

**Public Trails**

- Boardwalk
- Mudtrack
- Old Tracks (Non-designated)
- Tarmac Road
- Other
- 30m Buffer from Stream
- 30m Buffer from Wetland Marsh and Wetland Forest
- CCNR Gazetted Boundary

- Study Area
- NParks Managed Area
- Wetland Forest
- Wetland Marsh

**Habitat**

- Primary Forest
- Regeneration Forest A
- Regeneration Forest B
- Isolated Forest
- Streams
- Reservoir
- Golf Course / Recreation Facilities
- Developed Area

*Subject to changes from ongoing engineering feasibility study.

Rifle Range Link
Retailing Trail
Sime Trail
Golf Link
Fairway Drive
Pan Island Expressway (PIE)
BH01 BH02 BH03 BH04 BH05 BH06 BH07 BH08 BH09 BH10 BH11 BH12 BH13 BH14 BH15 BH16 BH17 BH18 BH19 BH20 BH21 BH22 BH23 BH24
MP01 MP02 MP03 MP04 MP05 MP06 MP07 MP08 MP09
N
Meters
0 250 500

Figure 6.1a Study Area and Habitat Map showing SI Locations (Rotary Boreholes, Mackintosh Probes, Horizontal Directional Coring) and Species of Conservation Interest - Alignment Option 1

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Date: 17/12/2015

Environmental Resources Management

ERM

## Key

- Rotary Borehole
- HDC
- Geophysical Survey Corridor

### Species of Conservation Interest (from Secondary Data)

- Mammals
- Herpetofauna - Reptiles
- Herpetofauna - Snakes

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

- Mammal
- Herpetofauna
- Fish
- Odonate

- Twin Tunnel Alignment Option 1*
- 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 Gazetted Boundary

- Study Area
- NParks Managed Area

### Habitat

- Primary Forest
- Regeneration Forest A
- Regeneration Forest B
- Isolated Forest
- Wetland Forest
- Wetland Marsh
- Streams
- Reservoir
- Golf Course / Recreation Facilities
- Developed Area

*Subject to changes from ongoing engineering feasibility study.

HSBC Tree Top Walk
Petaling Trail
Police Track I
Police Track II
Bukit Kalang Access Road
Terentang Trail
Eagle Trail
Venus Link
Island Club Road
Venus Drive
Venus Loop
MacRitchie Nature Trail
BH23
BH24
BH25
BH26
BH27
BH28
BH29
BH30
BH31
BH32
BH33
BH34
BH35
BH36
BH37
N
Meters
0
250
500

Figure 6.1b Study Area and Habitat Map showing SI Locations (Rotary Boreholes, Mackintosh Probes, Horizontal Directional Coring) and Species of Conservation Interest - Alignment Option 1

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Date: 17/12/2015

**Environmental Resources Management**

ERM

### 6.3.1 Summary Baseline Conditions Along the Geophysical Survey Corridor and at the Proposed Borehole Locations within the Study Area

*Figure 6.1* and *6.1a* and *6.1b* show the proposed geophysical survey corridor and location of rotary boreholes for Alignment Option 1. There are several habitat types found within the proposed geophysical survey corridor, in which Regeneration Forest is the dominant habitat type. Primary Forest, Wetland Forest, Wetland Marsh and Streams are recorded at the middle section of the geophysical survey corridor. Certain areas of the proposed geophysical survey corridor (west end) also fall within the Bukit Golf Course. Apart from the Bukit Golf Course and existing trails, as well as some existing disturbed routes mainly found in the western side of the corridor, there is limited accessibility within majority of the proposed geophysical survey corridor.

Within the CCNR gazetted boundary, rotary boreholes have generally been proposed along publicly accessible trails or bare ground areas, such as those existing clearings (BH01 and BH21), and Bukit Kalang Service Reservoir compound (BH32) and nearby roads (BH30, BH31 and BH33). The rotary boreholes proposed within the CCNR gazetted boundary have been numbered for ease of identification. Baseline information for the location of each borehole (BH1 and BH20-34), including details of the trail width, gradient, flora and fauna at the location and in the vicinity recorded during the field surveys, are provided in *Volume II, Annex 9*.

The rotary boreholes for Alignment Option 1 that fall outside the CCNR and within the Study Area lie in four habitats, namely *Regeneration Forest A*, Golf Course (Bukit Golf Course), *Isolated Forest* within or near to the golf courses and *Developed Area*.

Most of the rotary boreholes outside the CCNR have been positioned in a standard 25 m herring bone pattern along the alignment and have not been numbered as their locations are more conceptual. These locations will be further refined at a later stage of the engineering design process (*Chapter 2, Section 2.4.2*). It is expected that the future borehole locations can avoid the isolated forest or any tree cutting within SICC Island Golf Course. However, the proposed rotary boreholes BH02-19 and BH35-37 are near the CCNR gazetted boundary. General description of the habitats or areas where these boreholes are currently located based on the field surveys are provided below and further detailed descriptions of each group are provided in *Annex 9*.

- Boreholes BH02-BH07, BH09 and BH11 are all located in *Regeneration Forest A* habitat, which is extended from, and ecologically linked to, the large continuous forest within NParks' Managed Area, and considered of high sensitivity to disturbance. All these rotary boreholes are positioned on the Sime Trail which runs through the forest and is frequently used by recreational users. Some plant species of conservation interest have been recorded in the vicinity of these boreholes, such as *Ficus lamponga* (CR/RDB) and *Aquilaria malaccensis* (VU/IUCN; VU/ RDB). In addition some fauna of conservation interest, such as the Lesser Mousedeer (*Tragulus kanchil*) and Barking Deer (*Muntiacus muntjac*), have been recorded by camera trap. There is also anecdotal evidence of Sunda Pangolin (*Manis javanica*) (CR/IUCN; CR/RDB; CITES-II) foraging in the evening and at night at Bukit Golf Course, which is located approximately 60 m at its closest point and 250 m away at it farthest point away from these boreholes and this suggests that this species may reside in this *Regeneration Forest A* during the daytime. Wildlife along this trail however is considered more habituated to human presence and disturbance since it is a trail that is open to the public;

- BH08, BH10, BH12 have been relocated to sit within the Bukit Golf Course fairway, on the boundary of the *Regeneration Forest A*, and Bukit golf course. The locations are on grass between shrubs

which abut the *Regeneration Forest A* and the golf course fairways. Indicative pictures of the proposed locations are shown in *Annex 9*. No plant species of conservation interest were observed at these borehole locations. These boreholes are positioned as close as possible to the alignment but in areas which will avoid any damage to the existing shrubs and trees. The *Regeneration Forest A* habitat in this area is extended from, and ecologically linked to, the large continuous forest within NParks' Managed Area, and considered of high ecological and biodiversity value. However, the golf course habitat is considered of medium sensitive value to disturbance;

- BH13 - BH19 are also within the Bukit Golf Course fairway, but either at the edge of an area of *Isolated Forest* or *Regeneration Forest A*. No plant species of conservation interest were observed at these borehole locations however, the areas around BH15-18 include some trees tagged by NParks. All mature trees within the Island Golf Course have been tagged for conservation; there are a number of these conserved trees near where the proposed rotary boreholes are located. Overall the habitats at BH13 – BH19 are considered to have medium sensitive value to disturbance; and
- Boreholes BH35 - BH37, towards the east of Alignment Option 1, are located in *Regeneration Forest A.* This area is considered of high sensitivity as results from primary baseline surveys show various species of conservation interest (avifauna, mammals and herpetofauna) frequently utilize areas in the vicinity to these boreholes (see *Volume II, Chapter 7, Figures 7.9 and 7.10* and *Volume III*, *Figure 6.1b*).

## 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 as 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:

- Sensitivities of ecology and biodiversity resources/ receptors; and
- Impact Magnitude.

Note 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* provides an overall evaluation of sensitivity of the baseline resources (habitats) and receptors (species) of the Project Study Area based on the secondary and primary 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 all of the above characteristics, the uniqueness and fragmented nature of CCNR and in consultation of stakeholders, magnitudes of impacts to ecology and

biodiversity for this C1001 EIA were defined for this EIA as five qualitative scales outlined in *Table 6.1* for habitats and species.

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

| Magnitude | Definitions |
|---|---|
| **Positive** | The effect brings beneficial outcomes to ecology or biodiversity and flora or fauna taxa. No magnitude will be assigned to a positive impact. |
| **Negligible** | Effect is within the normal range of natural variation and variation for the population of the species. |
| **Small** | Affects only a small area of habitat, such that there is no loss of viability/function of the habitat.<br>Effect does not cause a substantial change in the population of the species, or other species dependent on it. |
| **Medium** | Affects part of the habitat, but does not threaten the long-term viability/function of the habitat.<br>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 the entire habitat, or a significant proportion of it, and the long-term viability/function of the habitat is threatened.<br>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).<br>The population of species listed as CR or EN or VU in the Singapore Red Data Book are affected due to the presence of activities. |

### *6.4.3 Impact Significance*

Once the sensitivities of ecology and biodiversity resources/ receptors have been determined (as detailed in *Volume II, Chapter 7*) and the impact magnitude has been determined according the definitions above, a Significance Matrix is used to determine the significance of the impact. The matrix used with respect to ecology and biodiversity is referenced to *Volume I, Chapter 4, Figure 4.3*.

## *6.5 ASSESSMENT OF IMPACTS OF SI STRATEGY*

### *6.5.1 Avoidance/ Minimization of Impacts*

The mitigation hierarchy (described in *Volume I, Chapter 4*) aims to achieve the best possible outcome to minimize effects on ecology and biodiversity and should be applied sequentially to: avoid or reduce at source; abate on site; abate at receptor; repair or remedy; and finally compensate in kind or compensate through other means.

As described in *Volume I, Chapter 2 Section 2.4*, there have been a number of alternative Project locations and design options. Ecology and biodiversity concerns have been key factors in the deliberation of these options, helping to shape Alignment Option 1, in particularly the location of BHs and associated methods. Embedded controls included with the SI strategy for rotary BHs include the following:

- **Buffer Zones:** Recognizing the high natural value of the streams and wetland areas within the CCNR and their particular sensitivity to impacts, a 30 m buffer was set in place early in the Project development, where BH works would be restricted or prohibited. The buffer width was based on international guidance[1,2,3,4] as detailed in *Volume I, Chapter 2 Section 2.4.2* of this SI EIA Report. In addition, only borehole locations of gentle/ flat gradient and without any ditches leading down to the streams in the close vicinity were selected. The primary objective of the buffer is to separate potential pollution hazards from the streams and wetland areas and by extension to offer some protection to, or conservation of the aquatic and wildlife communities in the stream and wetland areas.

- **Minimization of Number and Location of Boreholes:** Rather than keeping to the standard placement of boreholes at 25 m intervals in a herringbone pattern along the whole of the Alignment, rotary boreholes within the CCNR were minimized in number. Where they are required, they have been relocated onto the existing trails (of limited vegetation) or modified areas such as bare ground just off trail, the Bukit Kalang Service Reservoir Compound and surrounding roads. Additionally, where rotary boreholes were close to the CCNR within forested areas, such as in *Regeneration Forest A* near the Bukit Golf Course, boreholes have been repositioned to be on the existing trail (Sime Trail) or moved to the periphery of the forest onto the Bukit Golf Course fairway grass. Such relocation/ re-positioning measures resulted in avoidance of tree/ vegetation removal (apart from the turf/ grass patches in the golf course) and habitat loss.

- **Use of Mackintosh Probes.** The locations of intrusive ground investigation within the CCNR have been refined such that where access constraints and environmental sensitivities limit the use of a conventional drilling rig, MPs will be used as an alternative. For example in locations towards the west of Alignment Option 1 that are close to or within the stream and 30 m buffer area, MPs involving hand held have been proposed instead of rotary boreholes.

- **Other NParks Requirements.** As detailed in *Vol I Chapter 3* NParks imposes a number of controls on activities within the CCNR. All of the SI activities will be undertaken during the daytime within the CCNR (between 09.00 and 17.00 with demobilization from 17.00 to 18.00, Monday to Friday, in accordance with NParks requirements). There will be no activities during dawn, early morning, dusk and night-time, and therefore no impacts from artificial light are considered in this assessment. The total working hours excluding demobilization per week is about 40 hours (8 hours per day for 5 days a week). The distribution of working hours in a week is presented below:

[1] United States Environmental Protection Agency. **Water-Best Management Practices. Riparian/ Forested Buffer**. Available at http://water.epa.gov/polwaste/npdes/swbmp/Riparian-Forested-Buffer.cfm [Accessed January 2015]

[2] Explanatory Statement for ' Site of Special Scientific Interest' land zooming in the Approved Sha Lo Tung Outline Zoning Plan No. S/NE-SLT/4. Available at http://www2.ozp.tpb.gov.hk/plan/ozp_plan_notes/en/S_NE-SLT_4_e.pdf

[3] TPB Paper No. 9645 for Consideration by the Town Planning Board on 28.4.2014 Consideration of Representations and Comments In Respect Of Draft So Lo Pun Outline Zoning Plan NO. S/NE-SLP/1.

[4] **Tung Chung New Town Extension Study. Summary of Technical Assessments**. Available at http://www.tung-chung.hk/TechnicalAssessment.pdf [Accessed January 2015].

| Days | Time | SI Work Activities excluding Demobilization |
|---|---|---|
| Monday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |
| Tuesday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |
| Wednesday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |
| Thursday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |
| Friday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |
| Saturday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |
| Sunday | 00.00-06.00 | |
| | 06.00-12.00 | |
| | 12.00-18.00 | |
| | 18.00-24.00 | |

As mentioned above, avoidance and minimization of environmental impacts have been considered throughout the design phase of the Project, particularly in relation to the locations and working methods for rotary BHs within the CCNR. For the borehole locations outside the CCNR, the standard 25 m herringbone pattern has been adopted as the basis for assessment. Along with consideration of key environmental findings it is assumed that the actual borehole locations will be refined to avoid/ minimize impacts on existing trees and the isolated forest within SICC Island Golf Course. The following sections present the embedded controls for the different aspects of the SI Strategy considered within this assessment.

### *Embedded Controls for Site Reconnaissance and Geophysical surveys*

As outlined previously, in addition to adopting standard good practices and complying with regulatory requirements to working within CCNR, the embedded controls to reduce environmental impacts associated with the site reconnaissance and geophysical surveys include:

- The site reconnaissance, geophysical surveys and MP surveys within the CCNR will be scheduled between 09.00 and 17.00 with mobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements; and

- Some of the survey equipment (eg the geophones and cables) will need to remain in the field overnight to allow for repeat surveys in the instance that further measurements are required. All these equipment will be properly stored. No sensitive recording equipment (eg the gravity survey meter, seismic recording system and accelerated drop weight) will be left at the survey locations overnight. These will be removed from CCNR. Other equipment, including string lines, are not expected to be left at any one location longer than two nights/ three days.

### *Embedded Controls for Rotary Borehole Works*

A key control to manage potential impacts to aquatic habitats has included the provision of a 30 m buffer around streams and wetland areas as described in *Section 6.5.1* and further detailed in *Volume I, Chapter 2 Section 2.4.2* of this Report. In addition, the following embedded controls, also detailed in *Chapter 3,* will be in place during operation activities of the rotary rigs to manage impact of run-off to surface (and ground) water and therefore manage harm to aquatic habitats:

- All drilling works will be conducted in accordance with the *Environmental Protection and Management Act, 2008, Environmental Protection and Management (Trade Effluent) Regulations, 2008*, *Public Utilities (Reservoir and Catchment Areas) Regulations, 2006* and LTA's *General Specification, Appendix A, Safety, Health and Environment (for Rail Project) December 2014 Edition*. These include controls to protect impact to surface water courses, such as prohibiting hazardous material release; provision of drip tray on site; limitations on suspended solids; measures controlling sanitary waste release; and best management practices. Detailed requirements are provided in *Volume I, Annex 1.0*;

- Wastewater generated during operation of the drilling rig will be contained within a FCT and pumped to an enclosed wastewater holding tank and removed on a regular basis for disposal to a licensed third party waste management facility. The FCT will be covered with a tight lid and the tote tank is to be enclosed;

- The small amounts of hazardous liquids (eg maintenance oil) will be stored in a dedicated locked steel container providing secondary containment;

- ECBs will be positioned within the CCNR during the set up phase beneath equipment at each unpaved worksite. These can not only help control erosion, but also help protect exposed roots along trails from heavy vehicles passing over;

- Vehicle and equipment maintenance checks will be undertaken prior to mobilization. Furthermore, any rig maintenance undertaken at each worksite (if required) will use drip trays to prevent release of pollutants to the ground; and

- The access routes and trails in proximity to some BH worksite will be temporarily closed during the rotary drilling works. Appropriate "No Entry" signs will be put up to inform public of the trail closures.

### *Embedded Controls for Horizontal Directional Coring*

A key control to manage potential impacts to aquatic habitats has included the provision of a 30 m buffer around streams and wetland areas as described in *Section 6.5.1* and further detailed in *Volume I, Chapter 2 Section 2.4.2* of the EIA Report. In addition, the following embedded controls, also detailed in *Chapter 3,* will be in place during operation of the HDC operations to manage impact of run-off to surface (and ground) water and therefore manage harm to aquatic habitats:

- All drilling works will be conducted in accordance with the *Environmental Protection and Management Act, 2008, Environmental Protection and Management (Trade Effluent) Regulations, 2008*, *Public Utilities (Reservoir and Catchment Areas) Regulations, 2006* and LTA's *General Specification, Appendix A, Safety, Health and Environment (for Rail Project) December 2014 Edition*. These include controls to protect impact to surface water courses, such as prohibiting hazardous material release; provision of drip tray for all fluid containers 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 FCT and pumped to an enclosed wastewater holding tank and removed on a regular basis for disposal to a licensed third party waste management facility. The FCT will be covered with a tight lid when not in use;

- The small amounts of hazardous liquids (eg maintenance oil) will be stored in a dedicated locked steel container providing secondary containment;

- ECBs will be positioned where the HDC worksite is unpaved, ie within Bukit Golf Course and the Kalang Service Reservoir Compound. These can not only help control erosion, but also help protect any exposed roots at the HDC worksites; and

- Rig maintenance will be undertaken at each worksite (if required) using drip trays to prevent release of pollutants to the ground.

- A temporary shelter/ cover will be constructed over each HDC worksite, to protect the rig and equipment, as well as the worksite from adverse weather events.

## *6.5.2 Potential Impacts due to SI Works*

The Preliminary Investigations (consisting of site reconnaissance), and the geophysical investigations proposed (seismic reflection and refraction, electrical resistivity, and gravity surveys, all supported by topographic surveys) are all considered less intrusive[1] investigation techniques as they involve hand held equipment; require few personnel to operate; and do not involve ground clearance or excavation (at most involving a geophone spike pushed into the ground). In addition, although MPs are considered an intrusive technique, the works are small scale (using hand held equipment) in comparison to other intrusive ground investigation techniques using larger scale machinery and vehicles. For the purpose of the impact assessment, these SI activities have therefore been grouped to assess their impacts on ecology and biodiversity.

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

The tentative sequence of geophysical survey events is summarized below (for further details refer to *Chapter 2*):

1) Topographical surveyors (2 nos.) identify survey route;
2) Gravity surveyors (2 nos.) mobilise to commence along with topographical surveyors covering 150 m wide corridor;

3) Seismic Reflection and Refraction surveyors (3 nos.) mobilise to set up and commence with topographical surveyors surveying three 200 m lines with 12 m separation over the Alignment Option 1;

4) Electrical Resistivity surveyors (3 nos.) mobilise to set up and commence with topographical surveyors surveying two 200 m lines with 12 m separation over the Alignment Option 1;

5) Topographical surveyors identify next accessible area/route; and

6) Survey team demobilize and mobilize to the next area.

*Table 6.2* summarizes the necessary resources for the activities being assessed, lists out the estimated numbers of required personnel, presents the total duration of works within the CCNR to carry out each activity and the assumed working footprint.

***Table 6.2*: *Summary of Necessary Resource, Duration of Works and Assumed Working Footprint for Preliminary Investigations, Geophysical Field Surveys and Mackintosh Probes***

| Survey | Primary Equipment Needed | Number Personnel Required (including elevation survey) | Duration (including set up and decommissioning) | Max. Assumed Working Corridor Width Above Alignment (Note 1) |
|---|---|---|---|---|
| Site Reconnaissance | • None | Up to 2 | Up to 2 days | 150 m |
| Topographic Surveys | • Controller (200(W) x 120 (L) x 45 (H) and 0.6kg)<br>• Receiver (196 (W) x 198 (H) and 3.3 kg) | Up to 2 | Will be present throughout the geophysical surveys to aid identification of the survey area and survey all locations<br><br>Approximately 5 minutes estimated to survey each geophysical survey location. | 150 m |
| Seismic Refraction / reflection | • Geophones (40(W) X 50(L) x 140(H) and 90g)<br>• Cables (15(W) and 25-30 Kg))<br>• Seismic source (6 kg or 15 kg)<br>• Data recorder | Up to 3 seismic refraction and reflection surveyors | One string line of 200 m length up to 3-4 days (includes mobilization, set up, survey, topographic survey, and equipment demobilization) if no accessibility restriction (Note2) | 24 m |
| Electrical Resistivity | • Geophones 40(W) X 50(L) x 140(H)<br>• Cables (15(W) and 25-30 Kg))<br>• Voltmeter<br>• Battery (290 (W) x 330(L) x 100(H) and 8kg | Up to 3 electrical resistivity surveyors | One string line of 200 m length up to 3 days (includes mobilization, set up, survey, topographic survey, and equipment demobilization) if no accessibility restriction (Note 2) | 12 m |
| Gravity | • Gravimeter (210(W) x 220(L) x 300(H) and 8 kg) | Up to 2 gravity surveyors | 15 minutes per location (includes mobilization to each location, set up, survey (5 minutes per reading), topographic survey, and equipment demobilization) | 150 m |
| Mackintosh Probes | • Mackintosh probe.<br>• Tripod.<br>• ~4.5 kg weight. | Up to 2 | Up to 2 days | Not applicable. Proposed spot locations indicated on *Figure 6.1* |

***Notes:***
Note 1 Personnel will not walk over the whole working corridor every day, but rather move in and out of each survey area from the existing trails. All Survey equipment will be portable and manually carried along the off trail.

*Table 6.3* summarizes the estimated length of survey routes and time required for the geophysical surveys assuming no access constraints along the alignment corridor.

***Table 6.3*: *Estimated Length of Survey Routes and Time Required for Geophysical Surveys Assuming <u>No Access Restriction</u>***

| Number of trips | Unit | Number of one way trips | Approx Duration | Max Length of trip (m) | Number of people (Note 1) | Total distance (m) | Contingency (m) (Note 2) | Including Contingency (m) | Notes |
|---|---|---|---|---|---|---|---|---|---|
| ***Seismic*** | ***Per 200 m line*** | | | | | | | | |
| Identify Start Point | | 2 | 1 hour | 200 | 2 (2xT) | 800 | 50% | 1200 | (1) Assumed that 3 surveyors can carry all geophones for on 200 m line (2.3kg x 14 sets = 32.3 kg, divided by 3 = <11kg/person). |
| Set up (1) | | 2 | 0.5 - 1 day | 200 | 5 (2XT, 3xS) | 2000 | 50% | 3000 | |
| Measurement(2) | | 2 | 0.5 - 1 day | 200 | 3 (3xS) | 1200 | 50% | 1800 | (2) Includes carrying drop weight and any time necessary for adjustments to geophones |
| Removal of equipment | | 2 | 0.5 - 1 day | 200 | 3 (3xS) | 1200 | 50% | 1800 | |
| | | | | | | | | **7,800** | |
| ***Electrical Resistivity*** | ***Per 200 m line*** | | | | | | | | |
| Identify Start Point | | 2 | 1 hour | 200 | 2 (2xT) | 800 | 50% | 1200 | (3) Assumed that 3 surveyors can carry all equipment for 200 m line in one trip as Cable =25-30kg +plus <4Kg for geophones. Cable roll carried and not dragged through behind. |
| Set up (3) | | 2 | 0.5 - 1 day | 200 | 5 (2XT, 3xS) | 2000 | 50% | 3000 | |
| Measurement(4) | | 2 | <0.5 day | 200 | 1 (1xS,) | 400 | 50% | 600 | |
| Removal of equipment | | 2 | 0.5 - 1 day | 200 | 3 (3xS) | 1200 | 50% | 1800 | (4) Measurement done from start point but includes allowance for two persons along the trail to do any necessary realignment due to measurement error. |
| | | | | | | | | **6,600** | |
| ***Gravity*** | ***per 28 survey points*** | *(ie max number per day, assuming 8 hour survey period less 1 hr break. 1 pts/ 15 min x 7 hr = 28 pts/day)* | | | | | | | |
| Identify Start Point | | 2 | 1 hour | 420 | 2 (2xT) | 1680 | 50% | 2520 | (5) Placement, measurement, topographical survey and equipment removal all done sequentially point by point. |
| Measurement & Topo Survey(5) | | 2 | 1 day | 420 | 4 (2xS, 2xT) | 3360 | 50% | 5040 | |
| | | | | | | | | **7,560** | |

Note 1 T = Topographical surveyor; S = Seismic Reflection and Refraction surveyor and E = Electrical Resistivity surveyor

Note 2 Contingency: To allow for bathrooms trips, rain and lunch breaks etc.

As outlined in *Chapter 2*, the rotary drilling rigs being considered for the boreholes along Alignment Option 1 are:

- DeltaBase 520 (DB520) type rig; and
- A crawler A-frame rotary rig (standard A-frame drilling rig adapted with a self-propelled crawler platform).

Full details of how rotary drilling will be conducted are provided in *Volume III, Chapter 2,* including details on the geotechnical testing (eg SPT, Packer Test), worksite area, equipment etc which will be required during operation of each drilling rig.

HDC is a technique where inclined boreholes are drilled underground with little visible effect except at the worksite areas where they are managed from. Details of how HDC will be conducted are provided in *Volume III, Chapter 2*.

An explanation of the potential impacts on ecology and biodiversity from the SI strategy is provided below.

### *Potential Impacts*

***Preliminary Investigations***

As part of the preliminary investigations, site reconnaissance will involve personnel walking over the proposed alignment route (*Figure 6.1*) along existing trails/ routes in particular visiting the proposed locations for the intrusive ground investigation works (MPs, rotary boreholes and HDC worksite areas). Associated potential impacts on ecology and biodiversity include disturbance to vegetation from walking over the site (ie trampling), disturbance to wildlife behavior due to human interference and possible disturbance of aquatic habitats when investigating where MPs are proposed.

***Geophysical Investigations (Seismic Reflection and Refraction, Electrical Resistivity, Gravity Surveys)***

Geophysical surveys will be undertaken along the section of Alignment Option 1 where it travels beneath the CCNR using a combination of seismic refraction and reflection, electrical resistivity and gravity surveys. The survey areas will be immediately above and in the vicinity of the tunnel alignment location within the CCNR.

The potential impacts associated with the geophysical surveys are as follows:

- The topographical survey of each geophysical survey location will also involve personnel walking along the existing trails and off trail throughout the 150m-wide geophysical survey corridor. Potential associated impacts will include vegetation disturbance from trampling, disturbance to wildlife behavior (from human interference) and disturbance of aquatic habitats.

- Seismic refraction/reflection surveys will involve setting an array of geophones at 5 m spacing at ground level with the geophones positioned in collinear 200 m string lines above and between the tunnel alignments. The geophones are small devices that are secured into the ground using a short spike and their connecting cable can be laid on the ground around physical obstructions, such as trees, dense areas of vegetation etc. During the survey, seismic waves are generated at five ground

level locations along each string line for the refraction survey and at every geophone positioned along a string line for reflection survey (ie up to 40 locations). Seismic waves for the surveys are generated using (up to six) blows at one seismic source location/geophone. Two methods have been provisionally allowed for seismic wave generation, requiring a steel plate (< 0.5 $m^2$) on the ground being struck manually by a sledge hammer (6 kg) or an accelerated drop weight (approximately 15 kg). These equipment are hand held. Full details of all geophysical investigation methods can be found in *Volume III, Chapter 2.*

Setting the geophones and cables as well as placement of the steel plate on the ground may cause disturbance to vegetation (from potential trampling impacts associated with walking off trail as elaborated upon below), disturbance to wildlife behavior (from human interference, noise and vibration generated during the activities) and disturbance to aquatic habitats.

- For the electrical resistivity surveys, two pairs of metal stakes will be inserted into the ground and connected by a single cable with multiple take-out connection points staked into the ground (typically around 60 points along one 200 m cable length, spaced at approximately 5 m intervals). An electrical current will be passed between them from a battery power source (12 volt). The cables will be placed on either side of the tunnel alignment and the process repeated with different probe spacing to build up a vertical profile. The electrical resistivity surveys may follow the similar survey areas/ routes of seismic refraction/reflection surveys.

- For the gravity survey, measurements must be taken at ground surface using a gravimeter at gridded survey locations typically on an approximate 15 m – 20 m grid over a 150 m wide corridor centered on the alignment. The gravimeter is a hand held piece of equipment which can be placed on the ground. The gravity surveys will cover wider areas but may share some of the identified survey areas/ routes of seismic refraction/reflection and electrical resistivity surveys. The area impacted will be larger than that of the seismic refraction/reflection and electrical resistivity surveys.

***Mackintosh Probes***

The MPs involve penetrating the ground with extendable rods with a sliding drop weight. As previously detailed, equipment is portable; the process is relatively quick (approximately 1 day per MP) and does not require drilling fluid. Impacts on ecology and biodiversity due to this activity are anticipated to be vegetation disturbance (from potential trampling effects associated with walking off trail), disturbance to wildlife behavior (from human interference, noise and vibration) and impacts on aquatic habitats. The locations of the MPs are in the Bukit Golf Course but also in areas within CCNR characterized as *Wetland Marsh* and *Wetland Forest*.

Survey equipment for the activities described above is portable and will be manually carried to survey locations. Where trollies may be employed to carry equipment (eg heavy batteries for electrical resistivity) these will be restricted to use along the existing trails within the CCNR. Therefore there are no impacts associated with motorized vehicle transport of equipment or machinery for these activities.

***Rotary Borehole Works***

The 16 rotary boreholes (BH01, BH20 – BH34 as illustrated in *Figure 2.1* and *Figure 6.1, Figure 6.1a and Figure 6.1b*) will be completed along the alignment section within the CCNR and these have all been located in publically accessibly locations, mainly on the public trails and Kalang Service Reservoir Compound. Two borehole locations (BH01 and BH21) are slightly off trail, however within existing clearings.

For the boreholes within the Study Area but outside the CCNR, locations have been generally plotted based a standard 25 m herringbone pattern, running either side of the tunnel alignment, but some boreholes adjacent or near to the CCNR have been adjusted according to the site environment and previous reconnaissance (eg, apart from BH35 – BH37, no boreholes will be located within Windsor Interim Green). During the Preliminary Investigation stage of the works, the borehole locations outside CCNR (ie along Island Club Road to Upper Thomson Road through SICC Island Golf Course and 400 m west of the PIE) will be reviewed and finalized to account for access constraints (eg, utilities and building surveys) and avoidance of isolated forest or tree cutting within the SICC Island Golf Course, along with key findings from the ecological baseline surveys such that any potential impacts can be reduced to as low as reasonably practicable (ALARP).

To undertake the work, the borehole rig will mobilize to the proposed borehole location with all its necessary associated equipment. In order for rigs to reach the proposed borehole locations, within the CCNR they will follow the main existing trails, either accessing through SICC Bukit Golf Course and Sime Trail at the west, or in the east from Island Club Road, then Terentang Trail and in some cases from Terentang Trail then Sime Trail as previously detailed in *Chapter 2*. The access routes and trails in proximity to each worksite will be temporarily closed during the rotary drilling works and appropriate "No Entry" signs in place to inform the public of the trail closures. Within the CCNR, the trails that will be used for mobilization and demobilization were observed to have overhanging vegetation in places that is lower than the height of the rig. Furthermore, the Terentang trail is narrow in places (based on observations recorded during the field surveys), implying that if a larger size rig (ie, the DB520) were used, it would most probably travel over vegetation along the verge of the trail in some areas. Overall, mobilization and demobilization of the rigs in CCNR may therefore cause some damage to overhead foliage and vegetation either side of the trail. Minimal vegetation cutting, in consultation with NParks, may be carried out, but wherever possible overhanging vegetation will be temporarily tied back as a protection to the rigs traveling along the trails.

Similarly, for borehole locations outside the CCNR, overhanging vegetation was observed during the field surveys in some areas, ie, along the access road from Bukit Golf Course to Sime Trail; in proximity to the boreholes locations within both the Bukit and Island Golf Courses themselves; and along the trails at BH35 – BH37. It is therefore envisaged that some overhanging vegetation will be present during the site reconnaissance and will need to be temporarily tied back (where possible). It is noted, that no removal of vegetation (including trees) will be undertaken for access to the borehole locations proposed along Alignment Option 1.

Mobilization and demobilization of rigs to worksites may also, in the worst case scenario, lead to accidental road-kill of wildlife. Rig operations will only be conducted during the daytime between 09.00 and 17.00, Monday to Friday (with demobilization from 17.00 to 18.00), and personnel will mobilize to and from the worksites daily (either by foot within CCNR and to BH35 – BH37 or by small vehicle to all other locations). In addition a small ancillary vehicle (see details provided in *Volume III, Chapter 2, Table 2.6*) will be required twice daily to transport fresh water to a tank at each worksite and remove wastewater. It could also be used to transport any samples (eg undisturbed samples [UD]), which will need to be analyzed ex-situ at laboratories or similar), away from the worksite. It is estimated that two (2) round trips will be required daily for the ancillary vehicles supporting BH works within the CCNR (ie, for the transport of water and removal of wastewater). Ancillary equipment to support the drilling works, as detailed in *Table 2.5*, will be manually carried to each worksite within the CCNR with the exception of BH22. As this location is far along the trail from the access point into CCNR, it is proposed to utilize the ancillary vehicle to carry equipment to and from this area only. This

will involve 5-10 round trips during the day equipment is mobilized to the worksite and another 5-10 trips on the day equipment needs to be removed from the area. Both personnel and vehicle movements may result in damage to vegetation due to potential trampling impacts associated with moving off trail. The ancillary vehicle required for daily support of borehole works may however cause some minimal disturbance to vegetation either side of the trails and is assessed further herein.

The works will require personnel on site daily for the duration of rotary borehole works and within the CCNR and NParks managed areas, where the abundance of wildlife is higher than outside these areas. Additional human presence both at the worksite during operation and accessing the site daily may give rise to some interference with wildlife, eg scaring wildlife away or being attracted to the site to forage.

For both rigs, boreholes will have a minimum 54 mm, maximum 100 mm core diameter and go to depths of 70-100 m. This is not expected to cause significant habitat loss/ conversion in addition to any compaction/ minimal disturbance of overhead foliage and vegetation either side of the trail that has been carried out for mobilization and set up. Therefore this is not assessed as an impact of concern.

During rotary borehole drilling itself, noise and vibration may also add to disturbance to wildlife behavior. The worksite will also physically occupy a small area (2 m x 11 m or similar), generally excluding the use of this area by wildlife therefore the loss of wildlife territory is considered insignificant for the purpose of further assessment.

As detailed in *Chapter 3*, potential impacts to the aquatic environment may also result from uncontrolled site run off reaching water bodies, either from erosion of trails during mobilization or from the rig worksites. The impact to surface water quality from the borehole operations is considered to be under control following application of several mitigation measures to limit potential discharge volume and the presence of the buffer zone so no borehole location is within 30 m of a surface water body or wetland area.

***Horizontal Directional Coring***

In total, drilling using HDC will be carried from three sites outside CCNR, one starting near to the PIE and Fairway Drive (HDC1) just outside the Study Area, another north of Bukit Golf Course and a third within the Kalang Service Reservoir compound, immediately to the east of the CCNR. Each of the proposed HDC worksite area (illustrated in *Figure 6.1*) is expected to be approximately 35 m by 20 m and covered by a temporary structure to protect them from adverse weather.

Drilling will be undertaken continuously in a 24-hour operation and the duration is expected to be between four and twelve months at each location. Provisional drill lengths will be between 500 m and 800 m. In situ packer tests and collection of undisturbed samples will occur during drilling. Impacts to ecology values that are associated with the operation of the HDC drilling include disturbance to wildlife behavior due to noise and vibration, including Sunda Pangolin recorded at the north of Bukit Golf Course. Since the drilling will be operating 24-hours, illumination will be required at the worksite at night and wildlife may also be disturbed by this artificial light in particular the HDC worksites within (HDC3) in close proximity to (HDC2) the CCNR.

The HDC worksite north of Bukit Golf Course is also close (approximately 100 m) and just uphill of the *Wetland Forest* area of the CCNR. The possibility of impacts to the aquatic environment from uncontrolled site run-off reaching water bodies is considered, either from erosion of access routes during mobilization or from the rig worksites, including consideration of the embedded controls to be implemented to address this.

*Table 6.4* provides a summary of the potential impacts on ecology and biodiversity associated with the overall SI Works.

***Table 6.4***: ***Summary of Potential Impacts on Ecology and Biodiversity from SI Works***

| Activity | Associated Impacts on Ecology & Biodiversity (Note 2) |
|---|---|
| Site Reconnaissance (Note 1) | • Disturbance to wildlife behavior due to human interference. |
| Seismic Refraction / reflection | • Disturbance to vegetation, from potential trampling impacts associated with walking off trail.<br>• Disturbance to wildlife behavior due to human interference and noise<br>• Disturbance to aquatic habitats |
| Electrical Resistivity | • Disturbance to vegetation, from potential trampling impacts associated with walking off trail.<br>• Disturbance to wildlife behavior due to human interference, noise and vibration.<br>• Disturbance to aquatic habitats |
| Gravity | • Disturbance to vegetation, from potential trampling impacts associated with walking off trail,<br>• Disturbance to wildlife behavior due to human interference and noise.<br>• Disturbance to aquatic habitats |
| Mackintosh Probes | • Disturbance to vegetation, from potential trampling impacts associated with walking off trail,<br>• Disturbance to wildlife behavior due to human interference, noise and vibration<br>• Disturbance to aquatic habitat |
| Mobilization and demobilization of rig, ancillary vehicles and personnel to borehole worksites, along existing trails | • Vegetation compaction/ minimal cutting e.g. of overhead foliage and vegetation either side of trails due to mobilization, set up<br>• Vegetation disturbance eg from daily movement of personnel/ vehicles along the existing trails and off road areas, such as within SICC Golf Courses<br>• Disturbance to wildlife behavior due to human interference<br>• Disturbance to aquatic habitats |
| Rotary Borehole Drilling Operation at Site | • Disturbance to wildlife behavior due to human interference, noise and vibration<br>• Disturbance to aquatic habitats |
| HDC and associated equipment mobilization and demobilization | • Vegetation Cutting eg of overhead foliage due to mobilization, for access road, set up<br>• Disturbance to wildlife behavior due to human interference |
| HDC Drilling Operation at Site | • Disturbance to wildlife behavior due to noise and vibration as well as illumination.<br>• Disturbance to aquatic habitats. |

Note 1 Temporary disturbance to vegetation unlikely to be anticipated since survey will follow existing trails/ routes to inspect the proposed intrusive ground investigation locations.

Note 2 Also refer to *Section 6.6 Impact due to Unplanned Events* for impacts concerning Injury to Wildlife

In addition, it is anticipated that some rotary borehole works will start while geophysical surveys are still ongoing and MP work may also be concurrent with rotary borehole works within the CCNR. Therefore the combined consequences of their associated impacts are considered.

### *Disturbance to Vegetation from Trampling Impacts Associated With Off trail Walking*

As presented in *Table 6.4*, impacts to vegetation are expected from a number of activities from the SI works. This will principally be due to off trail work associated with geophysical survey works and operation of MPs. For the Preliminary Investigations the site reconnaissance will involve up to (2) persons tracing the proposed alignment (along existing trails/ routes) and proposed intrusive ground investigation locations (illustrated on *Figure 2.1*) over the ground. In addition, rotary borehole works will, if carried out as planned, not directly cause significant impacts to vegetation due to trampling, except for potential damage to exposed roots, since all borehole works will be undertaken on existing trails and cleared areas, and no personnel or vehicles will be allowed off trail within the CCNR.

Literature regarding the effects of trampling is predominantly concerned with assessing more sustained trampling of a longer duration (eg over a number of years) or increasing intensity (eg more visitor numbers) on existing trails [1,2,3,4], although it is generally noted that first passes over virgin vegetation plots have more impact than later passes [5]. Farrier (2005) studied the effects of between 1 and 100 passes per week for a month over plots in forest and prairie habitats and noted no substantial effect on compaction of the soil. It was noted however, that as the frequency of walking off trail increased, the amount of leaf litter in the forest decreased and amount of bare ground increased.

*Table 6.5* provides an indication of the extent of impact in each habitat during the geophysical surveys, borehole and MP works along the alignment. This was developed with consideration of the length of the alignment across each habitat in the Study Area and the maximum assumed working corridor (as outlined in *Table 6.2* and *Table 6.3*). Due to the uncertainty of conditions off trail and the degree of access possible in each of these habitats, the initial analysis has been done assuming **no** access constraints. This has been done for illustrative purposes only and to provide a conservative scenario for assessment. In this regard it is important to note that the data represent a worse-case scenario of the total distance walked by all the survey team members within each habitat.

[1] Chatterjea K (Date unknown) **Sustainability of an Urban Forest: Bukit Timah Nature Reserve, Singapore.** Retrieved from http://cdn.intechopen.com/pdfs-wm/35234.pdf

[2] Turton SM (2005) **Managing Environmental Impacts of Recreation and Tourism in Rainforests of the Wet Tropics of Queensland World Heritage Area.** Geographical Research 43(2):140–151

[3] Marion JL (2006) **Assessing and Understanding Trail Degradation: Results from Big South Fork National River and Recreational Area.** United States Department of the Interior

[4] Ross PM (2006) **Macrofaunal loss and microhabitat destruction: The impact of trampling in a temperate mangrove forest, NSW Australia.** Wetlands Ecology and Management 14; 167-184

[5] Farrior C (2005) **The Effects of Social Trails on Soil Compaction and Vegetative Cover in Forest and Prairie Ecotypes.** PennScience Vol3 Issue2

***Table 6.5***: ***Estimated Total Distance Walked in Survey Areas of Alignment Option 1 across each Habitat and Location of Boreholes & MPs within Habitats***

| Habitat | Identified Maximum Distance Walked along 150 m wide Corridor (*Figure 6.1*) Worst Case Scenario – Assuming No Accessibility Restriction and multi-trips calculation making reference to *Table 6.3* | | | Number of MP in Habitat (*Figure 6.1*) | Numbered Boreholes in Habitat (*Figure 6.1*) |
|---|---|---|---|---|---|
| | Seismic Refraction and Seismic Reflection Survey Line (Total 3 lines along Alignment Option 1) | Electrical Resistivity Survey Line (Total 2 lines along Alignment Option 1) | Gravity Survey Area (areas within 150 m corridor) (ha) | | |
| ***Inside CCNR gazetted boundary*** | | | | | |
| Primary Forest (PF) | (total length of lines = ~450 m)<br>~17,550 m = 7,800x450/200 | (total length of lines = ~300 m)<br>~9,900 m = 6,600x300/200 | (~116 points within ~3.5 ha)<br>~31,320 m = 7,560x116/28 | | BH22 – On trail |
| Regeneration Forest A (RA) | (total length of lines = ~4,220 m)<br>~164,580 m = 7,800x4,220/200 | (total length of lines = ~2,870 m)<br>~94,710 m = 6,600x2,870/200 | (~651 points within ~19.4 ha)<br>~175,770 m = 7,560x651/28 | | BH01, BH20, BH21, BH23, BH24, BH25, BH26, BH27, BH28, BH29, BH34 – all on trail |
| Regeneration Forest B (RB) | - | (total length of lines = ~1 m)<br>~33 m = 6,600x1/200 | (~2 points within ~0.04 ha)<br>~540 m = 7,560x2/28 | | |
| Wetland Forest (WF) | (total length of lines = ~125 m)<br>~4,875 m = 7,800x125/200 | (total length of lines = ~80 m)<br>~2,640 m = 6,600x80/200 | (~37 points within ~1.1 ha)<br>~9,990 m = 7,560x37/28 | MP06 | |
| Wetland Marsh (WM) | (total length of lines = ~550 m)<br>~21,450 m = 7,800x550/200 | (total length of lines = ~370 m)<br>~12,210 m = 6,600x370/200 | (~90 points within ~2.8 ha)<br>~24,300 m = 7,560x90/28 | MP07, MP08, MP09 | |
| Developed Area (DA) | (total length of lines = ~125 m)<br>~4,875 m = 7,800x125/200 | (total length of lines = ~30 m)<br>~990 m = 6,600x30/200 | (~43 points within ~1.4 ha)<br>~11,610 m = 7,560x43/28 | | BH30, BH31, BH32, BH33 – on road/within compound |
| ***Outside CCNR gazetted boundary (Restricted to Areas Along Alignment Option 1 & within Bukit Golf Course)*** | | | | | |
| Regeneration Forest A (RA) | (total length of lines = ~670 m)<br>~26,130 m = 7,800x670/200 | (total length of lines = ~450 m)<br>~14,850 m = 6,600x450/200 | (~115 points within ~3.5 ha)<br>~31,050 m = 7,560x115/28 | | BH02 - BH07, BH09, BH11 – all on trail |
| Wetland Forest (WF) | (total length of lines = ~245 m)<br>~9,555 m = 7,800x245/200 | (total length of lines = ~165 m)<br>~5,445 m = 6,600x165/200 | (~24 points within ~0.7 ha)<br>~6,480 m = 7,560x24/28 | MP03, MP04, MP05 | |
| Isolated Forest (IF) | (total length of lines = ~170 m)<br>~6,630 m = 7,800x170/200 | (total length of lines = ~100 m)<br>~3,300 m = 6,600x100/200 | (~46 points within ~1.4 ha)<br>~12,420 m = 7,560x46/28 | | BH17 –on boundary of IF |
| Golf Course/ Recreational Facilities | (total length of lines = ~550 m)<br>~21,450 m = 7,800x550/200 | (total length of lines = ~375 m)<br>~12,375 m = 6,600x375/200 | (~63 points within ~1.9 ha)<br>~17,010 m = 7,560x63/28 | MP01, MP02 | BH08, BH10, BH12 – at periphery of Golf Course, on boundary with RA<br>BH13, BH14 – on boundary of RA<br>BH15, BH16, BH17, BH18 – on boundary of IF<br>BH19 – on golf course fairway<br>BH35, BH36, BH37 – all on trail |

If there were no access constraints, the trampling impacts would be expected to be significant given the extensive length of uncontrolled survey routes (*Table 6.5*) which may result in potential erosion, crushing of leaf litter, damage to plant species and loss of large number of seedlings (potentially including plant species listed as CR or EN or VU in the Singapore RDB). In addition, up to nine MPs will be undertaken at locations immediately above Alignment Option 1 (MP01 – MP09); four of these fall within the CCNR gazetted boundary and the remaining five are outside it (*Figure 6.1*). Most affected habitats for the MPs are of high value with the exception of MP01 and MP02 which fall on the Bukit Golf Course which is considered of medium sensitivity to disturbance (*Table 6.5*). Therefore the MP locations will likely affect wetland areas.

The site reconnaissance, as well as walking over the entire alignment where accessible along existing trails/ routes, will also specifically visit the proposed locations for the intrusive ground investigation works that are focused on the trails. Investigation of the proposed intrusive borehole locations within the CCNR boundary is not considered to lead directly to potential trampling impacts since these are all located on trails, bare ground, on roads or within the Bukit Kalang Service Reservoir Compound. For the numbered boreholes outside the CCNR gazetted boundary, they are all either on trails or within the SICC Bukit Golf Club.

### *Disturbance to Vegetation due to Mobilization / Demobilization and Site Access*

As presented in *Table 6.4*, impacts to vegetation are also anticipated during mobilization and demobilization activities at the rotary borehole and HDC locations.

***Rotary Borehole Works***

Volume II, *Annex 9* provided a detailed description of the key flora and fauna recorded at each rotary borehole location, as well as key physical observations such as gradient of the proposed location and nature of the ground (eg gravel, earth, etc). With regards to the extent of vegetation disturbance, no cutting will be required for mobilization and set up of the rigs. *Table 6.6* gives an indication of the extent of the impacts in each habitat noting the number of boreholes in each, their situation and how they might be accessed during rig mobilization.

With regards the effects of mobilization of the rig and associated personnel and equipment, access to borehole locations is a key consideration and will be via the nearest accessible road, or within the CCNR along the Sime Trail and Terentang public trails. In particular, recognizing that the rigs are 1.5 m wide and 1.9 m for the crawler A-frame and DB 520 respectively, it is noted that given the width of the Terentang Trail is less than 1.5 m between BH29 and BH34, possible damage of vegetation either side of the trail (arising from potential trampling impacts associated with walking off trail) would occur during mobilization of the rig over this route. This is notable around BH28 where at least two *Aquilaria malaccensis* individuals (VU/ *Singapore RDB, 2008*; VU/ *IUCN*) were recorded on the left side of the path (facing east) and numerous seedlings also along the left side of the path (facing east) between BH28 and BH29, in which the movement of rig and secondary vehicle should be avoided. Some overhanging branches along the trail will also need to be tied back prior to mobilization along the trails. Borehole locations have been concentrated along trails and in pre-established clearings so as to avoid vegetation clearance. It is noted that at the clearings where BH21 is situated, many surface roots were observed which may also be affected by accessing the area for the SI works.

Although the actual footprint of a drilling rig at any one location may not necessarily block the trail (the rigs are 1.5 m for crawler A-frame and 1.9 m for DB520) the worksites will be at least 2 m wide for crawler A-frame and 2.2 m for DB520 (including the width required for the rig).

Additionally, as discussed under embedded controls, access routes and trails in proximity to some borehole worksite will be temporarily closed during the rotary drilling works to avoid any impacts of trail users damaging vegetation either side of the trail as they seek to move past boreholes.

***Table 6.6***: ***Rotary Boreholes in each Habitat under Alignment Option 1***

| Habitat | Rotary Borehole # | Comments including Access route |
|---|---|---|
| ***Within CCNR gazetted boundary*** | | |
| Primary Forest (PF) | BH22 | Along trail at boundary of *Primary Forest* and *Regeneration Forest A*, just outside buffers for *Wetland Marsh* and stream Ha. Access from the east, via Island Club Road and Terentang Trail and Sime Trail. |
| Regeneration Forest A (RA) | BH01, BH20, BH21, BH23, BH24, BH25, BH26, BH27, BH28, BH29, BH34 | No temporary alternative-route for public use of trails is required at BH01 or BH21 as are both are just off trail on bare ground clearings. However access is potentially impeded by numerous surface roots at BH21.<br><br>BH20, BH23, BH24, BH25 on Sime Trail. Access from the east, via Island Club Road and Terentang Trail and Sime Trail<br><br>BH26, BH27, BH28, BH29, BH34 on Terentang Trail. Access from the east, via Island Club Road to Terentang Trail |
| Developed Area (DA) | BH30, BH31, BH32, BH33, | No temporary alternative-route for public use of trails is required at any of these boreholes. Access via main roads. |
| ***Outside CCNR gazetted boundary*** | | |
| Regeneration Forest A (RA) | BH02, BH03, BH04, BH05, BH06, BH07, BH09, BH11<br>BH35, BH36, BH37 | To the west of the alignment, near the CCNR boundary:<br>BH02, BH03, BH04, BH05, BH06, BH07, BH09, BH11 all on trail.<br><br>BH35, BH36, BH37 all east of CCNR within Windsor Interim Green and south of SICC Island Club House. Access from Island Club Road via lorry crane, lifting equipment onto MacRitchie trail |
| Isolated Forest (IF) | BH17 (on boundary of IF) | Also includes approximately 200 m affected by un-numbered boreholes distributed in 25 m herringbone pattern along the alignment outside CCNR (mainly in the west but small area near Venus drive in the east also). Access via main roads. |
| Golf Course/ Recreational Facilities | BH13, BH14, BH15, BH16, BH17 (on boundary of IF), BH18, BH19<br><br>BH08,BH10,BH12 | Also includes approximately 1,000 m affected by un-numbered boreholes distributed in 25 m herringbone pattern along alignment outside CCNR (mainly across SICC Island Club in the east but small area in the west also). Access via existing roads and routes though the golf course fairways.<br><br>BH08, BH10, BH12 all at periphery of Golf Course, on boundary with RA. |
| Developed Area (DA) | | Includes approximately 20 m affected by un-numbered boreholes distributed in 25 m herringbone pattern along Alignment outside CCNR at the far east of the alignment, and approximately 450 m affected by un-numbered boreholes distributed along Island Club Road. Access via main roads. |

***Notes:***
Details of the assessment of individual boreholes are further summarized in *Annex 2.0*.

The number of personnel required to carry out the rotary drilling works is small. Details of the set up and operation of both rigs are provided in *Volume III, Chapter 2*. Overall, crawler A-frame rigs would require a greater number of personnel and take longer to conduct the drilling than the DB520-type rigs, meaning a longer timeframe with personnel and small vehicles travelling to and from the worksites. Working to the current estimated timeframe, with the operation of two rigs within the CCNR, to do all the 16 boreholes within the CCNR boundary (two drilling rigs will operate at any one time) in addition to the other unnumbered boreholes outside the CCNR boundary (up to four drilling rigs may be operational concurrently) but near habitat of high value, it could take up to approximately 23 weeks and 30 weeks respectively using crawler A-frame rig or approximately 14 weeks and 18 weeks using DB520-type rigs. Although this disturbance to vegetation is assumed to be temporary, small and localized, the duration of these impacts are therefore likely to be at least half to one year, if not more. Overall none of the habitats through which these routes run are considered likely to suffer any loss of function as a result of this.

Details of the work to be carried out at particular boreholes are provided in *Volume III, Chapter 2, Table 2.3*. It is noted that in a number of boreholes water standpipes (WSP) or piezometers will be installed for groundwater monitoring following completion of the borehole and de-mobilization of the rig. It is also noted that rather than remove the standpipe (which would require remobilization of the rig) these monitoring wells will be infilled with grout by hand.

***HDC Works***

Two of the three HDC work areas fall outside the CCNR boundary and NParks Managed Areas - the one located between the PIE and Fairway Drive (HDC1) which falls in *Isolated Forest* and the one north of Bukit Golf Course (HDC2) which is adjacent to an area of *Isolated Forest* and within the *Golf Course/Recreational Facilities*. The HDC works area within the CCNR falls within the Kalang Service Reservoir compound, which is considered to be in a *Developed Area*.

The direct footprint of each of the HDC works area is approximately 700 sq. m (ie less than 0.01 ha), and the footprint of the access road required for HDC2 was not available during the preparation of this impact assessment and therefore cannot be fully assessed. It is understood, given consideration of possible access routes to HDC2, it will not require significant vegetation cutting.

All the HDC work areas are readily accessible after the setup, being close to good roads, and it is not considered that the effects of movement of personnel and transport of equipment during mobilization, drilling/coring and sampling, and demobilization will cause adverse impacts on the ecology and biodiversity of the Study Area if the access routes have been carefully planned as above.

### *Disturbance to Wildlife Behavior due to Human Interference, Noise and Vibration*

As presented in *Table 6.4*, all activities associated with the SI works will results in disturbance to wildlife behavior due to human presence and noise and vibration generated from the works.

***Site Reconnaissance & Geophysical Survey Works***

*Volume II, Chapter 7* shows frequent use of the CCNR by wildlife in MacRitchie area. *Figure 6.1* also shows that a high number of faunal species of conservation interest have been found in the vicinity of the alignment. The whole area is also considered of high importance to avifauna of conservation interest as indicated in the *Volume II, Chapter 7*, *Figure 7.10.*

If there were no access constraints, the disturbance to wildlife would be expected to be significant given the extensive length of uncontrolled survey routes (*Table 6.5*) which may result in potential erosion, crushing of leaf litter and associated small animals, disturbing wildlife resting in burrows/ holes during daytime and restricting wildlife utilizing the survey areas which may increase terrestrial conflicts, competition of food and shelters etc.

With regard to possible disturbance from noise and vibration (as detailed in *Volume III, Chapter 4),* the seismic surveys will emit metal-on-metal noise during the generation of seismic waves. Although noise levels will be elevated, impacts are expected to be intermittent over short durations and therefore unlikely to cause significant disturbance to wildlife. Vibration generated from the pounding of the ground during the use of drop weights for seismic refraction/reflection surveys is also likely to be localized and not considered significant. Noise generating geophysical surveys (ie seismic reflection and refraction), if conducted sequentially under the worst case scenario would last up to 20 weeks (with additional 2 weeks to buffer for lost time due to rain events). Although this may be considered medium term duration, the actual sound generated will be localized and sporadic (not continuous), only occur during the daytime within the CCNR (between 09.00 and 17.00, Monday to Friday, in accordance with NParks requirements) and the levels of noise and vibration generated will be relatively low compared to the rotary borehole works and associated vehicle movements.

***Rotary Borehole Works***

Up to five (5) personnel are required to mobilize/ demobilize and set up the crawler A-frame rigs and up to four (4) to operate it, while up to four (4) personnel are required to mobilize/ demobilize and set up the DB520 rig with up to three (3) required to operate it. Once the worksite has been set up, these personnel will work within the small worksite area. Considering all boreholes within the CCNR are on existing trails or cleared areas normally used by the public and the works will only be during daytime, it is considered unlikely that the presence of these personnel during operation will disturb any wildlife. Near some borehole locations, species of conservation interest have been recorded during the primary surveys. For example, with the Study Area there are records of a Lesser Mousedeer (*Tragulus kanchil)* (listed as CR in the *Singapore RDB, 2008*), Red Muntjac (*Muntiacus muntjak*) (regarded as locally extinct before the Second World War in Singapore in available literature) and Sunda Pangolin (*Manis javanica*) (listed as CR in the *Singapore RDB, 2008* and IUCN), all highly mobile mammals. However, since all boreholes within the CCNR and those in habitats continuous with high value habitat adjoining the CCNR, are either on public trails or existing clearings in the CCNR or at the edge of the golf course frequented by humans normally, these low numbers of personnel will also not cause a significant variation from the numbers of public users who normally utilize the trails in the CCNR. In the evening, although the worksites will occupy certain small areas with some equipment stored/ retained on site, nocturnal species including Sunda Pangolin can still utilise nearby habitats. Wildlife may temporarily avoid the small and localised worksite areas during drilling operation, and their behaviour/ habitat utilisation are expect to resume to normal after the completion of the work.

For safety reasons the access route and trail in proximity to some worksites will be temporarily closed during the rotary drilling works within CCNR:

- A diversion route will be required throughout the duration of drilling at BH 26, 27, 28, 29, 31 and 34. Footfall can be diverted to Bukit Kalang Service Reservoir Road, where visitors can enter or leave the CCNR from two trails extending from along the fence of the Bukit Kalang Service Reservoir Compound. Inspection of access points is required to prevent people from venturing into Terentang Trail during the

drilling phase. This is because the trail is particularly narrow at certain sections and visitors will not be able to walk around the rigs without trampling on vegetation at the side.

- A diversion route will also be required during the drilling operations at BH 23, 24 and 25. Visitors may circumvent the rigs by using the HSBC Treetop Walk and head down Petaling Trail boardwalk. It is noted, however, the HSBC Treetop Walk is a one-way route (originating from the Ranger Station).
- A full closure of Sime Trail and Petaling Trail will be required when BH22 is being drilled. Similarly, visitors may be diverted up the trail along the Ranger Station leading to the HSBC Treetop Walk only.
- Trail diversion will not be required for the operation of the drilling rigs at BH35, 36 and 37 as the section of trail in these areas is relatively wide. Visitors will be able to walk around the drillings rigs without encroaching on vegetated areas at the sides of the trail.
- A diversion route is not necessary during the drilling of BH01 and 21. These boreholes are located in a section of Sime Trail which is off trail to members of the public.

The temporary trail closure may shift the visitor usage of Terentang Trail and Sime Trail to other existing trails that also quite popular to be used by visitors, ie Bukit Kalang Service Reservoir Road, HSBC Treetop Walk, Peirce Trail and Petaling Trail boardwalk. It should be noted that diversion to Rifle Range Link trail through the stream is prohibited. The re-distribution of visitors may induce or disperse potential disturbance to wildlife to a wider MacRitchie area. However, significant increase in disturbance to wildlife is not anticipated as there will be no major increase on the overall number of visitors and visitors' activities should still be confined to the existing trails.

With regards to the impacts of noise, as detailed in *Chapter 4*, if two crawler A-frame rigs are used in the east of the CCNR (away from the expressway, with lower background noise levels), it is predicted that the operation of the rigs will generate noise levels of up to $L_{Aeq,,5min}$ 92 dB(A) at 1 m from the rigs. Elevated noise levels will be generated at a distance of up to 170 m from the rig before attaining current baseline noise levels. If using the DB520 rig, it is predicted that the rigs will generate noise levels of up to $L_{Aeq,,5min}$ 85 dB(A) at 1 m from the rigs and baseline noise levels of 59 dB(A) would be attained at a distance of 35 m; whereas baseline level characteristic of existing trails, ie 47 dB(A), would be attained at approximately 100 m. If simultaneously operating four crawler A-frame rigs just outside the CCNR, such as around BH02 to BH05, it is predicted that levels of up to $L_{Aeq,5min}$ 94 dB(A) will be generated at 1 m from the rigs; noise from the rigs will propagate at distances up to 125 m from the worksites before attaining current baseline noise levels of $L_{Aeq,12hr}$ 59 dB(A). It is noted that baseline noise levels at worksites in the west of the alignment, eg around BH02, could reach up to 72 dB(A) due to noise contribution from vehicular traffic.

The hearing sensitivity and capability of the vast majority of invertebrates remain unknown, although it can be roughly divided into those that can detect sound pressure and those which are sensitive to particle velocity and it is known that different invertebrates have different hearing ranges. As noted by Radford *et al* (2014)[1] 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

[1] 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

frequency for the 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).[1] With regard to the effects on wildlife in the CCNR of the elevated noise levels generated by the borehole drilling, many of the fauna within the Study Area is mobile to a distance of over 170 m (the maximum point of elevated noise levels) and could be considered to move away from the noise source, where there is sufficient space in the surrounding environment for them to transient/ by-pass. For any fauna that might be considered unable or unwilling to move away from the sound source, the duration of day-time operations (09.00 to 17.00, no works in weekend and during raining period as well) at any one borehole is estimated to be approximately 18 days (including mobilization and demobilization of the rig and ancillary equipment). In addition the majority of boreholes are on the trails commonly used by the public and where wildlife is generally used to the presence of humans. All works will be carried out during the daytime so any fauna using sound to navigate or communicate at night will not be affected.

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 hammer 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. *Chapter 4* also concludes that levels of vibration that will be generated from drilling and SPT will be low, and that the SPT activity will be of short duration.

However, the noise impacts to wildlife particularly species of distinct territorial nature and sensitive to noise may be higher if the commencement and operation of rotary borehole works and geophysical surveys conducted concurrently. The associated impacts of concurrent work are addressed further in the following sub-section.

### *Concurrent Commencement and Operation of Rotary Borehole Works and Geophysical Surveys*

For the purpose of this EIA, human and noise disturbance to wildlife is also considered for the concurrent commencement and operation of rotary borehole works and geophysical surveys. It is assumed that all the geophysical surveys will be mobilized and commenced at the same time at one end of the CCNR and the duration of each survey assumed to be as per *Table 2.2.* Based on this *Volume III, Chapter 2, Table 2.4* indicates a tentative two rig drilling sequence and access routes for rotary rigs and ancillary vehicles within CCNR and Windsor interim green. . Elevated noise levels will be generated at a distance of up to 170 m from the rotary borehole rig before attaining current baseline noise levels, therefore the potential area of influence is conservatively considered to be within a 170 m radius from each rig. In addition, the geophysical survey has a working corridor of 150 m and with the adoption of precautionary principle, the whole survey area is considered as the potential area of influence for the impact assessment. The potential areas of influence due to concurrent geophysical surveys and the rotary borehole works is therefore likely to include a radius of 170 m from each operating borehole as well as the 150 m corridor for the geophysical surveys.

Due to human disturbance and generation of noise from the drilling works and associated vehicle trips, it may lead to some animals avoiding areas in proximity to the works by moving away. This may pose a concern in particular for some fauna in the CCNR that exhibit distinct territoriality such as the Lesser

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

Mousedeer[1], Slow Loris[2], Colugos[3] and Pangolins[4]. For example: the Lesser Mousedeer is a highly solitary species with home-range size ranging from 4.4 ± 0.8 ha (female) to 5.9 ± 0.4 ha (male)[5, 6]; Slow Lorises are relatively gregarious primates, living in pairs with 1 to 4 offspring, generally covering home ranges from 3 to 35 ha[7], and; based on an observation of a single female in an offshore Singapore island, Sunda Pangolin's 100% and 95% home range is estimated at 6.97 ha and 5.63 ha respectively[8]. Movement away from the noise source or human activities may potentially bring such fauna into territorial conflict such as increased competition for food and shelter, particular in a highly fragmented habitat like that in the CCNR.

The disturbance to wildlife would therefore be expected to be significant given the large extent of the area of influence including that associated with crushing of leaf litter and associated small animals, disturbing wildlife resting in burrows/ holes during daytime and restricting wildlife utilizing the survey areas which may increase terrestrial conflicts, competition of food and shelters etc. For example, several individuals of Lesser Mousedeer (males) and Sunda Pangolin, and potentially other wildlife as well, may utilise the area of influence (which include various habitats and considered as the worst case scenario) that may potentially be influenced by the SI Works.

***HDC Works***

As discussed in *Chapter 4*, elevated noise levels are predicted to extend up to a radius of a maximum of 135 m from each HDC rig during the daytime, before attaining baseline noise levels characteristic of the surrounding, eg PIE, Island Club Road. A number of mitigation measures have been suggested to help minimize noise impacts, such as throttling down equipment that is used intermittently when not in use, using silenced generators, using acoustic enclosures for noise-generating equipment, erecting portable acoustic screens, etc. At night time, when traffic is less, the radius of noticeable elevated noise levels is likely to be slightly higher, but as discussed with regards to rotary boreholes above, and seeing as the drilling works will be underground (generated noise will mainly restricted at the entrance/ opening of the HDC), it is not expected to cause noticeable impacts on wildlife within the CCNR (HDC3) or in close proximity to the CCNR (HDC2).

With regard to human activities and illumination, the HDC worksite will be operational 24-hours per day and illumination will be required to enable night-time operations. Various natural processes can only happen during the night in darkness, such as resting and repairing as well as, for nocturnal species, celestial navigation and predating. Patterns of light and darkness can also be used to regulate circadian cycles of activity, to control behaviour, niche partitioning of diurnal, nocturnal and crepuscular animals and, by determining day length, to trigger seasonal events such as flowering or migration9. Evidence exists of a wide diversity of ecological impacts of night-time light pollution, including influences on organismal

[1] Timmins, R & Duckworkth JW (2015). *Tragulus kanchil*. The IUCN Red List of Threatened Species. Available at http://www.iucnredlist.org/details/136297/0

[2] Ecology Asia (2015) Sunda Slow Loris. Available at http://www.ecologyasia.com/verts/mammals/sunda-slow-loris.htm

[3] Animal Diversity Web (2015) *Galeopterus variegates*. University of Michigan, Museum of Zoology. Available at http://animaldiversity.org/accounts/Galeopterus_variegates/

[4] Norman Lim T-Lon (2007). Autecology of the Sunda Pangolin (*Manis Javanica*) in Singapore (MSc Thesis). National University of Singapore. Available at http://scholarbank.nus.edu.sg/bitstream/handle/10635/28320/Lim%20T-Lon,%20Norman%20MSc%20Thesis%20final.pdf?sequence=1

[5] Matsubayashi H, Bosi E and Kohshima S (2003) **Activity and Habitat Use of Lesser Mouse-Deer (*Tragulus javanicus*)**. Journal of Mammalogy, 84 (**1**):234–242.

[6] Matsubayashi H, Bosi E, & Kohshima S (2006) **Social system of the lesser mouse-deer (*Tragulua javanicus*)**. Mammal Study 31:111-114

[7] Nekaris KAI and Starr CR (2015) Conservation and ecology of the neglected slow loris: priorities and prospects. Endangered Species Research, 28: 87–95.

[8] Lim NT, Ng PKL (2007) Home range, activity cycle and natal den usage of a female Sunda pangolin *Manis javanica* (Mammaliaa: Pholidota) in Singapore. Endangered Species Research. Vol 3. Available at http://pangolinsg.org/files/2012/07/Home-range-activity-cycle-and-natal-den-usage-of-a-female-Sunda-pangolin.pdf

[9] Gaston KJ, Davies TW, Bennie J and Hopkings J. (2012) **Reducing the ecological consequences of night-time light pollution: options and developments**. Journal of Applied Ecology **49**, 1256-1266

movements, foraging, interspecific interactions, communication, reproduction and mortality[1]. The majority of activity by nocturnal and crepuscular organisms tends to occur immediately after dusk and immediately before dawn. It is noted that the HDC location towards the north of the SICC Bukit Golf course (HDC2), the nocturnal Large-tailed Nightjar Caprimulgus macrurus was recorded sitting on the ground on a number of occasions in the evening time during ecological baseline surveys. In addition, the Sunda Pangolin is also reported to forage within the SICC Bukit Golf course (HDC2) (up to 100 m from the edge of the Regeneration Forest A adjoining to the CCNR) after dark and in the absence of golfers. The illumination details of the HDC worksite have not been finalized but it is general practice that a temporary shelter/ cover will be constructed over each HDC worksite to enclose all the rig and equipment, as well as the worksite, and protect it from adverse weather events. The details of this temporary shelter/ cover will affect how much any illumination, as well as noise generated during work activities, is contained within the site. Without mitigation it is assumed that this will be open sided and therefore the surrounding area will suffer some light pollution and human disturbance. The HDC worksite within SICC Bukit Golf Course is just south of the CCNR and that in the Bukit Kalang Service Reservoir is within the CCNR and therefore this illumination and human disturbance has the potential to cause ecological impacts as described above. Around the SICC Bukit Golf Course at night there is currently very limited human activities and no artificial illumination and although the HDC work areas are small, the duration of impact is 4-12 months at any one location. It is observed however that precautionary principle in the absence of light specifications will be adopted at the work areas and work activities will be confined within the temporary shelter/ cover. The occupation of the HDC worksite within SICC Bukit Golf Course may reduce the foraging ground or restricting the habitat utilization of the nocturnal wildlife including Sunda Pangolin. However, it is observed that there are natural and preferred habitats within CCNR.

### *Disturbance to Aquatic Habitats*

As presented in *Table 6.4*, disturbance to aquatic habitats are anticipated due to the proximity of seismic refraction/ reflection/ gravity survey, MPs, rotary boreholes and HDC locations to nearby streams within the CCNR. Due to the topography and proximity of the Sime Trail to streams within the CCNR, mobilization/demobilization of vehicles, personnel and equipment to rotary borehole sites may also cause disturbance to aquatic habitats. However, rotary borehole works have all been located at flat areas (without any ditches leading to stream), away from streams (outside a 30 m buffer) and temporary disturbance to aquatic habitats is therefore not considered a potential impact from the operation of rotary boreholes (unless due to **Unplanned events**, as covered in *Section 6.6*).

Fish, especially those species encountered in the Study Area, can be affected by sediment run-off caused by site activities as high silt loads and suspended sediments are deleterious to the aquatic environment and have a number of effects on fish life. High-suspended sediment concentrations within rivers can affect fish by clogging gills or causing gill abrasion, which may increase susceptibility to disease[2]. It can also clog spawning gravels, which reduces available habitat and affects fish reproduction by lowering dissolved oxygen levels[3]. Sediment that smothers the riverbed can also affect the aquatic fauna especially the

[1] Gaston KJ, Davies TW, Bennie J and Hopkings J. (2012) **Reducing the ecological consequences of night-time light pollution: options and developments**. Journal of Applied Ecology **49**, 1256-1266

[2] Marks SD & Rutt GP (1997) Fluvial Sediment Inputs to Upland Gravel Bed Rivers Draining Forested Catchments: Potential Ecological Impacts. Hydrology Earth System Science, 1: 499 – 508

[3] Theurer FD, Larrod TR & Theurer M (1998) **Sedimentation and Salmonids in England and Wales. R&D Technical Report.** P194. Environment Agency R&D Dissemination Centre, Swindon, United Kingdom.

sessile organisms, hence reducing their abundance and diversity in the area[1,2]. Unfortunately, little is known about the absolute sediment tolerance thresholds of most fish species. For each organism, injury will occur above a different threshold concentration of suspended sediments and also vary among the different life stages (egg, larva, juvenile and adult). Fingerlings and juvenile stages of fish would be most vulnerable and sensitive to this effect.

Though the cessation of such activities would eventually enable the stream to visually return to the current state it is in, there would be two key consequences. Firstly, any sediment deposited in the streambed could, in addition to causing acute impacts on fish themselves, kill off other forage organisms, particularly benthic organisms, that form a crucial forage base for many fish species and this would resonate throughout the food chain. Secondly, in the long term, the water course depth and sediment quality profile could be permanently altered which in turn would have the effect of permanently changing the forage base and possibly making affected sections of streams unlivable for the current fauna.

The aquatic environment in the Study Area is mainly comprised of the stream network of the MacRitchie area and the related *Wetland Marsh* and *Wetland Forest* areas. The baseline data indicate that the streams that were surveyed in the Study Area were in a reasonably pristine state, despite the fact that the forested catchment surrounding it appeared disturbed and, to a very limited extent, developed for recreation. Specifically seven of the species listed in the *Singapore RDB, 2008* as Critically Endangered or Endangered have been found within MacRitchie area, including the Harlequin Rasbora (*Trigonostigma heteromorpha*) recorded during the recent surveys, and confirming the importance of the shaded forest streams found within this area of the CCNR where these species are generally confined to. *Wetland Marsh* and *Wetland Forest* areas were also considered to hold high ecological value given their linkage to the stream system and the record of species of conservation interest utilizing these habitats.

***Geophysical Survey Works (Seismic Refraction/ Reflection/ Gravity Surveys)***

Uncontrolled geophysical survey works may significantly disturb the aquatic habitats including streams, Wetland Forests and Wetland Marshes. Trampling impacts will be significant in waterlogged/ soft soil areas, and the aquatic plants as well as their root system particularly pneumatophore roots, could be damaged during the surveys. In addition, direct and indirect impacts on aquatic wildlife will also be expected.

***Operation of MPs***

The MP works have the potential to cause disturbance to the Wetland Forest and Wetland Marsh where they are located, which in turn may disturb aquatic wildlife. *Figure 6.1b* shows that in total eight MPs are located in these habitats or within the 30 m buffer area. Access to at least three of the eight MP locations will be from nearby existing trails or in non-wetland habitat of the buffer zones (MP02, MP06 and MP09). It is observed that MPs are relatively small (see *Chapter 2, Section 2.4.1*) and the activity at any one worksite will be of short duration and will involve a limited number of personnel.

[1] Donohue I, Verheyen E & Irvine K (2003) In-situ Experiments on the Effects of Increased Sediments Loads on Littoral Rocky Shore Communities in Lake Tanganyika, East Africa. Freshwater Biology, 48: 1603 – 1616

[2] Alin SR, Cohen AS, Bills R, Gasphagaza MM, Michel E, Tiercelin JJ, Martens K, Coveliers P, Mboko SK, West K, Soreghan M, Kimbadi S & Ntakimazi G (1999**) Effects of Landscape Disturbance on Animal Communities in Lake Tanganyika, East Africa**. Conservation Biology, 13 (5): 1017 – 1033

### 6.5.3 Significance of Impacts Prior to Mitigation

The magnitude of the impacts identified within each separate habitat within the Study Area are summarized in *Table 6.7*. Using the impact significance matrix outlined in *Volume I, Chapter 4* the impact to the different habitats will be of **Negligible to Major Significance (mainly Major within the CCNR)**.

It should be noted that following the Impact Assessment Standard presented in *Section 6.4.2*, the scale defining the magnitude of an impact has only four categories; *negligible*, *small*, *medium* and *large*. Therefore although relatively the magnitude of all these impacts within each habitat type may vary slightly, the classification of them generally is *'large'* as defined in *Table 6.1.* Equally with regard to disturbance to wildlife behavior or aquatic habitats, the magnitude of impacts on any particular species, as defined in *Table 6.1*, is considered *large* as well.

### 6.5.4 Mitigation and/ or Management Measures

Given the magnitude of potential impacts a number of mitigation measures have been discussed and agreed with LTA to help reduce the potential impacts. These are listed in *Table 6.8.* Subsequent text also provide a more detailed presentation of some of the key mitigation measures (ie the Accessibility Criteria, Working Zones and HDC Lighting) to provide further clarity on how these should work.

*Table 6.7*: *Summary of Magnitude of Impacts in each Habitat, Prior to Mitigation*

| Habitat | Ecology/ Biodiversity Sensitivity | *Magnitude of Each Identified Impact* | | | |
|---|---|---|---|---|---|
| | | *Compaction/ Minimal Cutting of overhead foliage and vegetation either side of the trail due to mobilization and set up of the rigs* | *Disturbance to vegetation, from walking off trail (ie trampling) and daily movement of personnel/ vehicles* | *Disturbance to wildlife behavior due to human interference, noise and vibration* | *Disturbance to Aquatic Habitats* |
| ***Within CCNR gazetted boundary*** | | | | | |
| Primary Forest (PF) | **High** | *Small* | *Large* | *Large* | - |
| Regeneration Forest A (RA) | **High** | *Small* | *Large* | *Large* | - |
| Wetland Forest (WF) | **High** | *Small* | *Large* | *Large* | *Large* |
| Wetland Marsh (WM) | **High** | *Small* | *Large* | *Large* | *Large* |
| Developed Area (DA) | **Medium** | *Small* | *Negligible* | *Negligible* | - |
| ***Outside CCNR gazetted boundary*** | | | | | |
| Regeneration Forest A (RA) | **Medium** | *Small* | *Large* | *Large* | - |
| Regeneration Forest A (RA) (patch adjoining the CCNR at the west of the Alignment Option 1 and a patch near Venus Drive) | **High** | *Small* | *Large* | *Large* | - |
| Isolated Forest (IF) | **Medium** | *Small* | *Negligible* | *Small* | - |
| Golf Course/ Recreational Facilities | **Medium** | *Small* | *Negligible* | *Small* | - |
| Developed Area (DA) | **Low** | *Negligible* | *Negligible* | *Negligible* | - |

***Table 6.8*: *Mitigation Measures***

| Mitigation Measures |
|---|
| ***General Measures to be carried out Prior to Preliminary Investigations, Geophysical Investigations and Mackintosh Probes*** |
| • The corridor for the gravity survey was initially planned for 150 m but after careful consideration of the likely accuracy and need for data this corridor has been reduced to 100m (*Figure 6.2*).<br>• All workers/ Contractor personnel to attend a a two hour training session of the ecological sensitivities within the CCNR and a toolbox health and safety briefing on wildlife encounters on and off trail and noise minimization measures. Health and safety briefing to include NParks requirements for working within CCNR. The training is to be provided at the Preparatory Works stage, prior to the onset of the SI works.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for geophysical surveys off trail.<br>• The Method Statements and Emergency Preparedness Plans should include details of site access locations for positioning of geophysical equipment and survey. This will be reviewed by an Environmental Advisor and verified by NParks prior to commencement of survey works.<br>• The Waste Management Plan prepared for the overall project to include details listed in Chapter 2, *Section 2.4.4*. |
| ***General Measures for Geophysical Investigations and Mackintosh Probes*** |
| • NParks staff and Ecologist accompanying geophysical surveys to support contractor in selection of off trail access routes and working areas following a set of Accessibility Criteria (*Annex 1*) which will minimize the disturbance to environmental sensitivities as far as practical including avoiding the risk of impacts on species of conservation interest.<br>• **Set-up No-Go Areas –** in order to reduce potential impacts associated with the site reconnaissance, MPs and geophysical surveys, a number of mitigation measures will be adopted including: 1) The survey will not be undertaken where the ground cover is waterlogged and inaccessible; and 2) The survey team will be prohibited from traversing through streams. The identified potential areas for geophysical surveys are presented in *Figure 6.2.*<br>• Survey areas should avoid the areas of steep gradients leading to streams, Wetland Forest and Wetland Marsh as shown in *Figure 6.2.*<br>• After careful consideration, the existing 9 MP locations are recommended to be removed, and replaced by 3 new MP locations as shown in *Figure 3.1* and *Figure 6.2*. The three new MPs involve penetrating the probes into the stream bed, avoiding aquatic plants and riparian vegetation, from the existing bridge with extendable rods with a sliding drop weight. As previously detailed, equipment is portable; the process is relatively quick (up to 2 days for the 3 MPs) and does not require drilling fluid. Impacts on ecology and biodiversity due to this activity are anticipated to be localized disturbance to the stream bed and disturbance to aquatic wildlife (from physical interference, noise and vibration). The locations of the MPs are accessible from existing bridges along Sime Trail avoiding the need for walking off trail.<br>• Vegetation clearance, cutting or breaking or damaging branches of trees, shrubs and climbers are strictly prohibited.<br>• All surveyors should walk in a single file and using the same route in and out of the survey locations.<br>• Arrange all of the geophysical surveys to be conducted in similar location and follow the same access routes, so as to minimize the impacts of walking off trail (ie trampling impact) and confine the disturbance to wildlife within a smaller area. This will be done through establishing 'working zones' for the works as further discussed below.<br>• As far as possible choose access routes that minimize the amount of walking through off trail areas, where there is limited groundcover and where the entry point is not obvious to trail users.<br>• Ensure the seismic refraction / reflection, electrical resistivity and gravity surveys will not be conducted concurrently, and only one type of geophysical survey will be conducted each day.<br>• Arrange at least one of the survey team members to stay at or patrol the entry point(s) along the existing trail, if required, to ensure no visitors follow the survey routes/ lines.<br>• After work is completed in each working zone any obvious entrances to off trail areas used for the survey |

**Mitigation Measures**

should be revisited and reviewed by NParks staff/ ecologist to identify/ implement any reinstatement actions such as placing logs at the entrance to avoid potential usage by other visitors/Park users.

- If in an use animal burrow is observed on or immediately adjacent to the survey routes then the routes should be rerouted.
- Arrange the geophysical surveys to avoid the peak flowering season (April and May) as much as possible.
- Align geophysical surveys with nearby borehole operation (if undergoing concurrently) wherever possible within each working zone so as:
  - to ensure the wildlife movement corridor connecting MacRitchie area and other CCNR areas being maintained and available throughout the SI works duration; and
  - to minimize the overall area of influence or cumulative disturbance to wildlife due to the geophysical surveys and rotary borehole works.
- All survey equipment involved should undergo maintenance checks and cleaning prior to mobilization into the CCNR and upon exit from the CCNR. No equipment washing to be undertaken within the CCNR.
- Conduct daily toolbox talks, SHE Inspections and progress/corrective action calls.
- All equipment to be manually carried to individual survey locations.
- Use of trolley for the mobilization of equipment, with use restricted to existing trails within the CCNR or access paths of golf courses.
- Movement through and placement of equipment within streams and waterlogged areas strictly prohibited.
- All survey equipment (with the exception of geophones and cable if laid out) should be removed daily or placed at a temporary storage area authorized by NParks. If stored within the CCNR, equipment should be properly covered and secured to avoid interference or attraction of wildlife and left for no more than two nights/ three days.
- Restrict the number of workers to those defined within *Chapter 2*, *Table 2.1* and *Table 2.9*.
- No works at night, dawn or dusk.
- Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.
- Restrict meal consumption to designated area.
- Use of trail/off trails as sanitary facility strictly prohibited. For work within the CCNR, public facilities within CCNR to be used. Outside CCNR, portable toilets to be provided and used.
- Operations to be suspended during rain.

***General Measures to be carried out Prior to Rotary Borehole Works***

- Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.
- Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA
  - refine location of un-numbered boreholes outside the CCNR and within the Study Area during the Preliminary Investigation phase of the works in order to avoid impacts to trees as well as flora species of conservation interest;
  - ensure final location of borehole worksites within CCNR are located on flat ground without any ditches leading to stream in the close vicinity;
  - ensure final location of borehole worksites BH08, BH10, BH12 and BH35 are at sufficient distance from nearby shrubs and trees so as to avoid disturbance; and
  - refine the borehole works schedule, minimizing the time for each activity in-so-far as practical.
- Contractor expertise operating in sensitive environmental habitats should be included as selection criteria.
- All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail. Health and safety briefing to include NParks requirements for working within CCNR.
- Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.
- Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle

movement on the trails to that outlined in *Chapter 2*, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.

- Waste Management Plan to include details listed in *Chapter 2*, *Section 2.4.4*.
- Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.
- All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.
- In the event that rotary borehole locations within the CCNR and golf courses need to be adjusted, boreholes should not be sited within the 30 m surface water buffer zone or at location of steep gradient, and be subject to LTA and NParks approval.
- Investigate the availability and deploy, if practicable, a DeltaBase 520 drilling rig or similar for proposed boreholes BH20 and BH21 where no access constraints prevail to reduce the overall length of time for the drilling works, noise levels and disturbance to wildlife.
- Tarpaulin and sandbags (double bagged for secondary containment) to be laid along access route from trail into the clearing at BH21. Rig to be moved over sandbags only and ancillary equipment to remain on nearby trail to limit impact to roots in the clearing. Ground protection equipment to be carefully removed following completion of the borehole. At BH01 similar measures to be considered based on condition of ground at time of the preliminary survey.
- Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.
- Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works. During site reconnaissance, extent of any flora species of conservation interest, as specified in *Annex 9* should be verified (eg *Aquilaria malaccensis* seedlings in proximity to BH28, and BH29, as well as *Dipterocarp* spp. trees in close proximity to the trail) should be reviewed and boreholes shifted slightly on the existing trail along the left side of the path (facing east), to avoid impact.
- The borehole locations outside CCNR (ie along Island Club Road to Upper Thomson Road through SICC Island Golf Course) to be reviewed to avoid the isolated forest or tree cutting within the SICC Island Golf Course.
- For work in Zone C (see further discussion below, ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.

***General Measures applicable to all phases of Rotary Borehole Works***

- Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to remain still and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.
- Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.
- Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.
- Maintain worksite footprint at 2 m in width and 11 m in length on trails only, with exception of BH01 and BH21.
- All workers prohibited from walking off trail with the exception of worksite areas at BH01 and BH21.
- Restrict meal consumption and sanitary facilities to a designated area and facilities (eg ranger station or setting up a temporary container office and portable toilet outside CCNR or on the Kalang Service Reservoir Road off Island Club Road, with prior approval by NParks and golf course representatives). Seek permission to enter golf course facilities if necessary.
- Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated

public waste bins outside CCNR and the golf courses daily.

- Contractor staff outside CCNR to monitor NEA rainfall forecasts and to update Contractor teams on site of any forecast rainfall events. Contractor teams to be equipped with walkie talkies to allow for communication with staff outside the CCNR and to check in prior to any vehicle movements along trail.

***Specific to Mobilization & Demobilization of Rotary Borehole Rigs***

- Use approved vehicle mobilization/demobilization route listed under the Method Statement.
- Ensure all equipment is secured on vehicles during mobilization and demobilization.
- Ensure no plant species listed as CR or EN or VU in the Singapore RDB will be damaged, in particular *Aquilaria malaccensis* and associated seedlings (recorded between BH28 and BH29), as well as *Dipterocarpus* spp. trees in close proximity to the trail.
- Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.
- Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.
- Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.
- Any small amounts of maintenance oil are required to be stored within a dedicated locked storage box at each worksite and during mobilization/ demobilization to and from each worksite.
- Strictly prohibit storage of fuel within the CCNR.
- Employment of pistol pumps and pipes fitted with flow control valves for refueling operations within the CCNR.
- Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.
- Temporary closure of public trails along mobilization and demobilization routes.
- No mobilization/ demobilization at night, dawn or dusk.
- In the event of any rainfall:
  - All vehicle movement along trails within CCNR and through SICC Golf Courses to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;
  - Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.
  - All manually carried ancillary equipment movement along trails within CCNR and through SICC Golf Courses to be suspended.
  - Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted only after at least an hour after rainfall has completely halted; and
  - Contractor ET to instruct when to commence manual movement of equipment and vehicle movement along trails and within SICC golf course, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further vehicle movement.
- Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR.
- Restrict the number of rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (*Chapter 2*, *Section 2.4.2*).
- No equipment washing is to be undertaken within the CCNR.
- Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast

dismantled.

***Specific to Borehole Equipment Set-up***

- In the event of rain:
  - Borehole set up at each worksite within the CCNR to be suspended;
  - All equipment to be covered in tarpaulin;
  - Close of wastewater tote tank;
  - Contractor ET to instruct when to recommence rotary borehole set up within CCNR, following a rainfall event. As a minimum ET to wait until rain has fully stopped before starting/recommence set up.
- Restrict the number of workers to those defined within the EIA Project Description (*Table 2.1* and *Table 2.9*).
- Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees
- Equipment positioning and laydown on the public trail only, no off trail storage.
- A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.
- Borehole locations to be selected in areas where trail is wide enough to accommodate access (if necessary) and avoid potential trampling impacts arising from walking on surrounding vegetation.

***General Measures to be carried out during Borehole Works***

- During drilling operations, number of vehicle trips limited to maximum two per day to and from the worksite.
- As a precaution, Contractor Environment Team to review weather forecast (http://www.nea.gov.sg/weather-climate/forecasts/24-hour-forecast) at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR and in the SICC golf courses, and completion of the geophysical surveys, to avoid periods of rainfall.
- In the event of any rainfall
  - Borehole drilling operations at each worksite within the CCNR to be suspended
  - All equipment to be covered in tarpaulin
  - Closure of wastewater tote tank;
  - Contractor ET to instruct when to commence rotary borehole drilling operations within CCNR, following a rainfall event. As a minimum ET to wait until rain has fully stopped prior to instructing rig operator to remove FCT lid and tarpaulin before starting/recommence drilling.
  - Movement of ancillary equipment along trails between each borehole worksite location to be suspended within the CCNR;
  - All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended;
  - Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and
  - Contractor ET to instruct when to commence vehicle movement along trails and within SICC golf course, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further vehicle movement.
- Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report
- Contractor to ensure storage of small volume of maintenance oil, oily rags etc at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.
- Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.
- No water extraction from streams/ ground water.
- Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.
- The Fluid Containment Tank (FCT) is to be
  - used at all times during operation of rotary borehole rigs;
  - positioned on absorbent mats or within secondary containment; and
  - fitted with a tight lid.

**Mitigation Measures**

- Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.
- Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.
- Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.
- All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.
- All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding environment.
- Apply refueling procedure as follow:
  - Inspect engine oil levels each morning and top-up as necessary.
  - Placing the transported diesel on ground with tarpaulin sheets and using handheld pistol pumps (with flow control valve fitted to the end of hose) to refuel the fuel tank on the rotary boring machine.
- All rigs and vehicles (including ancillary vehicle mobilizing water/wastewater to and from each worksite) in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works to prevent engine overheating.

***General Measures to be carried out after Borehole Works***

- Following completion of permeability testing, all groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs
- All worksites are to be reinstated following completion of SI works to same condition as found and in accordance with NParks approval.

***General Measures to be carried out Prior to HDC Works***

- All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters when working at the HDC sites. Health and safety briefing to include NParks requirements for working within CCNR.
- A Waste Management Plan to be prepared to include details listed in *Section 2.4.4*.
- Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.
- A 30 m wetland buffer zone to be maintained at all times for HDC drilling locations.
- Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan.

***Specific to Setting up and Operation of HDC work-site***

- Maximize the buffer distance to stream in particular the stream systems in CCNR as well as streams connecting to these areas.
- Restrict the number of workers to those defined within the EIA Project Description (*Table 2.1* and *Table 2.9*).

For HDC2 and HDC3 within and close to the CCNR:

- Enclose HDC worksite so as to reduce the artificial light intensity during the night.

***General Measures to be carried out during HDC Works***

- Restrict meal consumption and sanitary facilities to a designated area and facilities (with prior approval by golf course representatives and PUB). Seek permission to enter golf course facilities if necessary.
- Silenced generators and/or engines to be used at all times;
- The FCT is to be used at all times during operation of HDC rigs.
- FCT is to be positioned on absorbent mat or within secondary containment.
- Pump hose connecting FCT to wastewater tote tank to be secured.
- The small amounts of maintenance oil are to be stored within a dedicated locked storage box at each worksite and during mobilization/demobilization to and from each worksite.

**Mitigation Measures**

- Spill kits such as absorbent pads and drip trays are to be provided and used at each worksite.
- All drilling equipment, storage box, spill kits to be secured at all times to prevent access from wildlife.
- ECBs to be inspected and maintained continually during HDC works.
- All vehicles to maintain constant and low speed of less than 5 km/hour at all off main road locations.
- Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area daily from each worksite location by licensed third party contractor.
- Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside the golf courses daily.

For HDC locations close to the CCNR:

- Lighting management and maintenance to only provide illumination as and where required, avoid any light trespass outside the necessary area of the HDC work area, reduce the intensity and limit the duration of lighting required.
- Acoustic enclosures to be placed on noise generating equipment such as engines, generator set and water pumps throughout operation at HDC sites (unless full enclosures of HDC sites provided). For the construction of machinery enclosures, a sheet material mass of at least 10 kg/$m^3$ shall be used. 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 performance requirements for enclosures published by NEA under its Guidelines on Quieter Construction Fund.

***General Measures to be carried out after HDC Works***

- Worksite to be reinstated following completion of SI works to same condition as found and in accordance with SICC approval

***Working Zones***

In order to reduce the area of influence of the SI Works at any time, a series of working zones and associated working schedules have been established. The working zones are shown in *Figure 6.2*. The geophysical surveys will be mobilized and commenced at the same time and completed within each zone as much as possible before moving on to the next zone, starting from Zone A. The exact timing, extent of and location of the geophysical surveys within each zone is difficult to determine at this stage, as it will be dependent on the accessibility of off-trail areas. An indicative schedule is however provided in *Table 6.9*. This assumes no work will be completed off trail during the flowering period to further mitigate impacts on flora and fauna.

The indicative schedule of SI works has been designed such that both of the rotary borehole works (including two daily round trips for the ancillary vehicles and up to 10 round trips during the day as equipment is mobilized and demobilized to worksite) and geophysical surveys will be confined to both ends of the survey corridor during Weeks 1 to 21, and Weeks 34 to 39 (*Figure 6.3a-d*). This ensures the preservation of the wildlife movement corridor, including Zone C and the wetland marsh, that connects MacRitchie to other CCNR areas. The maintenance of this corridor minimizes the extent of fragmentation/ isolation caused by the rotary borehole works and geophysical surveys, thereby reducing disturbance to wilidlife and the likelihood of territorial fauna running into direct conflict as sufficient connectivity is maintained for them to move around the CCNR.

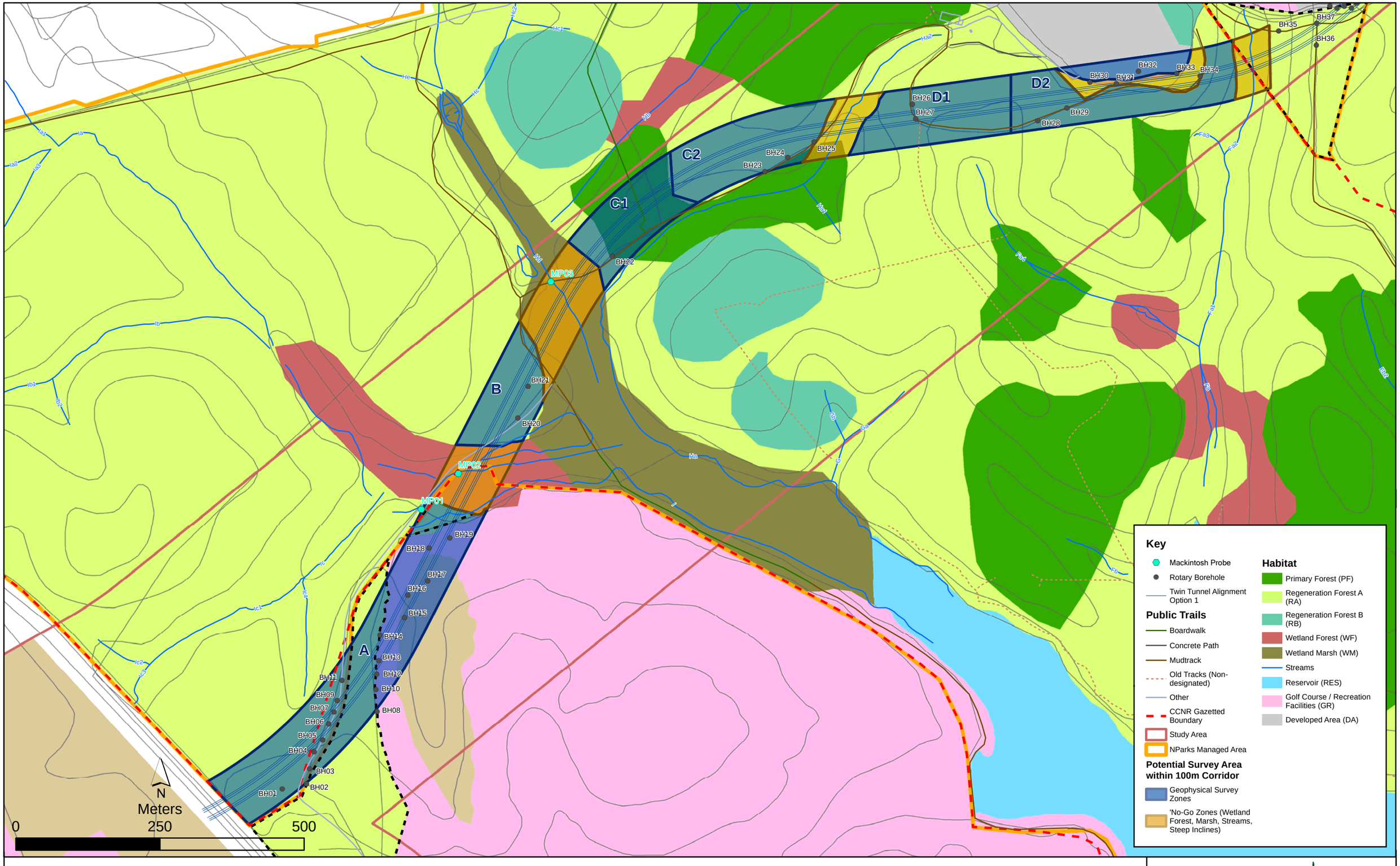


Figure 6.2 Zonation of Proposed 100 m wide Geophysical Survey Corridor for Scheduling with Demarcation of No Go Zones

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Date: 17/12/2015

**Environmental Resources Management**

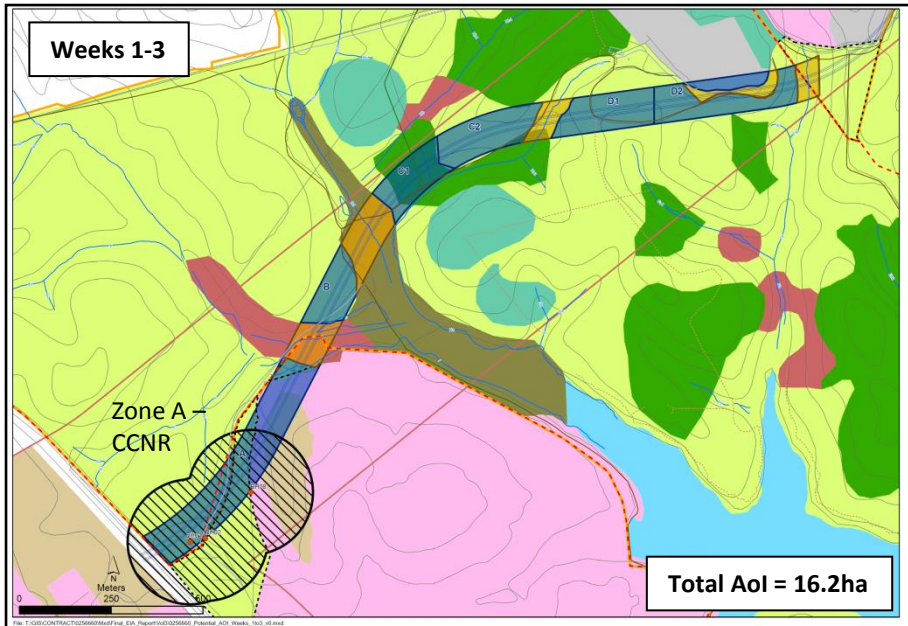
ERM

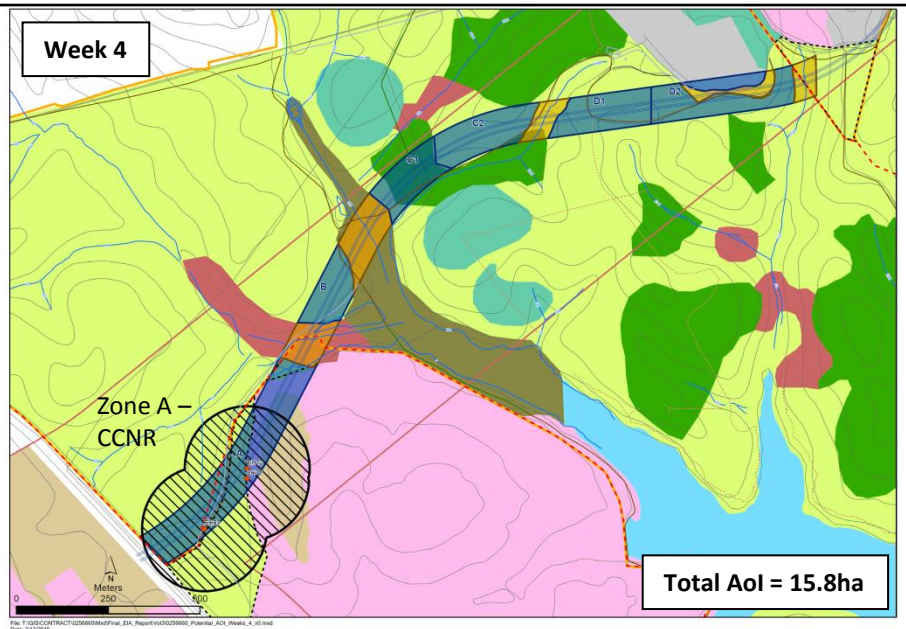
*Table 6.9: Indicative Geophysical Schedule Assuming Works Commence March 2016)*

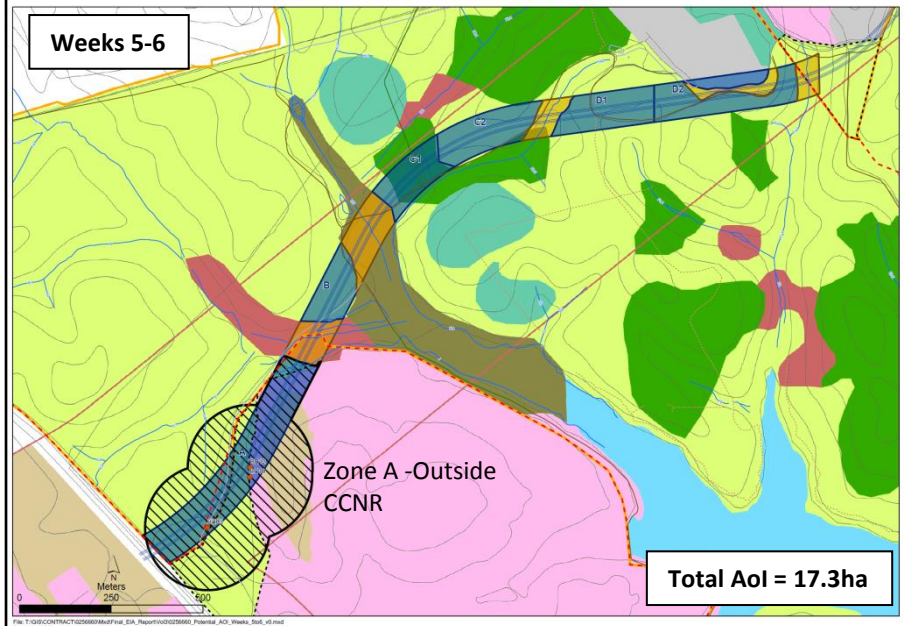
| Month | Mar | | | | Apr | | | | | May | | | | Jun | | | | Jul | | | | Aug | | | | Sep | | | | Oct | | | | Nov | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date (week ending) | 4 | 11 | 18 | 25 | 1 | 8 | 15 | 22 | 29 | 6 | 13 | 20 | 27 | 3 | 10 | 17 | 24 | 1 | 8 | 15 | 22 | 29 | 5 | 12 | 19 | 26 | 2 | 9 | 16 | 23 | 30 | 7 | 14 | 21 | 28 | 4 | 11 | 18 | 25 |
| Number Week | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| GRAVITY SURVEY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone A (Bukit Golf Course, Outside CCNR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone C1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone C2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone D1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone D2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SEISMIC SURVEY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone A (Bukit Golf Course, Outside CCNR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone C1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone C2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone D1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone D2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ELECTRICAL RESISTIVITY | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone A (Bukit Golf Course, Outside CCNR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone C1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone C2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone D1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zone D2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

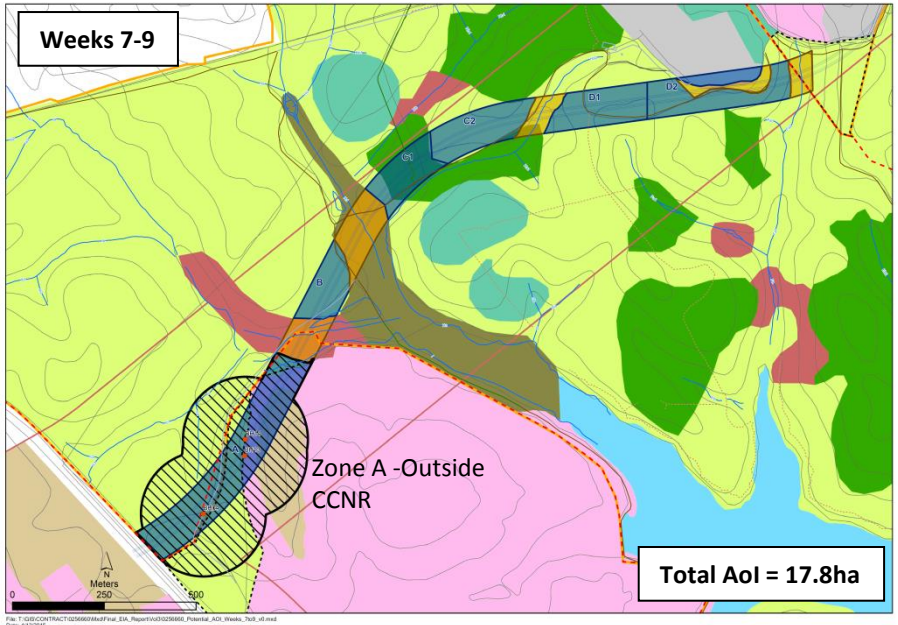
**Key:**

No Works during main flowering period in CCNR



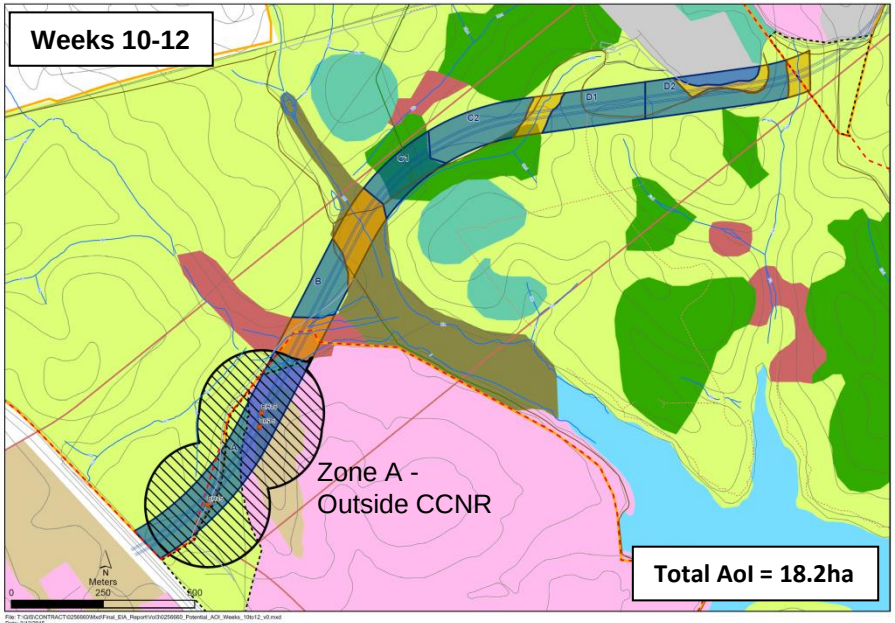

- All SI works within CCNR restricted to Monday to Friday (between 09.00 and 17.00, with demobilization from 17.00 to 18.00)
- Surveys/ operation to be suspended during rain
- Geophysical surveys to be arranged to avoid the peak flowering season (April and May) as much as possible
- Actual location of geophysical survey is quite localized in each day (ie up to 3-4 days for a string line of 200 m length)

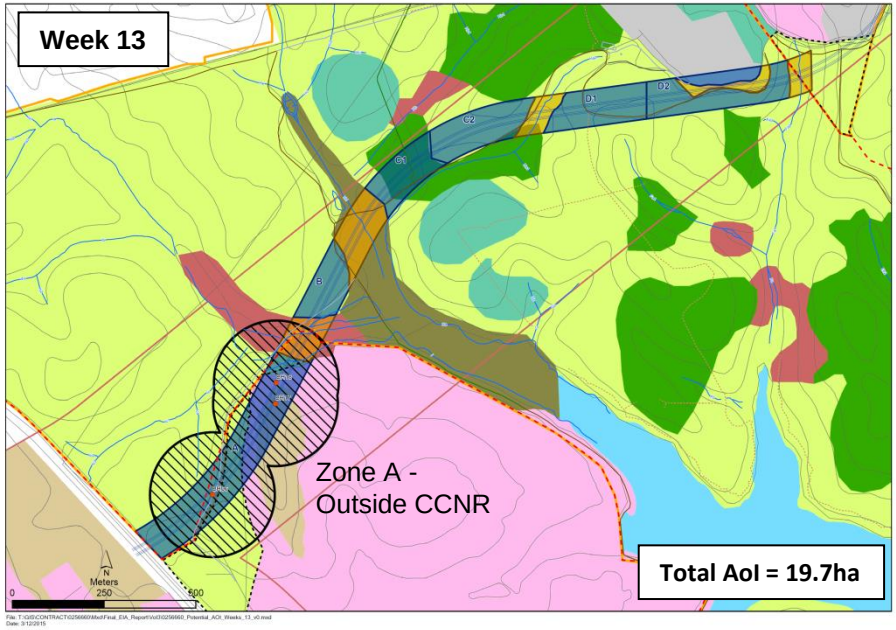
*Note: Elevated noise levels will be generated at a distance of up to 170 m from the rotary borehole rig before attaining current baseline noise levels. And therefore 170 m radius from the rig is considered as potential area of influence from conservative approach*

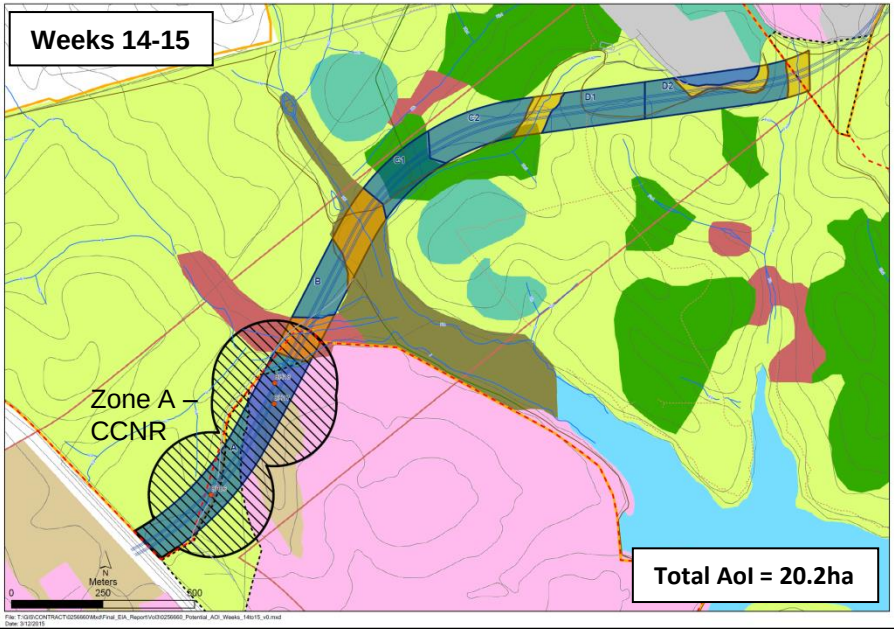
Figure 6.3a Potential Area of Influence due to Concurrent Geophysical Surveys and Rotary Borehole Works (Based on Indicative Schedule of SI Works)

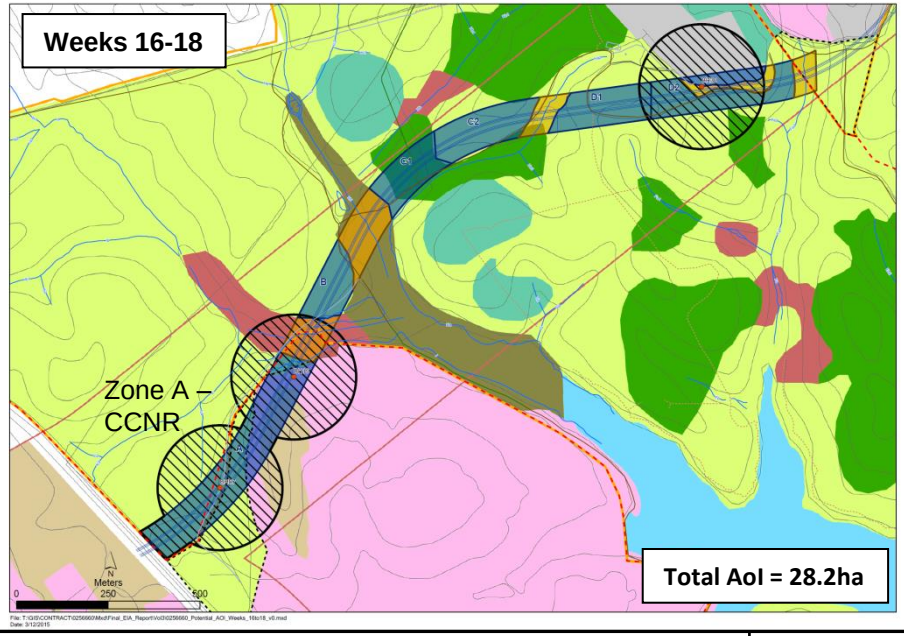
Environmental Resources Management

ERM



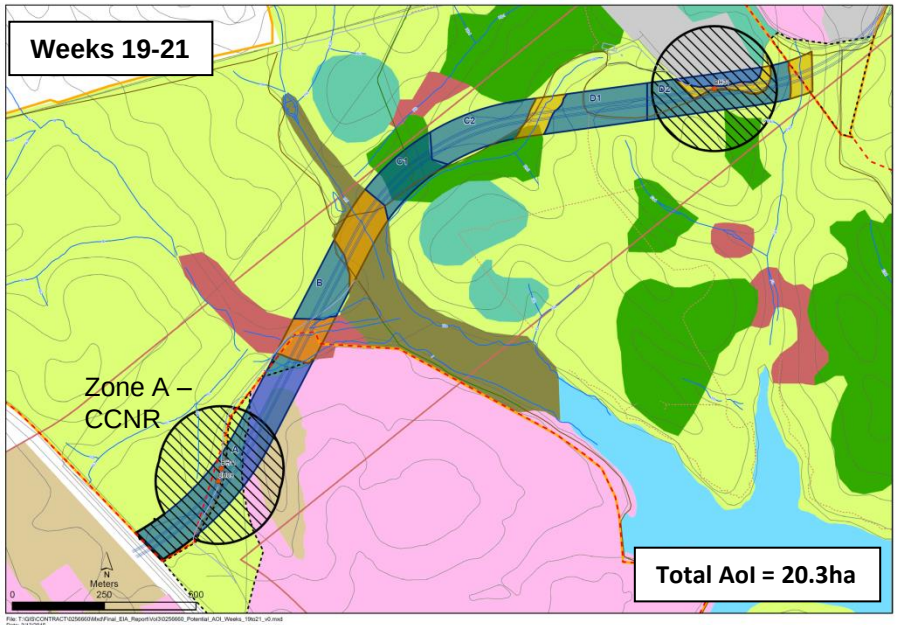

- All SI works within CCNR restricted to Monday to Friday (between 09.00 and 17.00, with demobilization from 17.00 to 18.00)
- Surveys/ operation to be suspended during rain
- Geophysical surveys to be arranged to avoid the peak flowering season (April and May) as much as possible
- Actual location of geophysical survey is quite localized in each day (ie up to 3-4 days for a string line of 200 m length)

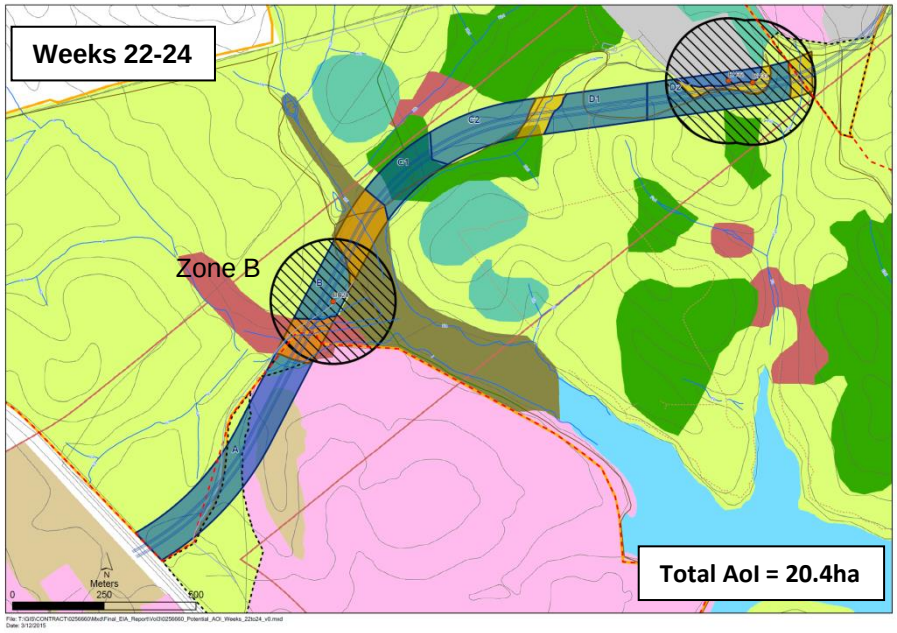
*Note: Elevated noise levels will be generated at a distance of up to 170 m from the rotary borehole rig before attaining current baseline noise levels. And therefore 170 m radius from the rig is considered as potential area of influence from conservative approach*

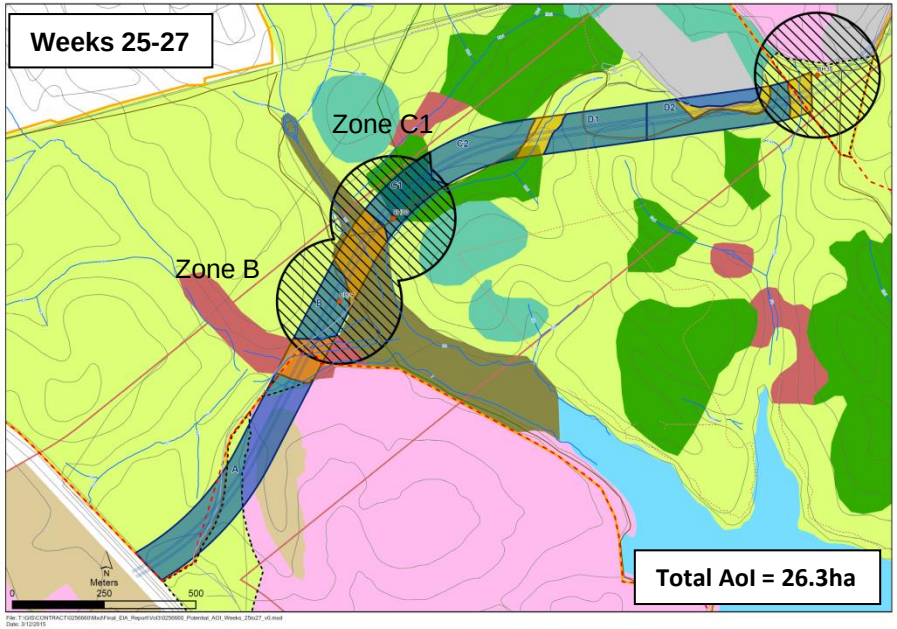
Figure 6.3b Potential Area of Influence due to Concurrent Geophysical Surveys and Rotary Borehole Works (Based on Indicative Schedule of SI Works)

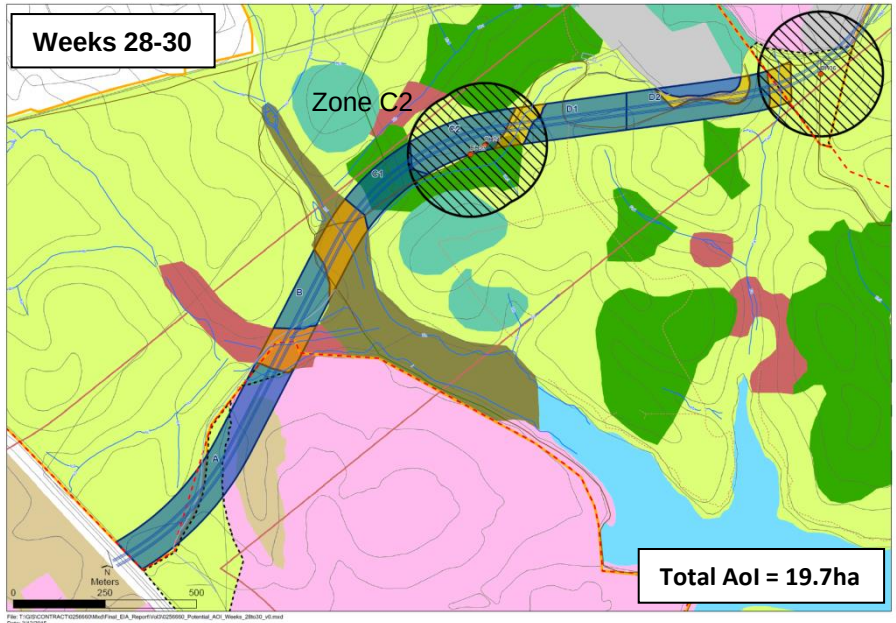
Environmental Resources Management

ERM



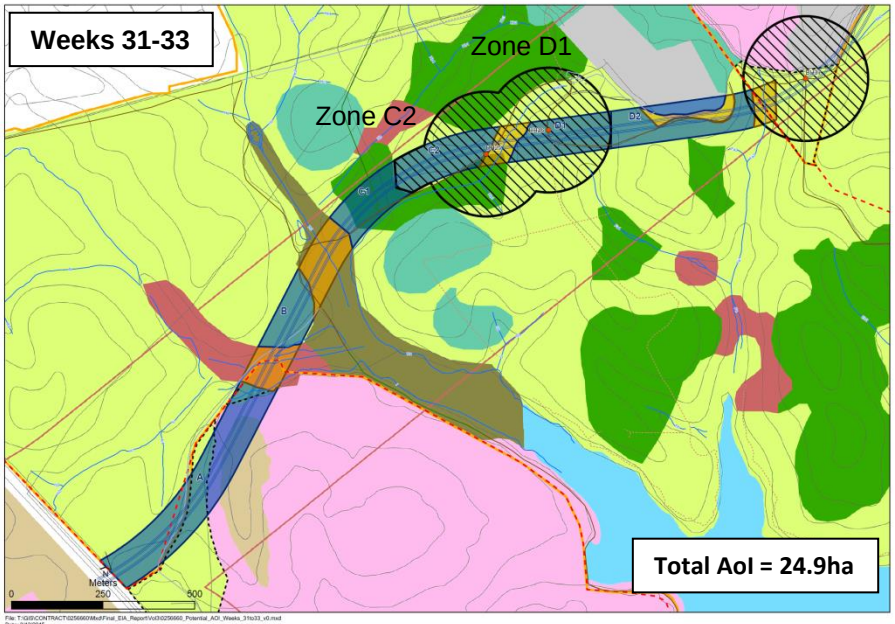

- All SI works within CCNR restricted to Monday to Friday (between 09.00 and 17.00, with demobilization from 17.00 to 18.00)
- Surveys/ operation to be suspended during rain
- Geophysical surveys to be arranged to avoid the peak flowering season (April and May) as much as possible
- Actual location of geophysical survey is quite localized in each day (ie up to 3-4 days for a string line of 200 m length)

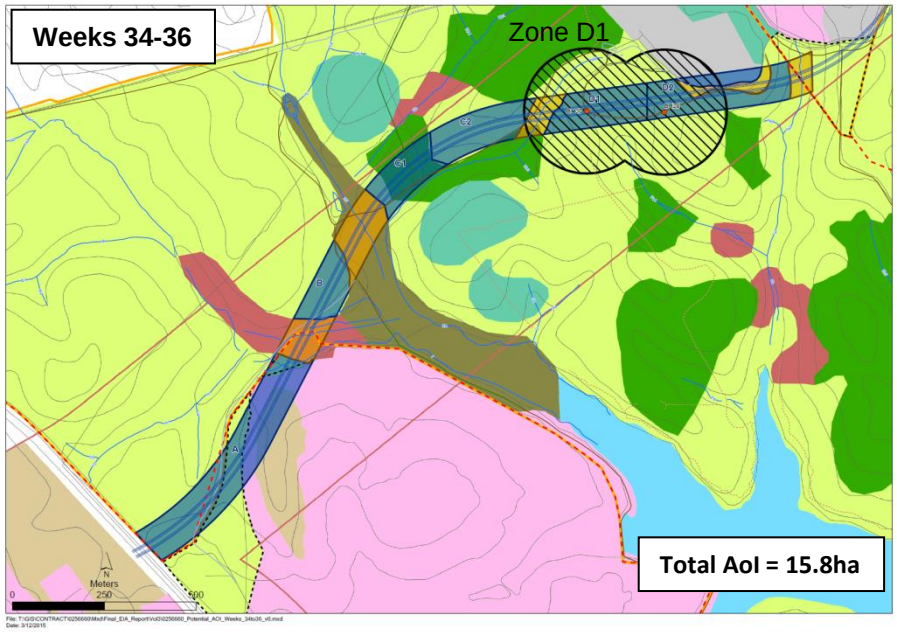
*Note: Elevated noise levels will be generated at a distance of up to 170 m from the rotary borehole rig before attaining current baseline noise levels. And therefore 170 m radius from the rig is considered as potential area of influence from conservative approach*

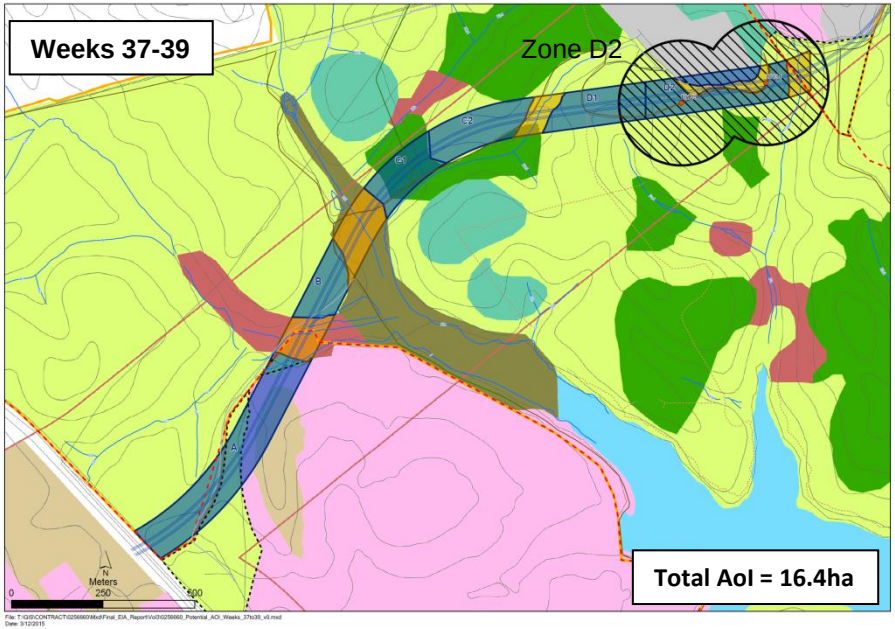
Figure 6.3c Potential Area of Influence due to Concurrent Geophysical Surveys and Rotary Borehole Works (Based on Indicative Schedule of SI Works)

Environmental Resources Management

ERM




- All SI works within CCNR restricted to Monday to Friday (between 09.00 and 17.00, with demobilization from 17.00 to 18.00)
- Surveys/ operation to be suspended during rain
- Geophysical surveys to be arranged to avoid the peak flowering season (April and May) as much as possible
- Actual location of geophysical survey is quite localized in each day (ie up to 3-4 days for a string line of 200 m length)

*Note: Elevated noise levels will be generated at a distance of up to 170 m from the rotary borehole rig before attaining current baseline noise levels. And therefore 170 m radius from the rig is considered as potential area of influence from conservative approach*

Figure 6.3d Potential Area of Influence due to Concurrent Geophysical Surveys and Rotary Borehole Works (Based on Indicative Schedule of SI Works)

Environmental Resources Management

ERM

During Weeks 22 to 33, the width of the wildlife movement corridor connecting MacRitchie to other CCNR areas will be reduced when the geophysical surveys in Zone C and the rotary borehole works (including two daily round trips for the ancillary vehicles and up to 10 round trips during the day as equipment is mobilized and demobilized to worksite) in the central part of the survey corridor (ie BH20-25) commence. During this period, the indicative schedule of SI works has been designed to restrict works only confined to areas within Zone B, the Wetland Forest and Marsh or within Zone C. This arrangement seeks to maintain, as much as possible, a maximum width of the wildlife movement corridor connecting MacRitchie to other CCNR areas.

It should also be noted that all SI works within CCNR are restricted to Monday to Friday (not more than 8 hours a day, between 09.00 and 17.00, and mobilization lasting one hour till 18.00) and the surveys/ operations will also be suspended during rain. As such, any potential interference with wildlife activity will be alleviated to a certain extent as movement corridors and foraging/ shelter areas will be fully maintained outside these hours. It is also noted that Lesser Mousedeer is more active during early morning (ie 05.00-07.00) and late afternoon (15.00-17.00)[1]. Given the restrictions to the extent (ie localization of geophysical survey activities and the actual area of influence is expected to be smaller than illustrated in *Figures 6.5a-d*) and duration of works, and with the implementation of the various embedded controls and Mitigation Measures, the risk of the territorial conflict, potential impacts on wildlife populations due to the concurrent commencement and operation of rotary borehole works and geophysical surveys are minimised as far as reasonably practical.

As recommended in mitigation measures, the geophysical surveys will avoid all of the aquatic habitats and the new MPs will only be undertaken at three stream locations (*Figure 6.2*). However, the MP works are expected to have minimal disturbance to the stream bed, water quality and aquatic wildlife given the small scale of the works, avoidance of aquatic plants and riparian vegetation and slow movement of investigation. Access to these three MP locations will be from existing trails and surveyors will remain on the existing bridge during investigation. Therefore disturbance to the stream habitats and riparian vegetation due to geophysical surveys and MPs is not expected. The MPs are relatively small and the activity at any one worksite will be of a short duration (can be completed all up to two days) and with limited number of personnel involved.

***Accessibility Criteria***

A set of Accessibility Criteria and an associated working method has been developed in consultation with NParks to minimize the impacts of offtrail walking as far as practical. NParks staff and the ecologist will use Accessibility Criteria (as presented in *Annex 1*) to avoid impacts on sensitive habitats and damage on plant species (particularly those listed as CR or EN or VU in the Singapore RDB). NParks staff and the Environmental Advisor/ecologist will supervise the adoption of these measures as well as other other Mitigation Measures (such as control on work hours, limiting number of surveyors etc, as presented in *Table 6.8*). The ecologist as well as NParks staff will be present during the geophysical and MP surveys to provide an environmental briefing before commencement of the work. This will inform the teams of sensitive areas to avoid, how to move through the habitats in a way that will cause the least disturbance to plants and animals, and the appropriate response if any fauna is encountered.

[1] Matsubayashi H, Bosi E and Kohshima S (2003) **Activity and Habitat Use of Lesser Mouse-Deer (*Tragulus javanicus*)**. Journal of Mammalogy, 84 (**1**):234–242.

Where the alignment is off trail, the route will be located by NParks staff and the ecologist together with topographical surveyors following the Accessibility Criteria (Mitigation Measures). The surveyors will walk along the identified acceptable survey route to lay out the survey equipment (rather than uncontrolled walking in and out of the forested area from the trail without the Mitigation Measures). In addition geophysical surveys including seismic, electrical resistivity and gravity surveys will not be undertaken where the ground cover is waterlogged and inaccessible (ie densely vegetated areas). Further to the implementation of the Mitigation Measures, these surveys will only pass through existing disturbed routes and areas of limited groundcover without vegetation clearance, cutting or breaking or damaging branches of trees, shrubs and climbers, hence reducing disturbance. It should also be noted that the potential area of operations within each zone are likely to be quite localized on each day of the survey following the implementation of Mitigation Measures. As such the potentially affected area can be easily supervised by NParks staff and the ecologist. Even though the survey team may have multiple trips (ie refer to *Table 6.5*) along the identified routes within the same day or over a number of days, the trampling impacts will be mainly confined along the same identified routes that meet the Accessibility Criteria.

Given the terrain off trail and weight of loads being carried it is recognized that survey members may slip or trip causing damage to vegetation. The likelihood and consequence of such incidents will be minimized through the implementation of Mitigation Measures including selection of appropriate routes (using the Accessibility Criteria) as well as training of staff and monitoring of behavior. As discussed further below, the works have also been scheduled to start in Zone A, which is generally considered to be less sensitive, to allow for the teams to gain experience in operating off trail and hence reduce risk of accidents in more sensitive areas. Impacts on plant species listed as CR or EN or VU in the Singapore RDB due to such slips or trips will also be limited as the Accessibility Criteria should ensure their absence within 1 m of the approved off trail routes.

It is noted that there are already a number of unofficial/illegal off trail routes that may be used to reach more remote off trail areas at Zones A and B as well as a limited number in Zones C and D. Therefore while there may a small amount of breakage of plant stems/ seedlings and disturbance of micro-habitats (ie leaf litter), potential trampling impacts on vegetation:

- Is not considered likely to cause any loss of function or viability of the habitats;
- Will be temporary; and
- Cover relatively small areas of disturbance within each habitat at the same time.

***HDC Lighting***

With regards to illumination from HDC worksites, there is a range of possible measures to prevent or reduce the ecological effects of night-time light pollution including (i) preventing areas from being artificially lit; (ii) limiting the duration of lighting, (iii) reducing the trespass of lighting, and (iv) reducing the intensity of lighting. [1] The best way of mitigating illumination impact is therefore to ensure the HDC temporary shelter/ cover is fully enclosed so as to contain all light. This would have the added benefit of reducing noise pollution. Should other factors require a more open worksite, it is suggested that those façades facing more sensitive ecological areas (ie the CCNR natural habitats) be enclosed ie enclose the shelter/cover on at least three sides. In addition, the lighting design, installation and maintenance should be carefully prepared to ensure illumination is only provided as and where

[1] Gaston KJ, Davies TW, Bennie J and Hopkings J. (2012) **Reducing the ecological consequences of night-time light pollution: options and developments**. Journal of Applied Ecology **49**, 1256-1266

required, any light trespass outside the necessary area of the HDC work area is avoided, the intensity and duration of lighting is reduced as much as possible, eg use directional, focused lighting, dimmer switches and light absorbent surfaces rather than reflective surfaces.

### *Residual Impact Assessment*

With the strict implementation of the above mitigation measures, residual impacts are expected to be reduced to *Small* to *Medium* magnitude. Thus the significance of residual impacts are mainly *Moderate* (*Moderate* to *Major*), with the possibility of escalating to *Major* only if the mitigating measures are not observed.

## 6.6 IMPACTS DUE TO UNPLANNED EVENTS

### *Embedded Controls for Unplanned Events*

During the development of the Project, and from initial information regarding the baseline ecology, one control in particular was put in place with the objective to helping to reduce the risk of unplanned water pollution from site runoff (sediment loading from runoff; accidental release from slurry tank; leaks of fuel/lubricant during transportation, storage and handling; drips from equipment and rig during mobilization, operation and demobilization etc.), the establishment of buffer zones around all streams within the CCNR and all *Wetland Forest* and *Wetland Marsh* areas both within and outside the CCNR.

The following embedded controls will be in place during operation activities of the rotary and HDC rigs and will help manage pollution to aquatic habitats:

- All drilling works will be conducted in accordance with the *Environmental Protection and Management Act, 2008, Environmental Protection and Management (Trade Effluent) Regulations, 2008*, *Public Utilities (Reservoir and Catchment Areas) Regulations, 2006* and LTA's *General Specification, Appendix A, Safety, Health and Environment (for Rail Project) December 2014 Edition*. These include controls to protect impact to surface water courses, such as prohibiting hazardous material release; provision of drip tray for all fluid containers on site; limitations on suspended solids; measures controlling sanitary waste release; fire safety and emergency planning; flammable material storage protocols and best management practices;

- Wastewater, slurry generated during operation of the rotary or HDC drilling rig will be contained within a FCT and pumped to an enclosed 1,000L wastewater tote tank and removed offsite on a regular basis by a small vehicle approved by NParks/LTA for disposal to a licensed third party waste management facility. The pump hose connecting FCT to wastewater tote tank should be secured so as to avoid any spillage from loose hoses;

- Hazardous liquids (eg maintenance oil) will be stored in a lockable steel container providing secondary containment;

- Vehicle and equipment maintenance checks and cleaning will be undertaken prior to mobilization into the CCNR and upon exit from the CCNR. No equipment washing will be undertaken within the CCNR and furthermore, rig maintenance will be undertaken at each worksite (if required) using drip trays to prevent release of pollutants to the ground.

### *Potential Impacts*

Unplanned events are considered include:

- Surveyors suffer accidents requiring emergency rescue off trail causing additional trampling impacts during geophysical surveys;
- Uncontrolled site runoff, wastewater and spill during rotary and HDC drilling works;
- Accidental spills during transportation of fuel/ lubricant/ drill/fluids;
- Vehicle running off trail/ brushing or colliding with wildlife and vegetation; and
- Fire due to SI associated activities.

All these events could lead to adverse impacts on wildlife, principally through the pollution or destruction of the habitat they use as well as physical injury. Potential impacts associated with these events are therefore considered including pollution of habitat in particular aquatic habitats from spills, erosion and sedimentation of the water, and injury as well as damage to wildlife and vegetation.

### *Likelihood of Unplanned Events*

Important to assessing the significance of unplanned events is the evaluation of how likely an event is to happen. It is important to note that likelihood is a measure of the degree to which an unplanned event is expected to occur, not the degree to which an impact is expected to occur as a result of the unplanned event.

*Table 6.10* provides definitions used in the *ERM IA Standard* for likelihood designations and the following text considers the likelihood of the unplanned events identified above for the SI works.

Due to the frequency of heavy rain in Singapore, consideration has been given to the likelihood and impact associated with uncontrolled site runoff, wastewater and spills due to sudden adverse weather during rotary drilling of boreholes. Such worksites will not store large volumes of contaminating material and will be subject to the embedded controls outlined previously. However given the number of boreholes and the length of the overall work program ERM has assessed the likelihood of such an event to be Possible.

***Table 6.10***: ***Definitions for Likelihood Designations***

| Likelihood | Definition |
|---|---|
| Unlikely | The event is unlikely but may occur at some time during normal operating conditions |
| Possible | The event is likely to occur at some time during normal operating conditions |
| Likely | The event will occur during normal operating conditions |

The geophysical surveys will be restricted to daytime work and no one person will be operating alone at any time. In addition, as the nature of works is considered low risk, the likelihood of surveyors suffering accidents requiring emergency off trail rescue is considered Unlikely. This reduces the potential of additional trampling impacts arising from any the emergency off trail rescue operation.

Consideration was also given to the likelihood of uncontrolled site runoff, wastewater and spills at HDC sites. These worksites will be covered and all the rig and equipment enclosed within, reducing the likelihood of such events during heavy rain. However, these sites are relatively large (direct footprint of approximately 700 $m^2$), will store larger volumes of material, involve a greater number of staff and new access roads at two locations. Compounded with the long duration of HDC drilling work (up to 24 months at each location), uncontrolled site runoff, wastewater and spill due to accidents or failure of controls within the HDC site are considered Possible.

While measures have been proposed for the containment of drilling fluid and secondary containment during refueling (as detailed in *Chapter 2*), the duration of rotary borehole work and HDC drilling is anticipated to span up to a year. In addition, for the work inside the CCNR, daily trips suppling fuel and water to the worksite and removing wastewater from the worksite will occur. Therefore accidental spills of fuel/ lubricant /drilling fluids during transportation, is considered Possible.

Measures have been proposed regarding rotary boreholes and HDC to ensure vehicles within the CCNR move slowly, keep to the existing trails and are equipped with spill kits such as absorbent pads/ mat. All boreholes within the CCNR are on public trails and vehicle routes will follow these existing routes. However given the relatively long duration of the works, the size of the drilling rigs themselves and the differences in mobility of different fauna, a vehicle running off trail/ brushing or colliding with wildlife or vegetation is also considered Possible.

Fires have occurred in CCNR previously[1], calling for the application of fire suppression measures within the CCNR. The drilling rigs and associated equipment and vehicles involved in the SI will undergo maintenance checks to ensure that they are fit for purpose prior to mobilization and during operation along Alignment Option 1. Generators that will be used on site will also be certified by a Licensed Electrical Worker (LEW) and comply with the Code of Practice for Electrical Installations in Singapore and the *Parks and Trees Act 2005 (revised 2006)*. Finally, as open fires and smoking within the CCNR is prohibited by the *Parks and Trees Regulations,* the likelihood of a fire as a result of the SI Works is considered Unlikely.

### *Potential Consequences*

As outlined above, the main different impacts on ecological resources and receptors that have been identified from unplanned events include:

- Additional off trail trampling impacts;
- Pollution of aquatic habitats;
- Injury to wildlife/damage to Vegetation; and
- Habitat and vegetation loss due to fire.

#### *Additional Off Trail Trampling Impacts*

Where the alignment is off trail, the route will be located by NParks staff and ecologist together with topographical surveyors following the Accessibility Criteria. In addition, geophysical surveys will not be undertaken where the ground cover is waterlogged, inaccessible (ie densely vegetated areas) and only

[1] Ee D, Call for Public Vigilance Against Bush Fire Threat. Retrieved from http://news.asiaone.com/news/singapore/call-public-vigilance-against-bush-fire-threat

pass through existing disturbed routes and areas of limited groundcover without vegetation clearance, cutting or breaking or damaging branches of trees, shrubs and climbers. This is expected to reduce disturbance. The geophysical survey locations will be visited almost together in the same time following the guidance of NParks staff, ecologist and topographical surveyors during the surveys. Should any accidents occur, an identified route of limited vegetation cover will be used for the emergency rescue, and therefore potential additional trampling impacts will be minimized as far as practical.

***Pollution of Aquatic Habitat***

The aquatic environment within the Study Area has been shown to be highly sensitive. As such, concerns around unplanned events for this Study Area would be adverse impacts on the aquatic environment from accidental runoff, wastewater spills reaching water bodies as well as erosion on trails and around worksites causing heightened sediment loads. There is also particular concern about harm to fauna that are critically endangered and the possibility of affecting key populations.

Given the location of boreholes within the CCNR (located outside the 30 m wetland/ stream buffer zone, and at flat ground without any ditches leading to the streams in the close vicinity), the Embedded Controls and Mitigation Measures and the size of worksites, as well as the likely volume of material involved, the consequence of an unplanned release from such boreholes is considered small.

The location of two of the HDC sites (HDC 1 and HDC 3) in relation to potential conduits to sensitive aquatic habitats suggest the impact on such habitats due to an unplanned event at either of these two sites is likely to be minimal. However the location of HDC 2 (to the north of Bukit Golf Course with a relatively steep gradient towards a stream and drainage channel that connects with the wetland forest in the CCNR), the size of the worksite and the likely volume of activity at this site suggest that the impact of an unplanned event has been minimized as far as practical with the provision of the embedded controls and mitigation measures.

***Injury to Wildlife/ Damage to Vegetation***

This impact may arise due to collisions with wildlife and vegetation during mobilization of drilling rigs and daily movement of small vehicles to and from the rotary borehole sites during operation. This may lead to the damage of vegetation, injury or even death to wildlife. The species that have been found along the trails vary in their mobility and hence their predisposition to such impacts. For example troupes of Long-tailed Macaques (*Macaca fascicularis*), which are listed in CITES Appendix II, have been recorded from the trail. This species is considered highly unlikely to suffer injury and similarly species such as the Red Junglefowl (*Gallus gallus*), which is listed as Endangered in the *Singapore RDB, 2008*, should be able to avoid any collisions. Some less mobile species of conservation interest were also recorded however which would be more prone to collisions. These include but are not limited to: the Spiny Hill Terrapin (*Heosemys spinosa*), which is listed as Vulnerable by *Singapore RDB, 2008*, Endangered by *IUCN* and is on CITES Appendix II and was found in the forests with juveniles closer to water bodies and likely having the Sime Trail (sections close to stream/ wetland) in their home range; as well as a juvenile Malayan Swamp Skink (*Sphenomorphus* sp.) encountered on the trail close to the edge of a stream in *Primary Forest* and *Regeneration Forest A*. Should these species be affected, however, it would not constitute a substantial change in the wildlife population size, plant communities or habitat conditions (even localized vegetation damage may occur).

Injury or killing of wildlife might also inadvertently occur during compaction/ minimal cutting of vegetation should any animals be present in the vegetation affected. Within the CCNR only minimal cutting of overhead foliage and vegetation either side of the trail is expected, while outside the CCNR

some tree felling may be required. Given any areas where tree felling may be required is small, it is unlikely that any injury to wildlife will not be with the normal range of variation for a population of a species.

***Habitat and Vegetation Loss due to Fire***

Should a fire occur, there is the potential for a significant area of habitat and vegetation to be destroyed. During a previous incident in the CCNR, press reports suggests that there were some delays in getting firefighting equipment and water to the site due to its location despite the fire being identified early. Given the worksites are relative accessible, mainly located along the trail or at the edge of the forest, firefighting is expected to be implemented relatively quickly which will limit the spread of fire and areas to be affected.

### *Significance of Impact prior to Mitigation*

How potential impacts due to unplanned events might affect various habitats and wildlife are detailed above. Overall pollution of habitat, in particular aquatic habitat, has largely been addressed through Embedded Controls including boreholes located outside a 30 m stream/ wetland buffer and at flat ground without any ditches leading to the streams in the close vicinity. Since it may affect species of conservation interest and given the pristine nature of the streams in particular but the overall high ecological value of all habitats within the CCNR boundary, the species and habitats are given a high ecological sensitivity and the overall significance of the impact is therefore *major* prior to mitigation.

With regards injury to wildlife/ damage to wildlife, there is some uncertainty around the population sizes of some fauna species of conservation interest that could possibly be affected, but the likelihood of the event that would cause this impact (vehicle running off trail/ brushing or colliding with wildlife and vegetation) is considered Possible prior to mitigation.

With consideration of the high sensitivity of all habitats within the CCNR and NParks Managed Areas and the moderate magnitude of impacts due to the damage of fire on habitats and vegetation as well as the ecosystems, the significance of the impact, in the absence of further mitigation, is considered to be *major* prior to mitigation, even if it may be Unlikely to happen.

### *Mitigation and/ or Management Measures*

Mitigation measures mentioned in previous sections are relevant to helping prevent unplanned events. Factors that should be considered particularly important to reducing the risk of unplanned events occurring include:

- Minimizing the duration of works, particularly those closest to streams that form part of the stream system within the CCNR;
- Ensuring implementation of a 30 m stream/wetland buffer zone;
- Use of erosion control blankets;
- All equipment at the worksite within CCNR to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding environment;

- Spill kits such as absorbent pads/ mats and drip trays, as well as secondary containment with impermeable surface should also be available at all times at each worksite in case of any emergency event. Spill kits and storage box to be secured at all times to prevent access from wildlife. Absorbent mats and spill kits should also be available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak;

- The FCT should be positioned on an absorbent mat or within secondary containment to contain potential spills/ leaks to the ground;

- Establishing a robust spill management plan;

- Development of an Emergency Preparedness Plan and Fire Safety Plan in accordance with LTA General Specification to outline resources, plans and procedures for response to a fire or similar emergency scenario. Emergency Preparedness Plan and Fire Safety Plan to include:

    - use of freshwater (rather than chemical suppressant) where appropriate and ensure compliance with the requirements of emergency authorities in Singapore (eg SCDF).

    - All SI operational personnel should be provided with training on implementation of the Emergency Preparedness Plan and Fire Safety Plan;

    - vehicle mobilization/demobilization schedule and routes, including turning area (if required). Schedule to minimize the volume of vehicle movement on the trail.

- The small amounts of hazardous fluids (ie, <5 liter oil and diesel) should be stored within a dedicated locked hazardous material storage box at each worksite and during mobilization/demobilization to and from each worksite;

- Minimize ancillary vehicle trips (maximum x2 per day);

- Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.;

- Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works;

- Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37;

- All rigs and vehicles (including ancillary vehicle mobilizing water/wastewater to and from each worksite) in intermittent use should be shut down or throttled down to a minimum in the intervening periods between works to prevent engine overheat;

- Following rainfall event, manual transport of ancillary equipment to and from each worksite should only be permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET;

- All Contractor personnel to attend a two hour training of the ecological sensitivities within CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail and noise minimization measures; Daily toolbox talks, SHE Inspections and progress/corrective action calls should be carried out; and

- In addition to the vehicle and equipment maintenance and compliance with NParks protocols (eg no smoking and open fires), minimize the likelihood of a fire through visual observations of generators and engines for signs of overheating. Refueling should only be conducted when the drilling rigs / generators are not operational.

## 6.7 CUMULATIVE IMPACTS

Cumulative impacts are those that arise from the combined effects of the Project's activity with external activities. How such impacts are assessed 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); and

- Chestnut Park Nature Park.

In addition, other situations where cumulative impacts are likely to occur include:

- Influence on visitor numbers to the NParks managed MacRitchie area; and

- Impacts due to borehole schedule, which assumes two rigs will operate within the CCNR boundary at any one time and up to four rigs outside CCNR at any one time (whether using crawler A-frame or DB520-type rigs).

It is also recognized that the CCNR is already considered a highly fragmented habitat, with other barriers limiting wildlife movement and dispersal and subject to a number of other pressures (see *Section 6.3*).

### *Potential Consequences*

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

***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 *Figure 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.[1]

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)[2] regarding the vascular flora, has a high ecological and biodiversity value. As reported by NParks (2015)[3] 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 built 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 have been found here, supporting the conclusion that it is a highly sensitive area ecologically. Currently no SI works are proposed in this area although a number a situated along the Island Club Road adjacent to it. 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 liaison continue between both Project Proponents, particularly when considering where the un-numbered boreholes along Island Club Road, to ensure there are no conflicts in scheduling or proposed works.

***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 [4] (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

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

[2] 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

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

[4] 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

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.

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 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.

***Chestnut Drive Nature Park***

Chestnut Nature Park is also part of a wider strategy to make nature more accessible to Singaporeans [1] and *Volume II, Chapter 7, Figure 7.1* indicates the location of this proposed park. It lies on the western fringes of the CCNR, across the Bukit Timah Expressway from Bukit Panjang and can act as another buffer to the CCNR (Similarly to the proposed Windsor Nature Park). Although the project does not overlap with the SI works, some information regarding its nature and linkage to the CCNR is noted below.

Chestnut Drive Nature Park is an 80 ha park due to be completed in September 2016. It will feature a seven-storey observation tower offering a panoramic view of the CCNR. Other park amenities are also proposed, including shelters, toilets, an information kiosk, hiking and biking trails, and interpretive signage for visitors to learn about the park's rich biodiversity. [2] It is reported that the area currently consists of mainly forested area and that a Biodiversity Impact Assessment (BIA) was tendered by NParks for this Project, looking to assess how streams, flora and fauna may be affected by the construction of the Park, as well as its use by humans upon completion.[3] Given the distance from the current SI works for Alignment 1 of this project, no adverse cumulative impacts are expected. However, the area is linked to the MacRitchie area (albeit with the restricted area buffering any habitats affected by the SI works) and it is suggested that there is some communication between Project Proponents to discuss any synergies in study findings that may be relevant to the other.

***Visitor Numbers to the NParks Managed MacRitchie area***

There are reported concerns with opening up park areas to the public as to whether visitors will behave responsibly, such as by sticking to designated trails and not forging illegal ones. Previously these have led to suggestions for areas falling under NParks' management to consider capping visitor numbers and stepping up ranger patrols.[4] These concerns are equally pertinent regarding the personnel involved in undertaking the SI works for the Project. A number of measures have been proposed above, however, which help to mitigate these concerns, such as restricting workers to the numbers defined in the EIA, recommending that an ecologist be present with the geophysical survey teams and the Mackintosh Probe survey teams and ensuring all workers to be trained in managing wildlife encounters. In addition, most of the more intrusive SI works proposed with the NParks Managed Area, have been

[1] 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

[2] Singapore La (Date not specified) **Chestnut Nature Park ready in 2 years.** Retrieved March 2015 from http://www.sporela.com/index.php/latest/384-chestnut-nature-park-ready-in-2-years

[3] The Strait Times (7 March 2014). **NParks calls for impact study of new nature park.** Retrieved from http://news.asiaone.com/news/singapore/nparks-calls-impact-study-new-nature-park

[4] The Strait Times (7 March 2014). **NParks calls for impact study of new nature park.** Retrieved from http://news.asiaone.com/news/singapore/nparks-calls-impact-study-new-nature-park

restricted to on-trail or sites that are already disturbed such as the Bukit Kalang Service Reservoir compound and surrounding road and bare ground sites. These areas of the Park are relatively highly utilized by the public.

While no cumulative impacts are anticipated from increased visitor numbers due to the SI works, care should be taken to implement the suggested mitigation measures and adhere to all NParks policies.

***Impacts due to Rotary Borehole schedule***

The current impact assessment has assumed no more than two rigs will operate within the CCNR and up to four rigs outside CCNR concurrently. The findings of this EIA Report, will help to determine a more precise schedule for how the Rotary Borehole works (including drilling and testing) and consideration should be given to minimizing any potential ecological and biodiversity impacts in such ways as scheduling the works to be undertaken as quickly as possible, specifically at locations recognized as being particularly sensitive (eg BH22). Further consideration should also be given to allow the operation of the two rigs within the CCNR, to ensure they operate at sufficient distance from each other to avoid cumulative concerns, but also to allow the overall schedule of Rotary Borehole works to be conducted as fast as practicable. Use of DB520 or similar type rigs would further reduce this schedule, the advantages of which generally include a shorter time period over which unplanned events can occur and a shorter duration of impacts. If work can be separated to avoid cumulative impacts from noise and vibration then the only disadvantage to such an approach would be the inconvenience due to closure of public trails. These issues may require further discussion and engagement with NParks to resolve.

### *Overall Significance of Cumulative Impacts*

Each of the projects or activities that might be considered to cause cumulative impacts has been discussed above and no significant cumulative impacts on ecological resources and receptors are anticipated. Nevertheless, it is clear that there are a number of projects that are either proposed or ongoing (including but not limited to the projects listed above), to increase the public's access to nature or with potential disturbance to CCNR and the associated flora and fauna. It is also recognized that the CCNR is already considered a highly fragmented habitat, with other barriers limiting wildlife movement and dispersal and subject to a number of other pressures (see *Section 6.3*). It is therefore recommended that the Project Proponents for all these projects overlapping with or adjacent to the Study Area, keep an open channel of communication to ensure each is aware of the others proposed scheduling, in order to adjust the schedule so as to avoid cumulative impacts within CCNR. These communications can also serve to exchange relevant and useful information between parties to mitigate impacts as low as practical.

# 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 in the vicinity of the CCNR. This encompasses the geophysical works, rotary boreholes, and horizontal directional coring. 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. It is noted impact mitigation measures associated with the use of Deltabase 520 drilling rig, although assessed within the impact assessment chapters, have been excluded from the EMMP. At the time of this SI EIA report (001) update, use of these equipment types had been excluded from the project.

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. The SI phases have been abbreviated and defined as per the stages outlined in the SI Strategy, ie preliminary investigation (Prelim

[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*

Investigation); geophysical works (Geophys); rotary boreholes (Rotary BH) and horizontal directional coring (HDC);

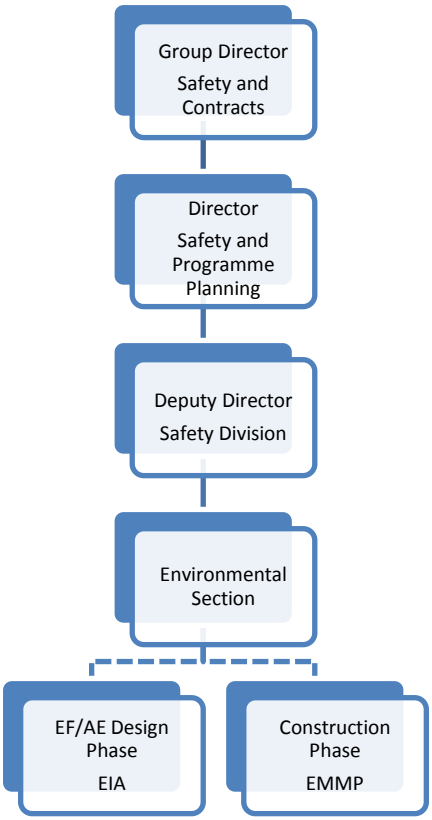
- The **Aspect** of the SI works and potential environmental impact/issue;
- **Reference** to the relevant statutory requirement, LTA requirement, and Chapter within the SI EIA;
- **Specific Actions** (ie mitigation) that require implementation. Actions are detailed from the mitigation measures identified 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

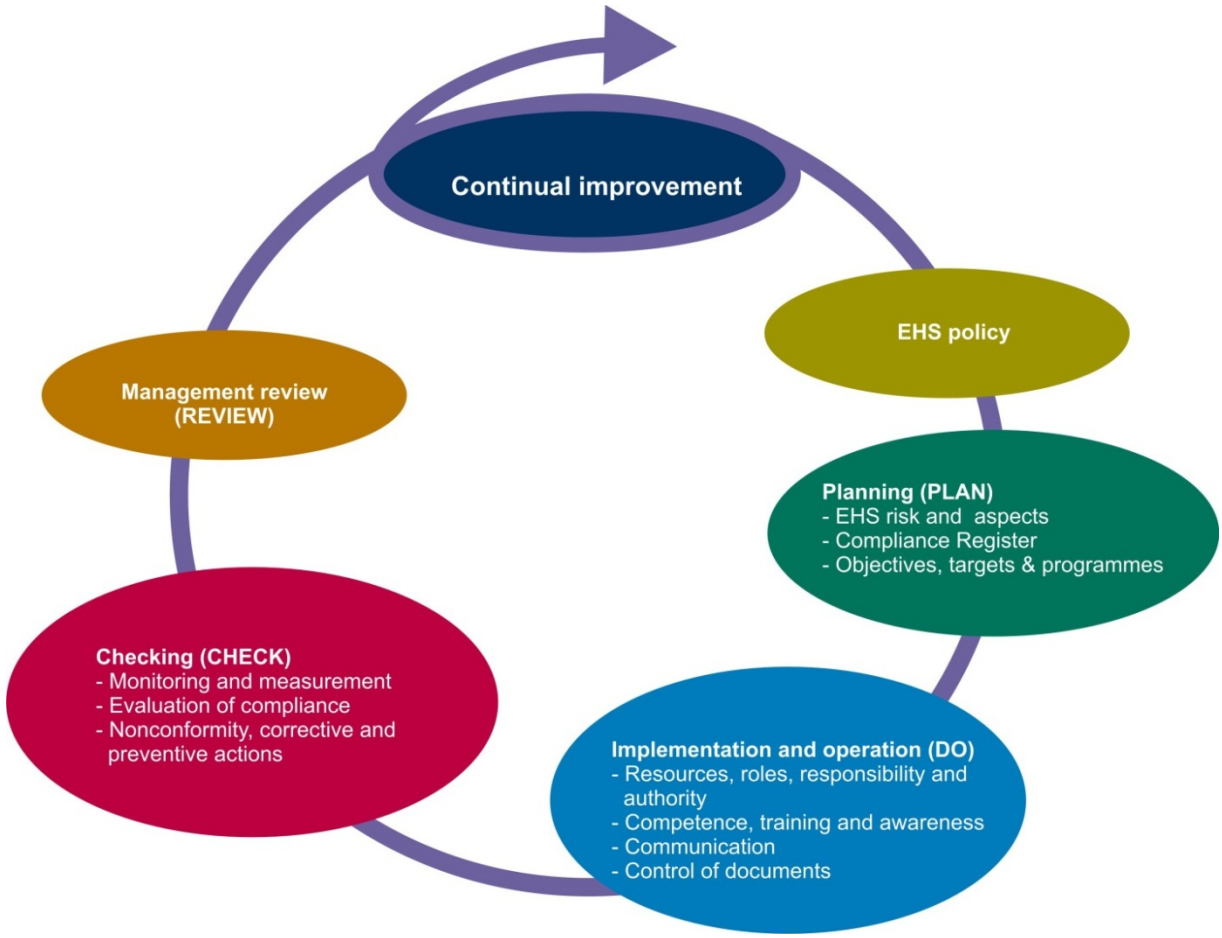
Date : 1 December 2014

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 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) 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* 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 General 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 off trail access route planning for geophysical works; and rotary borehole method statement verification *etc*. 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*, the project description from the SI EIA and the SI Strategy report 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 will arrange a planning meeting with the Contractor during the Preliminary Investigation Phase to provide training on the SI Strategy and EMMP. The training should include:

- Safety procedures and guidelines, including any specific requirements from authorities such as NParks;
- 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

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

- Stakeholder grievance process.

In addition, specific environmental training will also be provided to the team involved in the geophysical surveys, Mackintosh probes and rotary borehole operations within the CCNR, which will include applicable environmental sensitivities of work areas; 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 throughout the SI works. This will include the preliminary EMMP training; daily progress calls and corrective action discussions; and spot check site audits.

### *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);
- Weekly Report on ecological and biodiversity monitoring as identified in the EMMP planning table (Environmental Advisor);
- Minutes of Meeting of daily 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 the daily progress calls with LTA;
- Record recommended corrective action into the daily progress call Minute of Meeting;
- Circulate proposed modification through the daily progress 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 measure 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 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; Geophys; M.Probes, Rotary BH, or HDC) | 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<br><br>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 of Implementation | - | - | - | - | Air Pollution Control Plan<br>Noise Management Plan<br>Earth Control Measures Plan<br>Waste Management Plan<br>Water Pollution Management Plan<br>Biodiversity Monitoring and Management Plan<br>Emergency Preparedness Plan<br>Fire Safety Plan |
| *1.02* | General Management | All | Contractual | LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition<br><br>SI EIA Vol III, CPT 6.5.3 | Contractor should employ suitably experienced personnel to ensure compliance with all necessary measures to mitigate environmental impact | LTA | - | - | - | - | - | - |
| *1.03* | Noise, Vibration, Ecology and Biodiversity | All Phases | Human and Ecological Disturbance | Environmental Protection and Management Act, 2008<br><br>Code of Practice for Noise Control on Construction and Demolition Sites, SS602:2014<br><br>NParks Specification (June, 2015) | All SI works to be scheduled during daylight hours (09.00 - 17.00) with one hour (17.00 - 18.00) demobilization time from the Project area, Monday to Friday only, unless specified otherwise within. | Contractor | Approval of SI Works Schedule prior to commencement of SI works<br><br>SHE Inspections and Clock In/Out Procedure | Daily | - | Clock In/Out at NParks Ranger Station when works within CCNR; SICC when works outside CCNR | - | - |
| *1.04* | Water Quality, Ecology and Biodiversity | All Phases | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Impact to wild plants and animals | SI EIA Vol III, CPT 3.5.1 and CPT 6<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition | All survey equipment, rigs and vehicles (Geophys, M.Probes, Rotary Rigs, Vehicles) involved in the SI within the CCNR gazetted boundary and golf courses to undergo maintenance checks and cleaning prior to mobilization into the CCNR and upon exit from the CCNR. Note, no equipment washing to be undertaken within the CCNR. | Contractor | SHE Inspections<br>Maintenance Records and Certification of Equipment | Prior to mobilization into the CCNR | - | Contractor Equipment Storage Yards | SHE Inspection Report; Maintenance Records; and Equipment Certification | Water Pollution Management Plan<br>Emergency Preparedness Plan |
| *1.05* | Water Quality, Ecology and Biodiversity | M Probes | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Impact to aquatic habitats | SI EIA Vol III, CPT 3.5.2 | Relocate (and reduce the number of) MPs to the three locations presented in *Figure 3.1* . Field personnel to avoid traversing through streams or wetlands to access the MP locations. Personnel to operate MP equipment from a bridge. | Contractor | SHE Inspections | Daily | - | At MP01, MP02 and MP03 locations (see *Figure 3.1* of the EIA report) | SHE Inspection Report | Water Pollution Management Plan |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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* | Water Quality, Ecology and Biodiversity | Rotary BH<br>HDC | Wastewater runoff to ground and/or surface watercourses<br><br>Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas | SI EIA Vol III, CPT 3.5.1<br><br>Environmental Protection and Management Act, 2008 | Fluid Containment Tank (FCT) to be used at all times during operation of rotary and HDC 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 | Daily | Visual inspection of overflow to ground from FCT | All rotary & HDC rig operation locations | SHE Inspection Report (to include Corrective Action) | Water Pollution Management Plan |
| *1.07* | Water Quality, Ecology and Biodiversity | Rotary BH<br>HDC | Wastewater runoff to ground and/or surface watercourses<br><br>Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas | SI EIA Vol III, CPT 3.5.1<br><br>Environmental Protection and Management Act, 2008 | Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. Pump hose connecting FCT to wastewater tote tank to be secured so as to avoid any spillage from loose hoses, including being fitted with a valve to prevent drips to ground.<br><br>All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding environment. | Contractor | SHE Inspections | Daily | Visual inspection of overflow to ground from FCT | All Rotary and HDC rig operation locations | SHE Inspection Report (to include Corrective Action) | Water Pollution Management Plan |
| *1.08* | Water Quality<br>Ecology<br>Biodiversity,<br>Climate and Air Quality | Prelim Investigations<br>Rotary BH<br>HDC | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas<br><br>Human and ecological disturbance from dust | SI EIA Vol III, CPT 3.5.1<br><br>Environmental Protection and Management Act, 2008<br><br>Sewerage and Drainage (Surface Water Drainage) Regulations, 2007<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition<br><br>LTA Guidebook for Best Environmental Practices: Water Resource Management at LTA Sites, 2011 | During Preliminary Investigation phase, prior to commencement of the SI works, Erosion Control Blankets (ECB) to be positioned beneath equipment at all unpaved worksite areas. ECBs should be restricted to trails only, ie no disturbance of vegetation.<br><br>Inspection and maintenance of ECBs to continue during Rotary BH and HDC works. | Contractor | SHE Inspections (to include inspection schedule, checklist and maintenance schedule to be carried out by Contractor for all proposed erosion and sediment control measures) | Weekly | - | All unpaved areas utilized for rotary & HDC rig operations, including mobilization/demobilization routes | SHE Inspection Report(to include Corrective Action) | Earth Control Measures Plan<br>Air Pollution Control Plan<br>Water Pollution Control Plan<br>Biodiversity Monitoring and Management Plan |
| *1.09* | Water Quality, Ecology and Biodiversity | Rotary BH | Contamination of ground and surface watercourses | SI EIA Vol III, CPT 3.5.1 | In the event Rotary BH locations within CCNR and golf courses need to be adjusted, boreholes should not be sited within the 30 m surface water buffer zone or at or adjacent to location of steep gradient and be subject to LTA and NParks approval. | Contractor | Approval from LTA and NParks | - | - | - | - | - |
| *1.10* | Water Quality, Ecology and Biodiversity | Rotary BH<br>HDC | Contamination of ground and surface watercourses and impact to aquatic and wildlife communities | SI EIA Vol III, CPT 3.5.1<br><br>Environmental Protection and Management Act, 2008<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | The small amounts of hazardous fluids (ie, <5 liter maintenance oil) 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. Diesel storage within CCNR strictly prohibited.<br><br>Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface to be provided at each worksite. Storage box and spill kits to be secured at all times to prevent access from wildlife. | Contractor | SHE Inspections | Daily for Rotary BH's within CCNR<br><br>Weekly for HDC worksites | Visual inspection | All Rotary BH and HDC worksites | SHE Inspection Report (to include Corrective Action) | Water Pollution Management Plan |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.11* | Noise and Vibration | Rotary BH<br>HDC | Human Disturbance from Noise generated during Rotary BH and HDC operations | LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition<br><br>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:<br><br>i) Rotary borehole drilling rig (A-frame, crawler mounted): 105 dB(A) before enclosure and 101 dB(A) after use of wood enclosure for rig power source.<br>ii) Water pump (diesel operated): 96 dB(A) | Contractor | Review of vendor specifications against Code of Practice and SI EIA<br><br>SHE Inspection | During Preliminary Investigation Phase, prior to commencement of SI works | - | - | Method Statement | Noise Management Plan |
| *1.12* | Noise and Vibration | Rotary BH<br>HDC | Human Disturbance from Noise generated during Rotary BH and HDC operations | LTA General Specification, Safety, Health and Environment (for Rail Project) 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 |
| *1.13* | Noise and Vibration | Rotary BH<br>HDC | Human Disturbance from Noise generated during Rotary BH and HDC operations | LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition<br><br>LTA's Handbook for Best Environmental Practices: Noise Control at LTA Sites, July 2008 | All rigs and vehicles (including ancillary vehicle mobilizing water/wastewater to and from each worksite) in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works. | Contractor | SHE Inspection | Daily for Rotary BH's within CCNR<br><br>Weekly for HDC worksites | Visual inspection | All Rotary BH and HDC worksites | SHE Inspection Report | Noise Management Plan |
| *1.14* | Stakeholder Engagement | Prelim Investigations | Complaints from noise during SI works | SI EIA Vol III, CPT 4.5<br><br>SI EIA Vol I, CPT 6.5<br><br>Code of Practice for Noise Control on Construction and Demolition Sites, SS602:2014<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition | 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.<br><br>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 |
| *1.15* | 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 |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.16* | Noise and Vibration | Rotary BH | Human Disturbance from Noise generated during Rotary BH operations | Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008<br><br>Code of Practice for Noise Control on Construction and Demolition Sites, SS602:2014<br><br>LTA's Handbook on Best Environmental Practices: Noise Control at LTA Sites | In accordance with the *LTA's Handbook on Best Environmental Practices: Noise Control at LTA Sites,* continuous noise monitoring will be undertaken at noise sensitive receptors, ie at SICC Island Clubhouse during Rotary BH operations east of and at BH37.<br><br>In the event that the noise level measured at the aforementioned exceeds the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008, Contractor to temporarily stop work, notify LTA.<br><br>LTA to then engage SICC and NEA, and undertake a review of the schedule of works to avoid impacts to human receptors as well as exceedance of the construction noise limits. | Contractor<br><br>Contractor<br><br>LTA | Noise Monitoring Records attached to SHE Inspection Report<br><br>Noise monitoring records and notification of LTA of any exceedance during daily progress calls.<br><br>NEA agreement to schedule of works. | Continuously during SI works at locations identified (refer to Column K) | LAeq, T hrs (refer to relevant regulatory noise limits to determine T) | 1 m from façade of the NSR, ie at Singapore Island Country Club (Island location) clubhouse during Rotary BH operations, ie, at BH35-BH37 and boreholes east of BH37, which are within 150 m of the clubhouse. | Noise Monitoring Records<br><br>. | Noise Management Plan |
| *1.17* | Noise and Vibration | Rotary BH | Human Disturbance from Noise generated during Rotary BH operations | Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008<br><br>Code of Practice for Noise Control on Construction and Demolition Sites, SS602:2014<br><br>LTA's Handbook on Best Environmental Practices: Noise Control at LTA Sites | Should there be an exceedance of the permissible noise limits during continuous noise monitoring at noise sensitive receptors, ie the golf clubhouses, temporarily suspend works and notify the LTA. LTA to then engage SICC and NEA and undertake a review of the schedule of works to avoid impacts to human receptors as well as exceedance of the construction noise limits. | Contractor | Noise Monitoring Records attached to SHE Inspection Report | - | - | - | - | Noise Management Plan |
| *1.18* | Noise and Vibration | Prelim Investigations<br><br>Geophys<br><br>Rotary BH in golf courses | Human Disturbance from Noise generated during Rotary BH and HDC operations | SI EIA Vol III, CPT 4.5.1, CPT 4.5.2 & CPT 4.5.3 | Schedule works to avoid periods of peak usage in the Study Area, eg golf tournaments or marathons within CCNR. The schedule should be shared in advance with LTA and/or other stakeholders (NParks and SICC at a minimum) to obtain their agreement prior to commencement of works. | Contractor | Approved schedule of works | - | - | - | - | - |
| *1.19* | Noise, Vibration, Ecology and Biodiversity | Rotary BH<br>HDC | Human disturbance due to Noise from operation of Rotary BH Rigs and HDC | SI EIA Vol III, CPT 4.5.2<br><br>Environmental Protection and Management Act, 2008 | Low-noise generators and/or engines to be used at all times.<br><br>(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 5dB 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<br><br>Environmental Advisor (ERM) | SHE Inspection<br><br>Complete verification monitoring and technical note submission to LTA | -<br><br>Once during first week of SI works for each type of Rotary BH Rig and for a HDC | -<br><br>Laeq,5min | -<br><br>As per the vendor specifications for the silenced / low noise generators and/or engines | -<br><br>Technical Note to be submitted to the LTA within one week of verification monitoring. | Noise Management Plan |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.20* | Noise, Vibration, Ecology and Biodiversity | Rotary BH HDC | Human disturbance due to Noise from operation of Rotary BH Rigs | SI EIA Vol III, CPT 4.5.3 & CPT 4.5.4<br><br>Environmental Protection and Management Act, 2008<br><br>Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008 | Acoustic enclosures to be placed on noise generating equipment such as engines, generator set and water pumps throughout operation at HDC sites (unless full enclosures of HDC sites provided). For the construction of machinery enclosures, a sheet material mass of at least 10 kg/m3 shall be used. 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 performance requirements for enclosures published by NEA under its Guidelines on Quieter Construction Fund | Contractor to provide and ensure enclosures in place | SHE Inspection | - | - | - | - | Noise Management Plan |
| *1.21* | Noise, Vibration, Ecology and Biodiversity | Rotary BH | Human and Ecological Disturbance due to Noise from SPT testing and Rotary BH | SI EIA Vol III, CPT 4.5.1 & CPT 4.5.3<br><br>Environmental Protection and Management Act, 2008<br><br>Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008 | Portable acoustic screens at least 3 m high to be erected around the Rotary BH rig motors at the following worksites:<br><br>- Rotary BH worksites west of HDC 1;<br>- Rotary BH worksites east of (and inclusive of) BH35;<br>- Rotary BH worksites for BH08, BH10, BH12 to BH19;<br>- Rotary BH worksites for BH30 to BH33 and boreholes east of BH35 where there are no access restrictions and no vegetation clearing will be required for screen setup. | Contractor to provide and ensure screens in place. | SHE Inspection | - | - | - | - | Noise Management Plan |
| *1.22* | Noise, Vibration, Ecology and Biodiversity | HDC | Human and Ecological Disturbance due to Noise from HDC operations | SI EIA Vol III, CPT 4.5.4<br><br>Environmental Protection and Management Act, 2008<br><br>Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008 | Noise barriers at least 3 m high to be erected around the HDC worksites, ie between noise source and recreational users (note, if HDC fully enclosed, noise barriers may not be required). | Contractor | Site inspection | Prior to commencement of HDC works | - | HDC worksites | - | Noise Management Plan |
| *1.23* | Noise, Vibration, Ecology and Biodiversity | All Phases | Human disturbance due to Noise from vehicles used during SI works<br><br>Disturbance to wild animals and destruction of vegetation during SI works in CCNR | SI EIA Vol III, CPT 4.5.4<br><br>Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 | All vehicles used to mobilize/demobilize equipment, water/wastewater to and from worksites to be in compliance with the stipulated (*Environmental Protection and Management (Vehicular Emissions) Regulations, 2008* ) noise standards for new and in-use motor vehicles, eg 99 dB(A) and 107 dB(A) respectively for new and in-use goods vehicles with gross vehicle weight exceeding 3.5 tons. | Contractor | SHE Inspection<br>Vehicle Manufacturer's Certificate | - | - | - | - | Noise Management Plan |
| *1.24* | Noise, Vibration, Ecology and Biodiversity | Rotary BH | Human disturbance due to Noise from vehicles used during SI works within CCNR<br><br>Disturbance to wild animals during Rotary BH operations | SI EIA Vol III, CPT 4.5.4 and CPT 6 | Investigate if any other lower noise, compact vehicles are available to transport water/wastewater to and from the BH locations within CCNR and deploy if practicable (ie do not require turning circle) | Contractor | Method Statement Approval | - | - | - | - | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.25* | Noise, Vibration, Ecology and Biodiversity | Rotary BH | Human disturbance due to Noise from vehicles used during SI works within CCNR | SI EIA Vol III, CPT 4.5.5 | Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works. | Contractor | Approval of SI Works Schedule during Preliminary Investigation Phase<br><br>SHE Inspections | Daily within CCNR | - | Clock In/Out at vehicle entrance to CCNR. | SHE Inspection Report | - |
| *1.26* | Noise, Vibration, Climate and Air Quality, Ecology and Biodiversity | Rotary BH<br>HDC | Human disturbance due to Noise from vehicles used during SI works within CCNR<br><br>Dust generation from mobilization and demobilization<br><br>Disturbance to wild animals during SI works in CCNR | SI EIA Vol III, CPT 4.5.5 and CPT 6<br><br>Public Utilities (Central Water Catchment Area and Catchment Area Parks) Regulations 2003<br><br>Best Environmental Practices; Noise Control at LTA Sites, 2008<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition<br><br>Public Utilities (Reservoirs, Catchment Areas and Waterway) Regulations 2006 | All vehicles should be maintained at a constant and low speed of less than 3 km/hour at all off main road locations. | Contractor | SHE Inspection | Weekly spot checks | - | ad hoc off main road locations | SHE Inspection Report | Noise Management Plan |
| *1.27* | Ecology and Biodiversity | Rotary BH | Human disturbance due to wild animals during SI works in CCNR | SI EIA Vol III, CPT 6.5.3 | During mobilization/demobilization of rigs, secondary and tertiary vehicles along trail, a contractor to walk at a safe distance in front of rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to remain still and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br><br>Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas. | Contractor | Training records of Contractors attendance of EMMP Planning Meeting<br><br>SHE Inspection<br><br>Discussion and notification to LTA Project team during daily progress calls and SHE Toolbox talks<br><br>Notifications to NParks | Daily during mobilization/demobilization of rigs/vehicles | - | All trails utilized within CCNR | SHE Inspection Report to include comments on any wildlife encountered/reports to NParks | Biodiversity Monitoring and Management Plan |
| *1.28* | Noise and Vibration, Air Quality, Ecology and Biodiversity | Rotary BH<br>HDC | Human disturbance due to Noise from vehicles used during SI works within CCNR | SI EIA Vol III, CPT 4.5.5 | Operators of the crawler rigs and ancillary vehicles to maintain suitable driving qualification, such as a Class 4 driving license for heavy motor cars and motor tractors, the weight of which unladen exceeds 2,500 kg, in accordance with the Road Traffic (Motor Vehicles, Driving Licenses) Rules. | Contractor | Class 4 driving license | - | - | - | - | Noise Management Plan |
| *1.29* | Surface Water Quality, Ecology & Biodiversity | Rotary BH<br>HDC | Human and ecological disturbance from dust | SI EIA Vol III CPT 5.5.1<br><br>Environmental Protection and Management Act, 2008 | Strictly no stockpiling of spoil material generated during Rotary BH and HDC works. Waste material to be bagged and removed daily from each worksite location by licensed third party waste contractor. | Contractor | SHE Inspection<br>Waste Transfer Manifests | - | - | - | - | Air Pollution Control Plan<br>Waste Management Plan |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.30* | Surface Water Quality, Ecology & Biodiversity | All Phases | Effects to Water quality, Ecological and Biodiversity post SI works | Environmental Protection and Management Act, 2008 | All worksites to be reinstated following completion of SI works to same condition as found and in accordance with NParks and or SICC approval. | Contractor | NParks Permit to Work in CCNR; SICC Permit to Work in golfcourses and approval of reinstatement | - | - | - | Inclusion in detailed Rotary BH and HDC method statements | |
| *1.31* | Climate and Air Quality | Rotary BH HDC | Air Quality compliance, human and ecological disturbance from emissions to air from off road diesel vehicles | Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012.<br><br>Environmental Protection and Management (Vehicular Emissions) Regulations 2008<br><br>Schedule of the Environmental Protection and Management (Air Impurities) Regulations 2008 | In addition to ensuring all Rotary BH and HDC drilling and associated equipment complies with standard requirement of *Schedules of the Environmental Protection and Management (Vehicular Emissions) Regulations 2008 and the limits stipulated in the Schedule of the Environmental Protection and Management (Air Impurities) Regulations 2008;* all off-road diesel vehicles used in the CCNR and golf courses (ie the crawler mounted drilling rig, secondary and tertiary vehicle used to transport fresh water and wastewater to and from each worksite in the CCNR and the HDC and associate vehicles) to comply with the exhaust emission limits listed under Schedule of the *Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012* . | Contractor | Vehicle Exhaust Emissions Test Report submission | Prior to commencement of SI works | - | - | Emissions Test Report | Air Pollution Control Plan |
| *1.32* | Ecology and biodiversity | Prelim Investigations | Vegetation disturbance from drilling equipment mobilization | SI EIA Vol III CPT 2.4.2<br><br>Parks and Trees Act, 2005<br><br>Environmental Protection and Management Act, 2008 | Movement of Rotary BH rig along the CCNR trail to each worksite be completed with the A-frame mast dismantled. No damage to overhanging vegetation permitted, however should be tied back (where possible) to reduce any disturbance. Should there be overhanging obstruction which cannot be temporarily tied back, the Contractor should contact NParks to determine if an alternative approach can be taken. | Contractor | NParks' approval for clearance and monitoring during clearance works | Weekly during drilling works | disturbance/breakage of flora along access trails | Rig and vehicle access routes | Progress Reports and Minutes from daily progress calls between Contractor and LTA. | |
| *1.33* | Ecology and biodiversity | Prelim Investigations | Vegetation disturbance from drilling equipment | SI EIA Vol III CPT 2.4.2 | Rotary borehole worksites within the CCNR and in close proximity to the golf courses to be positioned on public trails only (with the exception of BH01 and BH21 which are within clearings within the forest) . Positioning of equipment and workers standing off trail during operations within CCNR is strictly prohibited. Rigs should also not to be placed where overhead plant canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees.<br><br>Rotary BH worksites on trail (except for those in clearings for BH01 and BH21) to occupy maximum footprint of 2m wide by 11 m length only. For BH01 and BH21 minimise overall footprint of worksites as far as practicable in the clearing (ie keep ancillary equipment on trail).<br><br>Environmental Advisor (ERM) to be present and verify the vehicle access routes (eg for overhanging foliage / sensitive flora and fauna etc) borehole locations within CCNR from ecological perspective during demarcation of final locations during the Preliminary Investigation Phase, prior to commencement of the works. | Contractor | SHE Inspection<br><br>Environmental Advisor (ERM) presence during demarcation of final borehole locations within CCNR | - | - | - | - | Earth Control Measures Plan |
| *1.34* | Noise | Prelim Investigations Geophysical Surveys | Human disturbance from geophysical surveys | SI EIA Vol III | Schedule the surveys at locations in close proximity to ongoing SI works, to ensure that CCNR trails closest to the survey lines are temporarily closed to public access. Temporary closure of trails should also apply to trails which transect the proposed survey line, eg Golf Link, Petaling Trail and Venus Link. | LTA | LTA and NParks Management procedure | - | - | - | - | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.35* | Stakeholder Engagement | Prelim Investigations Geophysical Surveys (reflection and refraction surveys) Rotary BH | Human and ecological disturbance from geophysical surveys and Rotary BH operations within CCNR | SI EIA Vol III | Post a notice providing details on the proposed SI activities and their duration within the CCNR, on signboards at the MacRitchie Visitor Centre and Ranger Station as well as other appropriate locations (to be confirmed with NParks) for the duration of the SI Program. | LTA | Confirmation from NParks | - | - | - | - | - |
| *1.36* | Air Quality, Noise, Water Quality, Ecology & Biodiversity | Rotary BH | Impacts from operation and sampling | SI EIA Vol III CPT 2.4.2 | Following completion of permeability testing, all groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs. | Contractor | SHE Inspection | During borehole decommissioning | - | - | SHE Inspection Report | - |
| *1.37* | Ancillary Facilities | All Phases | Waste | SI EIA Vol III CPT 2.4.4<br><br>Public Utilities (Reservoirs, Catchment Areas and Waterway) Regulations 2006 | Portable lavatories are to be positioned outside the CCNR at Kalang Service Reservoir (in agreement with PUB) and at the end of Sime Road through Bukit Golf Course (in agreement with SICC). No other areas within the CCNR are to be used for sanitation purposes. | Contractor | | | | | | |
| *1.38* | Water Quality, Ecology and Biodiversity | All Phases | Waste Management throughout SI works<br><br>Disturbance to wild plants and animals | SI EIA Vol III CPT 2.4.4<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition<br><br>Environmental Protection and Management Act, 2008 | Waste Management Plan (*Action Item No.1.01* ) to include the following:<br><br>• Bagging and daily removal of all solid waste from each worksite.<br>• Mobilization and demobilization procedures for the wastewater collection vehicle.<br>• Logging of waste generation and removal from each worksite.<br>• Strictly no use of trails or off-trail areas for sanitary purposes.<br>• Provision of sanitary facilities outside CCNR (eg portable toilets).<br>• Sanitary facility location outside CCNR (eg off Island Club Road, Sime Road or at Kalang Service Reservoir Compound), maintenance and waste removal procedures.<br>• Inspection procedures to ensure waste management implementation.<br>• Disposal protocols and documentation requirements by licensed third party contractors.<br>• Daily SHE inspection of Waste Management Plan and Feedback Management Plan. | Contractor | SHE Inspection | Daily | - | - | SHE Inspection Report | Waste Management Plan<br>Feedback Management Plan |
| *1.39* | Ecology and biodiversity | Rotary BH<br>HDC | Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas | SI EIA Vol III, CPT 6.5<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition | 30 m buffer zone each side of streams and wetland areas (wetland forest and wetland marsh), to be maintained at all times for Rotary BH and HDC drilling locations. | Contractor | SHE Inspection | Prior to commencement of SI works | - | - | - | Earth Control Management Plan |
| *1.40* | Ecology and biodiversity | Prelim Investigations Geophys | Disturbance to wild plants and animals during geophysical surveys | SI EIA Vol III, CPT 6.5.2<br><br>Environmental Protection and Management Act, 2008<br><br>Public Utilities (Reservoirs and Catchment Areas) Regulations, 2006<br><br>Wild Animals and Birds Act, 2000 | Geophysics Contractor to include details of site access locations for positioning of geophysical equipment and survey within their detailed method statement, for the Environmental Advisor (ERM) to review and NParks to verify prior to commencement of the survey works.<br><br>The same verified route to and from survey locations to be used at all times. All surveyors should walk in a single file and using the same route in and out of the survey locations. Prior approval to be sought from NParks should the off-trail route need to vary. | Contractor | Environmental Advisor (ERM) Review<br>NParks verification and approval | Prior to commencement of geophysics work | - | - | Inclusion in detailed geophysical method statement | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.41* | Ecology and biodiversity | Prelim Investigations | Disturbance to wild plants and animals during operation of drilling | SI EIA Vol III, CPT 6.5.2<br><br>Environmental Protection and Management Act, 2008<br><br>Public Utilities (Reservoirs and Catchment Areas) Regulations, 2006<br><br>Wild Animals and Birds Act, 2000 | Contractor to prepare a detailed method statement to include worksite access route details prior to Rotary BH and HDC worksite setup for the Environmental Advisor (ERM) to review and NParks/ SICC to verify. | Contractor | Environmental Advisor (ERM) Review<br>NParks and SICC verification and approval | Prior to commencement of Rotary BH and HDC worksite set-up. | - | - | Inclusion in detailed Rotary BH and HDC method statements | - |
| *1.42* | Ecology and biodiversity<br><br>Noise | Prelim Investigations<br>Geophys<br>Rotary BH<br>HDC | Disturbance to wild plants and animals during geophysics survey and operation of drilling | SI EIA Vol III, CPT 6.5.2<br><br>Environmental Protection and Management Act, 2008<br><br>Public Utilities (Reservoirs and Catchment Areas) Regulations, 2006<br>Wild Animals and Birds Act, 2000 | All Contractor personnel to attend a two hour training of the ecological sensitivities within CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail and noise minimization measures. Health and safety briefing to include NParks requirements for working within CCNR.<br><br>The training is to be provided at the Preparatory Works stage, prior to the onset of the SI works. | Environmental Advisor (ERM) | Training record of completion | Prior to commencement of SI works | - | - | Training record | - |
| *1.43* | Ecology and biodiversity | Geophys<br>M.Probes | Disturbance to wild plants and animals during equipment mobilization and demobilization for geophysical survey and M.Probes | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Trolley required for mobilization of equipment for geophysical survey and M.Probes, to use existing trails within CCNR or existing access paths of golf courses. All equipment used for geophysical survey and M.Probes to be manually carried to individual survey locations as per Project Description (*SI EIA Volume III, Chapter 2* ) | Contractor | SHE Inspection | Mobilization of geophysical and M.Probes equipment into CCNR along existing trails | - | - | SHE Inspection Report | - |
| *1.44* | Ecology and biodiversity | Geophys<br>M.Probes | Disturbance to wild plants and animals during geophysical investigations and M.Probes | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Limit generation of noise during M.Probes and geophysical survey as far as practicable (eg metal-on-metal noise emissions; limit drop weights during seismic survey). Refer to *Action Item No. 1.42* | Contractor | Refer to *Action Item No. 1.42* | - | - | - | - | - |
| *1.45* | Ecology and biodiversity | Geophys<br>M.Probes | Disturbance to wild animals in high sensitive habitat | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | All survey equipment (with the exception of geophones and cable if laid out) should be removed daily or placed at a temporary storage area authorized by NParks. If stored within the CCNR, equipment should be properly covered and secured to avoid interference or attraction of wildlife and left for no more than two nights/ three days. | Contractor | Detailed Method Statement approval by NParks<br>SHE Inspection | Prior to commencement of SI works | - | - | SHE Inspection Report<br>SI Works Method Statement | - |
| *1.46* | Ecology and biodiversity | Prelim Investigations | Disturbance to aquatic environment | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Geophysical surveys prohibited in streams/ wetland area. This applies to movement through and placement of equipment within streams and waterlogged areas too. (Geophysical survey route to be reviewed during Preparatory works; reviewed by Environmental Advisor (ERM); and approved by NParks (*Refer to Item 1.70* )) | Contractor | Environmental Advisor (ERM) to Review Method Statement<br><br>Detailed Method Statement approval by NParks<br><br>SHE Inspection | Prior to commencement of geophysical survey works | - | - | SHE Inspection Report<br>SI Works Method Statement | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.47* | Ecology and biodiversity | Prelim Investigations<br>Geophys<br>M.Probes<br>Rotary BH | Disturbance to wild plants and animals in high sensitive habitat | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Restrict the number of workers completing the SI works within the CCNR at all times to those defined within the SI EIA Project Description (*Volume III, Chapter 2* , ie<br><br>*Geophysical Surveys:*<br>- Seismic Refraction and Reflection: Up to 3 personnel<br>- Electrical Resistivity: Up to 3 personnel<br>- Gravity Survey: Up to 2 personnel<br>- Topographical Surveyors: 2 personnel<br><br>*Mackintosh Probes*<br>- Up to 3 personnel<br><br>*Rotary Boreholes(including daily transport of water/wastewater)*<br>- 5 personnel per rig for mobilization/demobilization and set up; 5 personnel for operation<br><br>*HDC*<br>- Up to 5 personnel | Contractor | Method Statement<br>NParks Permit to Work in CCNR | Throughout SI Works in CCNR | - | Geophys and Rotary BH's within CCNR | - | - |
| *1.48* | Ecology and biodiversity | All Phases | Disturbance to wild plants and animals | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Strictly no littering throughout SI works. All general waste to be bagged and disposed at dedicated public waste bins outside CCNR and the golf courses daily. Refer to *Action Item No. 1.29* for spoil waste management. | Contractor | SHE Inspection | Daily | - | All worksite areas | - | Waste Management Plan |
| *1.49* | Ecology and biodiversity | Prelim Investigations | Disturbance to wild plants and animals | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Communicate with NParks and golf courses representatives to get an agreed area for meal consumption at a fixed lunch hour and sanitary usage, permission to enter golf course facility if requested.<br><br>Restrict the workers to utilize the designated areas for meal consumption and sanitary facilities at all times.<br><br>Set up temporary container office for meal consumption/sanitary facilities outside CCNR. | Contractor | Visual inspection | Prior to commencement of SI works | - | - | - | - |
| *1.50* | Ecology and biodiversity | Geophys<br>M.Probes<br>Rotary BH<br>HDC | Disturbance to wild animals during equipment | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | Ensure all drilling equipment and geophysical survey equipment is secure at each worksite when being left overnight so as to avoid interference and potential harm to wild animals.<br><br>Equipment should also be secured on vehicles during mobilization and demobilization. | Contractor | SHE Inspection | Spot checks weekly during operations | - | - | SHE Inspection Report | Emergency Preparedness Plan |
| *1.51* | Ecology and biodiversity | Prelim Investigations<br>Rotary BH<br>M.Probes<br>Geophys | Disturbance to wild plants and animals during SI Operations in CCNR | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008<br><br>Public Utilities (Reservoirs and Catchment Areas) Regulations, 2006 | Method Statement and Emergency Preparedness Plan for Rotary Borehole, M.Probes and Geophys to include vehicle mobilization/demobilization schedule and routes as outlined in the *SI EIA Volume III, Chapter 2* . | Contractor to incorporate within Emergency Preparedness Plan<br><br>Environmental Advisor (ERM) to Review Emergency Preparedness Plan | Environmental Advisor (ERM) Review<br>NParks verification and approval | During Preliminary Investigations prior to SI works | - | - | SI Works Method Statement | Emergency Preparedness Plan |
| *1.52* | Ecology and biodiversity | Geophys<br>M.Probes<br>Rotary BH<br>HDC | Disturbance to wild animals during SI works in CCNR | SI EIA Vol III, CPT 6.5.3 | Meet with NParks prior to commencement of the surveys to agree if any additional informaiton to be included within NParks wildlife encounters plan, eg if a snake is on a branch extending into the trail, particularly for geophysical surveys off trail | Contractor | Wildlife Encounter Plan<br><br>NParks Permit to Work in CCNR | During SI works | - | - | - | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.53* | Ecology and biodiversity | Rotary BH | Disturbance to any flora species of conservation interest, as specified in Annex 9 (e.g. *Aquilaria malaccensis* seedlings) from Rotary BH works | SI EIA Vol III, CPT 6.5 | During site reconnaissance, extent of any flora species of conservation interest, as specified in Annex 9 should be verified to avoid impact.<br>For example, in the vicinity of BH28 two *Aquilaria malaccensis* trees (VU/RDB; VU/ IUCN) were observed on the left side of path (facing east) and numerous seedlings also along the left side of the path (facing east) between BH28 and BH29, as well as Dipterocarp trees in close proximity to the trail. These Rotary BH locations should be shifted slightly on the existing trail to avoid the worksite impacting the seedlings.<br><br>During mobilization and demobilization, to ensure abovementioned plant species and species listed as CR, EN or VU in the Singapore RDB will not be damaged.<br><br>Environmental Advisor to review method statement and verification by NParks and LTA | Contractor | Method Statement Review by Environmental Advisor (ERM)<br>NParks Permit to Work in CCNR | Prior to commencement of SI works particularly in vicinity of BH28 | - | All boreholes (including those outside the CCNR) but in particular Terentang Trail between BH28 and BH29 | - | - |
| *1.54* | Ecology and biodiversity | Rotary BH | Disturbance to wild plants and animals during operation of rotary borehole | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008<br><br>Public Utilities (Reservoirs and Catchment Areas) Regulations, 2006 | Restrict the number of Rotary Rigs/ associated daily support vehicle on the trail operating at any one time within CCNR as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br><br>Restrict to three rigs operating concurrently outside CCNR (with the exception of BH01-BH19, BH35 - BH37). To review schedule of where four worksites operate concurrently within the Island Golf Courses with SICC to align with course closure planning. | Contractor | NParks Permit to Work in CCNR and along nearby trails.<br><br>SICC Permit to Work in Golf Courses<br><br>LTA spot check & daily progress call | - | - | - | - | - |
| *1.55* | Ecology and Biodiversity | All Phases | Disturbance to wild plants and animals | SI EIA Vol IV, CPT 6.5.3 | Conduct daily check of work site boundaries to ensure that they are not breached and that damage does not occur to surrounding areas. | Contractor | SHE Inspection | Daily | - | All worksite areas | - | Biodiversity Monitoring and Management Plan |
| *1.56* | Ecology and Biodiversity | Geophys | Disturbance to wild plants and animals | SI EIA Vol IV, CPT 6.5.3 | All geophysical survey equipment (with the exception of geophones and cable if laid out) should be removed daily or placed at a temporary storage area authorized by NParks. | Contractor | SHE Inspection | Daily | - | All worksite areas | - | Biodiversity Monitoring and Management Plan |
| *1.57* | Stakeholder Engagement | Prelim Investigations | Human and ecological disturbance from geophysical surveys and Rotary BH operations within CCNR | SI EIA Vol III | Provide SICC management with the schedule of the proposed SI activities within the golf courses and promptly notify them of any schedule changes, to facilitate management of golfing activities in proximity to the worksites. To include geophysics schedule through Bukit Golf Course. | LTA | Confirmation from SICC | - | - | - | - | - |
| *1.58* | Water Quality, Ecology and Biodiversity, Stakeholder Engagement | Prelim Investigations<br><br>Post SI works | Damage to access route ground conditions | SI EIA Vol III, CPT 3 and CPT 6<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | During the Preliminary Investigation stage, prior to commencement of the SI works, the Contractor to survey, photograph and document the ground conditions of the mobilization/demobilization access routes. Survey to include noting where there are potential areas prone to flooding for the Contractor ET to review when scheduling the works. Environmental Advisor to advise on presence of roots in areas of BH01 and BH21.<br><br>Following completion of the SI works, prior to reopening of the trails to the public and golf courses, Contractor to cross check ground status and reinstate any damage to the trails/access routes. Equipment and material details required along with a schedule for any reinstatement works to be provided to NParks and SICC for approval prior to completing the works. A post-reinstatement survey should be completed, documented and submitted to LTA, including photographs. | Contractor<br><br>Environmental Advisor (ERM) | Ground condition survey report submission to and approval by LTA<br><br>Post SI works ground condition survey report submission to and approval by LTA | - | - | - | - | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.59* | Water Quality, Ecology and Biodiversity | Geophys<br>Rotary BH<br>M.Probes | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Disturbance to aquatic environment | SI EIA Vol III, CPT 3 and CPT 6<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | As a precautionary measure, Contractor ET to review weather forecast (http://www.nea.gov.sg/weather-climate/forecasts/24-hour-forecast) at end of each day and review schedule for mobilization/demobilization of ancillary vehicle and equipment within CCNR, around BH02 - BH07, BH09, BH11, BH35 - BH37 and in the SICC golf courses, and for completion of the geophysical surveys to avoid periods of rainfall.<br><br>Contractor staff outside CCNR to monitor NEA rainfall forecasts and to update Contractor teams on site of any forecast rainfall events. Contractor teams to be equipped with walkie talkies to allow for communication with staff outside the CCNR and to check in prior to any vehicle movements along trail.<br><br>Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report. | Contractor | Review and approval of upcoming weather forecast and works schedule during daily progress call with LTA.<br><br>Notification of Contractor field team of forecast and schedule during daily toolbox talks.<br><br>SHE Inspection Reporting | - | - | - | - | Biodiversity Monitoring and Management Plan<br><br>Water Pollution Management Plan |
| *1.60* | Water Quality, Ecology and biodiversity | Rotary BH | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Disturbance to aquatic environment | SI EIA Vol III, CPT 3.5.1<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | <u>Rainfall and Rotary Borehole Drilling Operations</u><br>Borehole drilling operations at each worksite within CCNR and at BH02 - BH07, BH09, BH11, BH35 - BH37 and in the SICC golf courses to be suspended during rainfall and all equipment to be covered with tarpaulin; FCT to be fitted with tight lid; closure of wastewater tote tank; storage of hazardous liquids/materials (eg maintenance oil, oily rags etc) within lockable enclosure to prevent generation of contaminated run-off and overflow.<br><br>Contractor ET to instruct when to commence rotary borehole drilling operations within CCNR following a rainfall event. As a minimum ET to wait until rain has fully stopped prior to instructing rig operator to remove FCT lid and tarpaulin before starting/recommence drilling.<br><br>Movement of ancillary equipment along trails between each borehole worksite location to be suspended within the CCNR.<br><br>All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. | Contractor | Visual inspection of access routes and worksites for signs of change in the ground conditions as a result of rainfall that would enable sediment runoff from worksite area | Weekly inspection | Changes to pre-work ground conditions, eg creation of surface water pools or channels as a result of the presence of the rotary drilling worksite | Access routes and rotary drilling and HDC worksites | Document within weekly SHE Inspection Report<br><br>Issues / Corrective actions to be raised during daily progress calls with LTA | - |
| *1.61* | Water Quality, Ecology and biodiversity | Rotary BH | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Disturbance to aquatic environment | SI EIA Vol III, CPT 3 and CPT 6<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | <u>Rainfall and Manual Transport of Rotary Borehole Ancillary Equipment</u><br>Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br><br>Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed halted and as instructed by the Contract ET. | Contractor | Review of schedule and rainfall during daily progress call with LTA. | *As per item 1.59* | *As per item 1.59* | *As per item 1.59* | *As per item 1.59* | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.62* | Water Quality, Ecology and biodiversity | Rotary BH | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Disturbance to aquatic environment<br><br>Unplanned Events | SI EIA Vol III, CPT 3 and CPT 6<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | <u>Rainfall and Vehicle Movement Along Trails and within SICC Golf Course</u><br>No vehicle movement permitted along trails within CCNR and through SICC Golf Courses during rain. In the event of an unforeseen rainfall event while there is ancillary vehicle moving occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, at BH02 - BH07, BH09, BH11, BH35 - BH37 and within the SICC Golf Courses.<br><br>Contractor ET to instruct when to commence vehicle movement along trails and within SICC golf course following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further vehicle movement. | Contractor | Review of schedule and rainfall during daily progress call with LTA. | *As per item 1.59* | *As per item 1.59* | *As per item 1.59* | *As per item 1.59* | - |
| *1.63* | Water Quality, Ecology and biodiversity | Geophys | Sediment loading of stormwater / increased sediment discharge to surface watercourses<br><br>Disturbance to aquatic environment | SI EIA Vol III, CPT 6<br><br>LTA Guidebook for Best Environmental Practices; Water Resource Management at LTA Sites, 2011 | <u>Rainfall and Geophysical Surveys</u><br>All geophysical surveys within CCNR to be suspended during rain. To limit amount of movement, in particular off trail, geophones and cables etc to be left in situ during rainfall, however equipment easily removed (eg the data recorder) to be placed under cover.<br><br>Contractor ET to instruct when to commence geophysical surveys following a rainfall event. As off trail areas will remain damp regardless of the period of time lapsed following rainfall, Contractor ET to review access constraints and safety issues prior to instructing recommencement of geophysical surveys following a rainfall event. | Contractor | Review of schedule and rainfall/access issues during daily progress call with LTA. | - | - | - | - | - |
| *1.64* | Water Quality, Ecology and Biodiversity | HDC | Sediment loading of stormwater / increased sediment discharge to surface watercourses and potential impact to aquatic environment | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008 | HDC site to have temporary shelter with measures to manage rainfall onto the shelter to limit ground erosion. | Contractor | SHE Inspections | Prior to commencement of SI works | - | HDC work sites | SHE Inspection Report | Earth Control Measures Plan |
| *1.65* | Ecology and biodiversity | Prelim Investigations | Disturbance to wild plants and animals during SI Operations in CCNR | SI EIA Vol III, CPT 6.5<br><br>Environmental Protection and Management Act, 2008<br><br>Public Utilities (Reservoirs and Catchment Areas) Regulations, 2006 | Using the geophysical survey results (if conducted prior the rotary borehole works) and initial findings of the EIA to:<br><br>• Refine location of un-numbered boreholes outside the CCNR and within the Study Area during the Preliminary Investigation phase of the works;<br>• Ensure final location of borehole worksites BH08, BH10, BH12 and BH35 are at sufficient distance from nearby shrubs and trees so as to avoid disturbance; and<br>• Refine the borehole works schedule, minimizing the time for each activity in-so-far as practical. | Contractor to incorporate within Emergency Preparedness Plan<br><br>Environmental Advisor (ERM) to Review Emergency Preparedness Plan | Environmental Advisor (ERM) Review<br>NParks verification and approval | During Preliminary Investigations prior to SI works | - | - | SI Works Method Statement | Emergency Preparedness Plan |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.66* | Ecology and biodiversity | Rotary BH | Disturbance to visible roots at BH21 | SI EIA Vol III, CPT 6.5 | For BH21 select location in area with least exposed roots and as far from neighbouring trees as practical. For access to this location, place tarpaulin along rig access route from trail and lay double bagged sand bags on top of tarpaulin to protect underlying roots. Drive rig over sandbags to worksite location. Rig only to be positioned within clearing while ancillary equipment to remain on the nearby trail. All equipment to be removed following completion of the borehole. For BH01 similar measures to be considered based upon condition of ground at the time of the preliminary survey. | Contractor | SHE Inspections | - | - | - | - | Biodiversity Monitoring and Management Plan |
| *1.67* | Ecology and biodiversity | Rotary BH | Leaks to ground or unplanned event | SI EIA Vol III, CPT 6.5<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition | Ensure absorbent mats available on vehicles at all times during mobilization and demobilisation for use in the event of an emergency spillage/leak | Contractor | SHE Inspections | - | - | - | - | Emergency Preparedness Plan<br>Fire Safety Plan |
| *1.68* | Ecology and biodiversity | Rotary BH | Leaks to ground or unplanned event | SI EIA Vol III, CPT 6.5<br><br>LTA General Specifications, Safety, Health and Environment (for Rail Projects) December 2014 Edition | All equipment at each borehole worksite to be enclosed within tertiary containment with impermeable surface to prevent accidental leakage to ground. | Contractor | SHE Inspections | - | - | - | - | Emergency Preparedness Plan<br>Fire Safety Plan |
| *1.69* | Ecology and biodiversity | Geophys | Disturbance to ground vegetation | SI EIA Vol III, CPT 6 | The geophysical surveys:<br>- to avoid densely vegetated areas . Vegetation clearance, cutting or breaking or damaging branches of trees, shrubs and climbers are strictly prohibited (Refer to *Item 1.70* ).<br>- Arrange all of the geophysical surveys (if conducted concurrently) to be conducted in similar location and share the same access routes as much as possible, so as to minimize potential imapcts from walking off trail as well as disturbance to wildlife.<br>- Arrange at least one of the survey team members to stay at or patrol the entry point(s) along the existing trail to ensure no visitors follow the survey routes/ lines.<br>- As far as possible choose access routes that minimize the amount of walking through off trail areas, where there is limited groundcover and where the entry point is not obvious to trail users. | Contractor<br>NParks<br>Environmental Advisor's Ecologist | SHE Inspections<br><br>Environmental Advisor (ERM) present to identify sensitive flora during surveys.<br><br>NParks' approval of Geophysical survey areas. | - | - | - | - | Biodiversity Monitoring and Management Plan |
| *1.70* | Ecology and biodiversity | Geophys | Disturbance to ground vegetation and wildlife from Geophys surveys | SI EIA Vol III, CPT 6, Annex 1.0 | NParks staff and the Environmental Advisor's Ecologist to accompany geophysical surveys to identify species of conservation concern (the ecologist's role) and approve the survey area (NParks' role) using the Accessibility Criteria detailed in the *SI EIA Volume III, Annex 1.0* . | Nparks and Environmental Advisor's Ecologist | Nparks' approval of Geophysical survey areas | All times during the Geophysical Survey | As per the Accessibility Criteria (*SI EIA Volume III, Annex 1.0* ) | - | NParks, Environmental Advisor's Ecologist to provide daily field log of approved areas to contractor.<br>Minutes from daily progress calls between contractor and LTA. | Biodiversity Monitoring and Management Plan |
| *1.71* | Ecology and biodiversity | Geophys | Reinstatement after Geophys Surveys | SI EIA Vol III, CPT 6 | After work is completed in each zone any obvious entrances to off trail areas used for the survey should be revisited and reviewed by NParks staff/ ecologist to identify/ implement any reinstatement actions such as placing logs at the entrance to avoid potential usage by other visitors/Park users. | NParks | NParks verification and approval | After completion of geophysical surveys at each zone | - | At any obvious entrances to off trail areas | | - |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 |
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| | | | | | | | | Timing and frequency of monitoring | Parameters | Location | Reporting requirements | |
| *1.72* | Ecology and biodiversity | Geophys | Disturbance to wildlife during Geophysical surveys | SI EIA Vol III, CPT 6.5 | If in use animal burrow is observed on or immediately adjacent to the survey routes then the routes should be rerouted | Ecologist<br>NParks | NParks approval & field notes | All times during the Geophysical Survey | - | - | | Biodiversity Monitoring and Management Plan |
| *1.73* | Ecology and biodiversity | Geophys | Disturbance to plants and wildlife during Geophysical surveys | SI EIA Vol III, CPT 6.5 | Align geophysical surveys to avoid the peak flowering season (April and May) as much as possible. | Contractor to incorporate within Method Statement<br><br>Environmental Advisor (ERM) to review Method Statement<br><br>NParks to approve Method Statement | Method Statement Review by Environmental Advisor (ERM)<br><br>Method Statement Approval by NParks | Prior to commencement of the Geophysical survey | - | - | | Biodiversity Monitoring and Management Plan |
| *1.74* | Ecology and biodiversity | Geophys | Disturbance to wildlife during Geophysical surveys | SI EIA Vol III, CPT 6.5 | Align geophysical surveys with nearby borehole operations (if undergoing concurrently) and within the zones as per the schedule outlined in *Volume III, Chapter 2* so as to:<br>- Ensure wildlife movement corridor connecting MacRitchie area an dother CCNR areas is maintained and available throughout the SI works duration; and<br>- Minimize the overall area of influence or cumulative disturbance to wildlife due to the geophys surveys and rotary borehole works. | Contractor to incorporate within Method Statement<br><br>Environmental Advisor (ERM) to review Method Statement<br><br>NParks to approve Method Statement | Method Statement Review by Environmental Advisor (ERM)<br><br>Method Statement Approval by NParks | Prior to commencement of the Geophysical survey | - | - | | Biodiversity Monitoring and Management Plan |
| *1.75* | Ecology and biodiversity | Rotary BH | Disturbance to wildlife during Rotary Borehole Surveys | SI EIA Vol III, CPT 6.5 | The borehole locations outside CCNR (ie along Island Club Road to Upper Thomson Road through SICC Island Golf Course) to be reviewed to avoid the isolated forest or tree cutting within the SICC Island Golf Course. | LTA | SICC verification and approval | Prior to confirmation of borehole locations; and<br>During actual positioning of drilling rig worksites | - | - | | - |
| *1.76* | Ecology and biodiversity | Geophys; Rotary BH | Disturbance to wildlife during Rotary Borehole Surveys | SI EIA Vol III, CPT 6.5 | For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations. | LTA | Review of Tender Document Specifications<br>Review of Method Statement | - | - | - | Tender Document Specifications<br>Method Statement | - |
| *1.77* | Water Quality, Ecology and Biodiversity | Rotary BH | Wastewater runoff to ground and/or surface watercourses<br><br>Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas | SI EIA Vol III, CPT 6.5 | Apply refueling procedure as follow:<br>- Tarpaulin sheets, spill kits and absorbent mats will be placed on the ground to prevent spillage of fuel into ground<br>- Inspect engine oil levels each morning and top-up as necessary<br>- Placing the transported diesel on ground with tarpaulin sheets and using hand pump (with valve to end of hose) to refuel the fuel tank on the rotary boring machine<br><br>Note, storage of fuel within CCNR strictly prohibited. | Contractor | Visual Inspection | During SI works | - | Drilling rig boring machines | SHE Inspection Record | Biodiversity Monitoring and Management Plan<br><br>Water Pollution Management Plan |

| s/n | Topic | SI Phase (All Phases; Prelim Investigations; Geophys; M.Probes, Rotary BH, or HDC) | 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 | |
| *1.78* | Water Quality | Rotary BH | Wastewater runoff to ground and/or surface watercourses<br><br>Potential pollution hazards to aquatic and wildlife communities in the stream and wetland areas<br><br>Unplanned events | SI EIA Vol III, CPT 6.5 | Emergency Preparedness Plan and Fire Safety Plan to include:<br>- Use of freshwater (rather than chemical suppressant) where appropriate and ensure compliance with the requirements of emergency authorities in Singapore (eg SCDF)<br>- All SI operational personnel should be provided with training on implementation of the Emergency Preparedness Plan and Fire Safety Plan;<br>- Vehicle mobilization/demobilization schedule and routes, including turning area (if required). Schedule to minimize the volume of vehicle movement on the trail | Contractor | Review of Emergency Preparedness Plan and Fire Safety Plan | Prior to SI Works<br><br>During occurrence of unplanned event | - | - | Training record | Emergency Preparedness Plan<br><br>Fire Safety Plan |
| *1.79* | Water Quality | Rotary BH | Unplanned events | SI EIA Vol III, CPT 6.5 | Minimize the likelihood of a fire through visual observations of generators and engines for signs of overheating, ie turn off engine if looks to be overheating | Contractor | Visual Inspection | During SI works | - | - | SHE Inspection Record | Fire Safety Plan |
| *1.80* | Water Quality, Ecology and Biodiversity | Rotary BH | Leaks to ground or unplanned event | SI EIA Vol III, CPT 6.5 | Refueling to be conducted when drilling rigs/generators are not operational. | Contractor | Visual Inspection | During SI works | - | - | | Water Pollutino Management Plan |
| *1.81* | General Management | Rotary BH, Geophys | Scheduling | SI EIA Vol III, CPT 6.5 | Ensure that the seismic refraction/reflection, electrical resistivity and gravity surveys will not be conducted concurrently, and only one type of geophysical survey will be conducted each day. | LTA | Review of Tender Document Specifications<br>Review of Method Statement | - | - | - | | Method Statement |
| *1.82* | Ecology and Biodiversity | HDC | Artificial light impact to CCNR during HDC night time operations | SIA EIA Volumen III, CPT 6.5 | To reduce artifical light effecting surroundings:<br>- Enclose the HDC worksite to reduce the artificial light intensity during the night.<br>- Ligthing design should be carefully prepared to ensure light only provided where necessary. Directional, focused lighting with dimmer switches and light absorbent surfaces should be incorporated into the design as much as possible.<br>- Lighting should be directed away from CCNR<br>- Above measures will be applied throughout installation, operation, decommissioning and maintenance activities to reduce impact of light. | Contractor | Visual Inspection | During SI works | - | - | SHE Inspection Record | Biodiversity Monitoring and Management Plan |

Annex 1.0

# Accessibility Criteria

## *ANNEX 1.0 GEOPHYSICAL SURVEY ACCESSIBILITY CRITERIA*

### *Table A-1: Accessibility Criteria for Geophysical Survey Zones*

| 1) Ground Cover | 2) Openness and Degree of Tree/ Sapling Density | 3) Thickness of Leaf Litter |
|---|---|---|
| • *No Go* for vegetation ground cover >30% or without sufficient space for one person to stand/ walk pass; and<br><br>• *No Go* if there is a risk of trampling on plant species with conservation status (under the Singapore Red Data Book) due to high density (eg no species of conservation interest within 1 m of where a person is standing).<br><br>See *Figure A.1* and *Figure A.2* for examples of high and low density ground cover. | • The access should be wide enough for minimal one person to pass through without entanglement or possibility of damage to surface plant (eg pneumatophore) roots.<br><br>• Access route should not require vegetation clearance, cutting or breaking or damaging branches of trees, shrubs and climbers.<br><br>• *No Go* for areas/ access route of high degree of tree/ sapling density – eg closed vegetation layer.<br><br>See *Figure A.3* for examples of open, semi-open and closed areas based on tree/sapling density. | • Only areas of relatively thin layer of leaf litter on ground will be considered acceptable for access.<br><br>• *No Go* for access routes where average thickness of leaf litter > 5 cm (2 inch) over extended distance (ie greater than 1m). Crossing areas of deeper leaf litter to access other areas of less thick leaf litter can be considered if other criteria are met and measures to mitigate trampling of leaf litter are taken.<br><br>See *Figure A.4* for examples of thin and thick leaf litter. |

*General Remarks:*

- Vegetation clearance, cutting or breaking or damaging branches of trees, shrubs and climbers are strictly prohibited.
- Ensure no animal burrows found within 2 m along the survey route.
- Survey works to be limited to areas of gentle slope (ie < 15% in gradient) and cannot approach streams within 5 m.

***Figure A.1 Examples of High Density Ground Cover***

***Figure A.2 Examples of Low Density Ground Cover***

***Figure A.3 Openness & Degree of Tree / Sapling Density***

***Figure A.4 Leaf Litter Thickness***

Annex 2.0

# Individual Borehole Impact Assessment

## ANNEX 2

### BH01 Regeneration Forest A (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Transportation route avoided stream/ wetland buffer zone | High | Clearance of overhead foliage to access BH01 is not expected. Vehicle noise short term and emissions are low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH01. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Tarpaulin and sandbags (double bagged for secondary containment) to be laid along access route from trail into the clearing at BH1 based on condition of ground at time of the preliminary survey. Rig to be moved over sandbags only and ancillary equipment to remain on nearby trail to limit impact to roots in the clearing. Ground protection equipment to be carefully removed following completion of the borehole.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank; | Moderate | Assume truck access to BH01 is through Sime Road.<br><br>Assume integrity of trails and bridges etc to access BH01 have been checked and are sufficient to withstand mobilization of equipment<br><br>No vegetation clearance or cutting is expected; using existing trails without any widening works<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | - Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37. | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | - Transportation route avoided stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any | Moderate | |

## ANNEX 2

### BH02-07, BH09 and BH11 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| 1 | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Transportation route avoided stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Clearance of overhead foliage to access BH02-07, BH09 and BH11 is not expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH02-07, BH09 and BH11. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| 2 | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Boreholes located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only. | Moderate | |
| 3 | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Boreholes located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR and SICC Golf Courses;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the NParks Managed Area to be suspended;<br>- Borehole drilling operations at each worksite within the NParks Managed Area to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation. | Moderate | Assume truck access to BH02-07, BH09 and BH11 is through Sime Road.<br><br>Assume integrity of trails and bridges etc to access BH02-07, BH09 and BH11 have been checked and are sufficient to withstand mobilization of equipment.<br><br>No vegetation clearance or cutting is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| 4 | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Boreholes located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak. | Moderate | |
| 5 | Demobilization | Noise and human disturbance to wildlife | High | - Transportation route avoided stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Crane, truck operation to borehole location to demobilise rig and equipment. Likely to demobilise in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR/ NParks Managed Area.<br>• Movement of rotary borehole rig along the CCNR/ NParks Managed Area trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding environment. | Moderate | |

## ANNEX 2
### BH08, BH10 and BH12 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | Medium | - Transportation route avoided stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Clearance of overhead foliage or damage of vegetation to access BH13-BH19 are not expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail or through SICC Golf Courses to BH13-BH19. | Small | Minor | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR/ NParks Managed Area;<br>- All vehicle movement along trails within CCNR/ NParks Managed Area and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite to be suspended;<br>- Borehole drilling operations at each worksite to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• No equipment washing is to be undertaken within the SICC Golf Course.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily. | Minor | Assume truck access to BH08, BH10 and BH12 is through SICC Golf Courses.<br><br>The locations are on grass on the periphery of the Golf Course fairway adjacent to the Regeneration Forest A. No plant species of conservation interest were observed at these borehole locations They are positioned as close as possible to the alignment but in areas which will avoid any damage to the existing shrubs and trees.<br><br>Limited vegetation clearance or cutting at borehole location is expected but no damage to plant species of conservation interest. |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | Medium | - Boreholes located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Placement of rig and equipment SICC Golf Course only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Minor | | Minor | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | Medium | - Boreholes located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Minor | | Minor | |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | Medium | - Boreholes located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Minor | | Minor | |
| **5** | Demobilization | Noise and human disturbance to wildlife | Medium | - Transportation route avoided stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Crane, truck operation to borehole location to demobilise rig and equipment. Likely to demobilise in 1 day and utilize SICC Golf Course only. (Same as Item No. 1) | Small | Minor | | Minor | |

## ANNEX 2
### BH13-19 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | Medium | - Transportation route avoided stream/ wetland buffer zone | - | Clearance of overhead foliage or damage of vegetation to access BH13-BH19 are not expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail or through SICC Golf Courses to BH13-BH19. | Small | Minor | General Measures to be Carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR/ NParks Managed Area;<br>- All vehicle movement along trails within CCNR/ NParks Managed Area and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite to be suspended;<br>- Borehole drilling operations at each worksite to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• No equipment washing is to be undertaken within the SICC Golf Course.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily. | Minor | Assume truck access to BH13 - BH19 is through SICC Golf Courses.<br><br>BH13 - BH19 are within the Bukit Golf Course fairway, at the edge of an area of Isolated Forest or the Regeneration Forest A. No plant species of conservation interest were observed at these borehole locations.<br><br>No vegetation clearance or cutting at borehole location is expected. |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | Medium | - Boreholes located upstream of stream/ wetland buffer zone | - | Placement of rig and equipment SICC Golf Course only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Minor | | Minor | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | Medium | - Boreholes located upstream of stream/ wetland buffer zone | - | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Minor | | Minor | |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | Medium | - Boreholes located upstream of stream/ wetland buffer zone | - | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Minor | | Minor | |
| **5** | Demobilization | Noise and human disturbance to wildlife | Medium | - Transportation route avoided stream/ wetland buffer zone | - | Crane, truck operation to borehole location to demobilise rig and equipment. Likely to demobilise in 1 day and utilize SICC Golf Course only. (Same as Item No. 1) | Small | Minor | | Minor | |

## ANNEX 2
### BH20 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Clearance of overhead foliage to access BH20 is not expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH20. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00, from Monday to Friday with demobilization from 17.00 to 18.00, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located just outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Investigate the availability and deploy, if practicable, a DeltaBase 520 drilling rig or similar for proposed boreholes BH20 and BH21 where no access constraints prevail to reduce the overall length of time for the drilling works, noise levels and disturbance to wildlife.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>• For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located just outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid. | Moderate | Located adjacent to stream/ wetland buffer zone and transportation route will pass through the stream/ wetland buffer zone<br><br>Assume truck access to BH20 is through Sime Road, entering Sime Footpath/ Track.<br><br>Assume integrity of trails and bridges etc to access BH20 have been checked and are sufficient to withstand mobilization of equipment<br><br>Limited vegetation clearance or cutting at borehole location is expected but damage to plant species of conservation interest can be avoided; using existing trails without any widening works<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilise rig and equipment. Likely to demobilise in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

## ANNEX 2
### BH21 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | High<br>Transportation route cannot avoid stream/ wetland buffer zone | High | Clearance/ potential damage of overhead foliage to access BH21 is expected.<br>Vehicle noise short term and emissions low. Minimal personnel (ie <10) involved in mobilisation of rig and equipment along public trail to BH21. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using thesite reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | -<br>Borehole located just outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <10) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Investigate the availability and deploy, if practicable, a DeltaBase 520 drilling rig or similar for proposed boreholes BH20 and BH21 where no access constraints prevail to reduce the overall length of time for the drilling works, noise levels and disturbance to wildlife.<br>• Tarpaulin and sandbags (double bagged for secondary containment) to be laid along access route from trail into the clearing at BH21. Rig to be moved over sandbags only and ancillary equipment to remain on nearby trail to limit impact to roots in the clearing. Ground protection equipment to be carefully removed following completion of the borehole.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>• For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs; | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | -<br>Borehole located just outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <5) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | | Moderate | Located adjacent to stream/ wetland buffer zone and transportation route will pass through the stream/ wetland buffer zone<br><br>Assume truck access to BH21 is through Sime Road, entering Sime Footpath/ Track.<br><br>Assume integrity of trails and bridges etc to access BH21 have been checked and are sufficient to withstand mobilisation of equipment<br><br>Limited vegetation clearance or cutting at borehole location is expected but damage to plant species of conservation interest can be avoided; using existing trails without any widening works<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | -<br>Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | High<br>Transportation route cannot avoid stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demoblize rig and equipment. Likely to demoblize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

## ANNEX 2

### BH22 (Between the edge of Primary Forest, PF and RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH22 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH22. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located just outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>• For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located just outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37. | Moderate | Located adjacent to stream/ wetland buffer zone and transportation route will pass through the stream/ wetland buffer zone<br><br>Assume truck access to BH22 is through Sime Road, entering Sime Footpath/ Track.<br><br>Assume integrity of trails and bridges etc to access BH22 have been checked and are sufficient to withstand mobilization of equipment<br><br>Limited vegetation clearance or cutting at borehole location is expected but damage to plant species of conservation interest can be avoided; using existing trails without any widening works<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demoblize rig and equipment. Likely to demoblize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage | Moderate | |

## ANNEX 2

### BH23 (Between the edge of PF and RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | High<br>Transportation route cannot avoid stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH23 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH23. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | -<br>Borehole located just outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>• For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | -<br>Borehole located just outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses. | Moderate | Located adjacent to stream/ wetland buffer zone and transportation route will pass through the stream/ wetland buffer zone.<br><br>Assume truck access to BH23 is entering through Island Club Road, Terentang Trail (width <1.5m at certain locations) and then Sime Track.<br><br>Assume integrity of trails to access BH23 have been checked and are sufficient to withstand mobilization of equipment<br><br>Limited vegetation clearance or cutting at borehole location is expected but damage to plant species of conservation interest can be avoided; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | -<br>Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | High<br>Transportation route cannot avoid stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

## ANNEX 2

### BH24 (Between the edge of PF and RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) to access BH24 will be required in areas.<br>Trail at site is 2.1m wide, therefore no trampling during mobilization.<br>Short term vehicle noise and emissions are low.<br>Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH24. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using thesite reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located just outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>• For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip traysas well as secondary containment with impermeable surface are to be provided and used at each worksite. | Moderate | Located adjacent to stream/ wetland buffer zone and transportation route will pass through the stream/ wetland buffer zone.<br><br>Assume truck access to BH24 is entering through Island Club Road, Terentang Trail (width <1.5m at certain locations) and then Sime Track.<br><br>Assume integrity of trails to access BH24 have been checked and are sufficient to withstand moblization of equipment<br><br>Vegetation clearance or cutting at borehole location is not expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located just outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | | Moderate | |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

## ANNEX 2

### BH25 (Between the edge of PF and RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH25 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in moblization of rig and equipment along public trail to BH25. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located just outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>• For work in Zone C (ie on boreholes BH20-25), to coordinate with the geophysical survey contractor to limit the area and extent of influence of activities in this zone as far as practical through co-ordination of working times and locations.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located just outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses. | Moderate | Located adjacent to stream/ wetland buffer zone and transportation route will pass through the stream/ wetland buffer zone.<br><br>Assume truck access to BH25 is entering through Island Club Road, Terentang Trail (width <1.5m at certain locations) and then Sime Track.<br><br>Assume integrity of trails to access BH25 have been checked and are sufficient to withstand moblization of equipment<br><br>Vegetation clearance or cutting at borehole location is not expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demoblization | Noise and human disturbance to wildlife | High | High Transportation route cannot avoid stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demoblize rig and equipment. Likely to demoblize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

## ANNEX 2
### BH26 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH26 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH26. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation. | Moderate | Assume truck access to BH26 is entering through Island Club Road and then Terentang Trail (width <1.5m at certain locations).<br><br>Assume integrity of trails to access BH26 have been checked and are sufficient to withstand mobilization of equipment |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET. | Moderate | Limited vegetation clearance or cutting is expected at borehole location but damage to plant species of conservation interest can be avoided; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily. | Moderate | |

## ANNEX 2
### BH27 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH27 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH27. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation. | Moderate | Assume truck access to BH27 is entering through Island Club Road and then Terentang Trail (width <1.5m at certain locations).<br><br>Assume integrity of trails to access BH27 have been checked and are sufficient to withstand mobilization of equipment.<br><br>No vegetation clearance or cutting at borehole location is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET. | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily. | Moderate | |

## ANNEX 2
## BH28 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| 1 | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH28 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH28. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works. During site reconnaissance, extent of *Aquilaria malaccensis* seedlings in proximity to BH28, and BH29 should be reviewed and boreholes shifted slightly on the existing trail along the left side of the path (facing east), to avoid impact.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>· Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>· All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>· All equipment to be covered in tarpaulin<br>· Borehole set up at each worksite within the CCNR to be suspended;<br>· Borehole drilling operations at each worksite within the CCNR to be suspended<br>· Close of wastewater tote tank;<br>· Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>· Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>· Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Ensure no plant species listed as CR or EN or VU in the Singapore RDB will be damaged, in particular *Aquilaria malaccensis* and associated seedlings (recorded between BH28 and BH29), as well as *Dipterocarp* spp. trees in close proximity to the trail.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>· used at all times during operation of rotary borehole rigs;<br>· positioned on absorbent mats or within secondary containment; and<br>· fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding environment | Moderate | Assume truck access to BH28 is entering through Island Club Road and then Terentang Trail (width <1.5m at certain locations).<br><br>Assume integrity of trails to access BH28 have been checked and are sufficient to withstand mobilization of equipment<br><br>Seedlings of plant species of conservation interest Aquilaria malaccensis (vulnerable species in Singapore Red Data Book and IUCN) recorded along the trail at these two borehole locations.<br><br>No vegetation clearance or cutting at borehole location is expected; using existing trails without any widening works<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| 2 | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | | Moderate | |
| 3 | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | | Moderate | |
| 4 | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorised equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| 5 | Demobilization | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

## ANNEX 2
### BH29 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH28 will be required in areas. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH29. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using the site reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works. During site reconnaissance, extent of *Aquilaria malaccensis* seedlings in proximity to BH28, and BH29 should be reviewed and boreholes shifted slightly on the existing trail along the left side of the path (facing east), to avoid impact.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground. | Moderate | Assume truck access to BH29 is entering through Island Club Road and then Terentang Trail (width <1.5m at certain locations).<br><br>Assume integrity of trails to access BH29 have been checked and are sufficient to withstand mobilization of equipment |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | - Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Ensure no plant species listed as CR or EN or VU in the Singapore RDB will be damaged, in particular Aquilaria malaccensis and associated seedlings (recorded between BH28 and BH29), as well as Dipterocarp spp. trees in close proximity to the trail.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET. | Moderate | Seedlings of plant species of conservation interest Aquilaria malaccensis (vulnerable species in Singapore Red Data Book and IUCN) recorded along the trail at these two borehole locations.<br><br>Limited vegetation clearance or cutting at borehole location is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily. | Moderate | |

## ANNEX 2

### BH30 (On the Bukit Kalang Service Reservoir Road (Developed Area) and at the edge of RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH30 will not be expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH30. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground. | Moderate | Assume truck access to BH30 is entering through Island Club Road.<br><br>Assume integrity of trails to access BH30 have been checked and are sufficient to withstand mobilization of equipment<br><br>No vegetation clearance or cutting is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimise spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | - Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak. | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding | Moderate | |

## ANNEX 2

### BH31 (On the Bukit Kalang Service Reservoir Road (Developed Area) and at the edge of RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH31 will not be expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH31. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground. | Moderate | Assume truck access to BH31 is entering through Island Club Road.<br><br>Assume integrity of trails to access BH31 have been checked and are sufficient to withstand mobilization of equipment<br><br>No vegetation clearance or cutting is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | - Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak. | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding | Moderate | |

## ANNEX 2

### BH32 (Within the Bukit Kalang Service Reservoir - Developed Area)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH32 will not be expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH32. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground. | Moderate | Assume truck access to BH32 is entering through Island Club Road.<br><br>Assume integrity of trails to access BH32 have been checked and are sufficient to withstand mobilization of equipment<br><br>No vegetation clearance or cutting is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | - Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak. | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding | Moderate | |

## ANNEX 2

### BH33 (On the Bukit Kalang Service Reservoir Road (Developed Area) and at the edge of RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH33 will not be expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH33. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily. | Moderate | |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground. | Moderate | Assume truck access to BH33 is entering through Island Club Road.<br><br>Assume integrity of trails to access BH33 have been checked and are sufficient to withstand mobilization of equipment<br><br>No vegetation clearance or cutting is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High<br>Borehole located at existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | - Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak. | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High<br>Mainly along existing paved road | -<br>Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding | Moderate | |

## ANNEX 2
### BH34 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| 1 | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Borehole located outside stream/ wetland buffer zone | High | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails (ie Terentang Trail) and to access BH34 will not be expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH34. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• Using thesite reconnaissance results (if conducted prior the rotary borehole works) and initial findings of the EIA to ensure final location of borehole worksite is located at flat ground without any ditches leading to stream in the close vicinity;<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Strictly no cutting of overhanging branches along public trails unless undertaken in conjunction and agreement with NParks.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA. | Moderate | |
| 2 | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | • All rigs, equipment and ancillary vehicles involved in the SI within the CCNR are to undergo maintenance checks and cleaning prior to mobilization into and upon exit of the CCNR.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks/SICC to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works.<br>General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Placement of ECBs to be restricted to trails only to ensure no disturbance of vegetation. These ECBs are to be inspected and maintained continually during rotary borehole works.<br>• Maintain worksite footprint at 2 m in width and 11 m in length on trails only.<br>• All workers prohibited from walking off trail. | Moderate | |
| 3 | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | High | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | • Restrict meal consumption and sanitary facilities to a designated area and facilities. Seek permission to enter golf course facilities if necessary.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR and the golf courses daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR and through SICC Golf Course to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite within the CCNR to be suspended;<br>- Borehole drilling operations at each worksite within the CCNR to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail and through the golf courses to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc within CCNR, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET. | Moderate | Assume truck access to BH34 is entering through Island Club Road.<br><br>Assume integrity of trails to access BH34 have been checked and are sufficient to withstand mobilization of equipment.<br><br>No vegetation clearance or cutting at borehole location is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| 4 | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | High | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| 5 | Demobilization | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | High | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | • Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• Temporary closure of public trails along mobilization and demobilization routes.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• Small, compact, low noise vehicle to be used for transport of water/wastewater/auxiliary equipment to and from each rotary borehole location within the CCNR<br>• No equipment washing is to be undertaken within the CCNR.<br>• Movement of rotary borehole rig along the CCNR trail to each worksite to be carried out with the A-frame mast dismantled.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• Equipment positioning and laydown on the public trail only, no off trail storage.<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily. | Moderate | |

## ANNEX 2
### BH35-37 (RA)

| No. | Impact Activity | Impact Source | Sensitivity of Ecological Receptor | | | Magnitude of Impact | | Impact Significance | Mitigation Measures | Residual Impact | Assumptions / Variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Terrestrial Habitats, Flora and Fauna | Aquatic Habitats, Flora and Fauna | Protected Areas | *Duration / Extent / Scale / Frequency / Likelihood* | | | | | |
| **1** | Mobilization of Rig & associated equipment | - Noise and human disturbance to wildlife<br>- Exhaust from trucks and dust emissions from vehicular movement.<br>- Movement of truck along public trail causing potential damage to vegetation | High | - Borehole located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Clearance of overhead foliage, potential damage to branches and trampling on the ground cover along the trails and to access BH35-37 will not be expected. Vehicle noise short term and emissions low. Minimal personnel (ie <5) involved in mobilization of rig and equipment along public trail to BH35-37. | Small | Moderate | General Measures to be carried out Prior to Rotary Borehole Works<br>• Operation of rotary borehole drilling rigs and SPTs to be scheduled only between 09.00 and 17.00 with demobilization from 17.00 to 18.00, from Monday to Friday, in accordance with NParks requirements.<br>• All contractor personnel to attend a two hour training of the ecological sensitivities within the CCNR and a toolbox health and safety briefing including a briefing on wildlife encounters on and off trail.<br>• Method Statements and Emergency Preparedness Plans to be prepared to include vehicle mobilization/demobilization schedule and routes. The schedule should minimize the volume of vehicle movement on the trails to that outlined in Chapter 2, and include access restrictions, driver training requirements, emergency procedures (breakdown/ spillage/ accident) and reporting procedures etc. These will be reviewed by an environmental advisor and verified by NParks prior to commencement of survey works.<br>• Waste Management Plan to include details listed in Chapter 2, Section 2.4.4.<br>• Water pollution management plan and Earth control measures plan to incorporate spill and erosion protection measures as documented through the SI EIA.<br>• Method statement to be prepared detailing worksite access route details prior to worksite setup for Environmental Advisor to review and NParks to verify.<br>• Meet with NParks prior to commencement of the surveys to agree if any additional information to be included within NParks wildlife encounters plan, particularly for rotary borehole works. | Moderate | |
| **2** | Setup of drilling equipment | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Placement of rig and equipment along trail only. Set up by hand with exception of rig positioning by crane which would be short term and of low noise/exhaust levels. Minimal personnel (ie <5) involved in setup. | Small | Moderate | General Measures applicable to all phases of Rotary Borehole Works<br>• Rigs and ancillary vehicles to move along trail at a constant and low speed of less than 5 km/hour with a contractor walking (slowed to 3 km/hr) at a safe distance in front of the rig/vehicle to spot for any wildlife (including that which may be present on vegetation which extends over the trails). If encountered, vehicles to stop movement, contractors to till and silent until such time as the wildlife has moved away from the trail. In the instance wildlife does not move from the trail/vegetation, Contractor to notify NParks and await further instruction before continuing to move vehicles.<br>• Contractors are strictly prohibited from handling/touching any wildlife encountered, including forcing movement of wildlife away from the work areas.<br>• Restrict meal consumption and sanitary facilities to a designated area and facilities.<br>• Strictly no littering throughout works. All general waste to be bagged immediately and disposed of at dedicated public waste bins outside CCNR daily.<br>• Restrict the number of workers and rigs/ associated vehicle on the trail at any one time as defined within the EIA Project Description (Chapter 2, Section 2.4.2).<br>• In the event of any rainfall<br>- Movement of ancillary equipment along trails between each borehole worksite locations to be suspended within the CCNR;<br>- All vehicle movement along trails within CCNR to be suspended. In the event a vehicle is mid-travel to a borehole worksite and rain commences, the vehicle should continue to its destination and wait until rain stops before further movement;<br>- All equipment to be covered in tarpaulin<br>- Borehole set up at each worksite to be suspended;<br>- Borehole drilling operations at each worksite to be suspended<br>- Close of wastewater tote tank;<br>- Following a rainfall event, manual transport of ancillary equipment to and from each worksite is permitted at least on hour after rainfall has completely halted; and<br>- Following rainfall, vehicles only permitted to travel along the trail after a minimum of one hour. Visual checks should be made along the trail to ensure that there is no pooling or flooding through which vehicles would need to maneuver. If pools/flooding present, vehicle movement should not recommence until the water has infiltrated into the ground.<br>- Contractor ET to instruct when to commence manual movement of equipment/ vehicle movement/ rotary borehole set up/ rotary borehole drilling operations etc, following a rainfall event. As a minimum ET to wait one hour after rain has fully stopped before instructing further operation.<br>Specific to Mobilization & Demobilization<br>• Use approved vehicle mobilization/demobilization route listed under the Method Statement.<br>• Ensure all equipment is secured on vehicles during mobilization and demobilization.<br>• Prohibit manual transport of ancillary equipment along trails between each borehole worksite locations during rainfall. In the event of an unforeseen rainfall event while there is manual equipment movement occurring along the trail, transportation should continue to the planned destination and then stop (eg stop at the worksite or access point to the trail) until further notification from the Contractor ET. Contractor ET to wait at least one hour and review of the access route to confirm no signs of flooding, prior to approving further movement along the trails within CCNR, and at BH02 - BH07, BH09, BH11, BH35 - BH37.<br>• Following rainfall event, manual transport of ancillary equipment to and from each worksite permitted at least one hour after rainfall has completed/halted and as instructed by the Contractor ET.<br>• Absorbent mats and spill kits available at all times on vehicles during mobilization. Ensure absorbent mats available on vehicles at all times during mobilization and demobilization for use in the event of an emergency spillage/leak.<br>• Any small amounts of hazardous fluids 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.<br>• Plan logistics and resources to limit the number of trips required for haulage of water/wastewater to as low as possible (max 2 trips a day), during drilling works.<br>• No mobilization/ demobilization at night, dawn or dusk<br>• No equipment washing is to be undertaken within CCNR.<br>Specific to Borehole Equipment Set-up<br>• Rigs not to be placed where overhead vegetation canopy is too low or closed, or immediately adjacent to fruiting trees/mature trees<br>• A 30 m buffer zone to be maintained at all times for rotary borehole drilling locations.<br>General Measures to be carried out during Borehole Works<br>• As a precaution, Contractor Environment Team to review weather forecast at end of each day and review schedule for mobilization/demobilization of rig, ancillary vehicle and equipment within CCNR to avoid periods of rainfall.<br>• Contractor ET to share upcoming daily works schedule, including weather forecast projection and schedule, during daily progress call with LTA project team; daily toolbox talk with onsite contractors; and document within weekly SHE Inspection report<br>• Contractor to ensure storage of small volume of hazardous liquids/materials (eg maintenance oil, oily rags etc) at each worksite within lockable container and provision of drip trays or secondary containment with impermeable surface as required to prevent leakage to ground.<br>• Conduct daily check of worksite boundaries to ensure that damage does not occur to surrounding areas.<br>• No water extraction from streams/ ground water.<br>• Cover all equipment and rig with tarpaulin or similar impermeable covering materials after work daily.<br>• The FCT is to be<br>- used at all times during operation of rotary borehole rigs;<br>- positioned on absorbent mats or within secondary containment; and<br>- fitted with a tight lid.<br>• Wastewater from the FCT to be pumped to an enclosed 1,000 liter tote tank and removed offsite by a small vehicle approved by NParks/LTA to a licensed third party waste management facility. The pump hose connecting the FCT to the wastewater tote tank is to be secured to avoid any spillage from loose hoses.<br>• Stockpiles of excavated spoil prohibited. Spoil to be immediately bagged and removed to area outside CCNR daily.<br>• Spill kits such as absorbent pads and drip trays as well as secondary containment with impermeable surface are to be provided and used at each worksite.<br>• All drilling equipment, storage box, spill kits to be secured at all times (even when left overnight) to prevent access from wildlife.<br>• All equipment at the worksite to be enclosed with tertiary containment with impermeable surface to prevent accidental leakage to surrounding environment.<br>• Apply refueling procedure as follow:<br>- Inspect engine oil levels each morning and top-up as necessary.<br>- Placing the transported diesel on ground with tarpaulin sheets and using hand pump (with valve to end of hose) to refuel the fuel tank on the rotary boring machine.<br>• All rigs and vehicles (including ancillary vehicle mobilizing water/wastewater to and from each worksite) in intermittent use to be shut down or throttled down to a minimum in the intervening periods between works to prevent engine overheating.<br>General Measures to be carried out after Borehole Works<br>• Following completion of permeability testing, all groundwater piezometers to be decommissioned by infilling with grout to avoid remobilization of drilling rigs<br>• All worksites are to be reinstated following completion of SI works to same condition as found. | Moderate | Assume truck access to BH35-37 is entering through Island Club Road.<br><br>Assume integrity of trails to access BH35-37 have been checked and are sufficient to withstand mobilization of equipment.<br><br>No vegetation clearance or cutting at borehole location is expected; using existing trails without any widening works.<br><br>Equipment positioning and laydown on the public trail only. No off trail storage. |
| **3** | Rig Operation & Sampling | Runoff to nearby vegetated areas potentially leading to water courses if uncontrolled<br><br>Noise and exhaust from rig and equipment operation<br><br>Human disturbance to wildlife from worker presence within CCNR | High | - Borehole located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Rig operation during 2-3 weeks (worst-case scenario); introduction of new noise/exhaust source to the environment; minimal personnel (ie <4) involved in operation; runoff from worksite area during rainfall event; slurry tank / fluid recirculation operation. | Small | Moderate | | Moderate | |
| **4** | Reinstatement (Waste Management and Reinstatement) | Noise and human disturbance to wildlife<br>Concrete/Grout mixing on site causing potential pollution | High | - Borehole located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | No motorized equipment so noise generation likely low. Mixing grout on site by hand but within secondary containment to minimize spillage beyond borehole location (water for grout transported by hand to borehole location). Immediate coverage of borehole following backfill. Minimal personnel (ie <5) involved in reinstatement. | Small | Moderate | | Moderate | |
| **5** | Demobilization | Noise and human disturbance to wildlife | High | - Borehole located outside stream/ wetland buffer zone | Located outside CCNR or NParks Managed Area but at habitat extended from CCNR | Crane, truck operation to borehole location to demobilize rig and equipment. Likely to demobilize in 1 day and utilize public trail only. (Same as Item No. 1) | Small | Moderate | | Moderate | |

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