Prepared by SUEZ Recycling & Recovery Australia

Lucas Heights Resource Recovery Park Project

Response to Submissions and Preferred Project Report

SUEZ Recycling & Recovery

PART 3 - Appendix D

June 2016

Appendix D

Response to OEH comments – attachments

SITA Australia Pty Ltd

Lucas Heights Resource Recovery Park Project

Biodiversity Assessment Report

May 2016

Executive summary

SITA Australia (SITA) is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights. The following activities are proposed at the LHRRP:

- Reprofiling of the landfill
- Relocation and expansion of the existing Garden Organics (GO) facility
- Construction and operation of a fully enclosed advanced resource recovery technology (ARRT) facility

This report has been prepared by GHD Pty Ltd to identify the potential impacts of the proposal on biodiversity values using the Framework for Biodiversity Assessment (FBA) (OEH 2014) as an input to the environmental impact statement. This included:

- Desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the proposal.
- Field survey to describe the biodiversity values of the proposal footprint and surrounding study area and determine the likelihood of threatened biota and their habitats occurring in the proposal footprint or being affected by the proposal.
- FBA calculations using the credit calculator v.4 to quantify the biodiversity impacts of the proposal and to determine the biodiversity credits that would be required to offset these impacts.

The majority of the proposal footprint is located within the existing landfill, which has been cleared and substantially modified. The proposed ARRT and GO facility have been positioned within vegetated land of which much had been previously cleared but is now regenerating. The proposal's impacts are therefore substantially less than would be associated with an undisturbed 'green field' site. The proposal has been purposefully designed to avoid or further reduce impacts on biodiversity values as far as is practicable. The GO facility would be constructed as soon as possible following project approval. The construction of the ARRT facility would not be immediate,as it would be dependent upon SITA securing a guaranteed, long term waste supply to ensure that the substantial upfront investment is able to be recouped.

The proposal would remove a total of 9.25 hectares of native vegetation. Of this, 4.84 hectares would be removed for the construction of the GO facility, while 4.41 hectares would be removed at a later date for the construction of the ARRT facility. Impacts associated within the landfill (4.06 ha of vegetation on top of waste) have not been considered in the biobanking credit calculations as these impacts relate to the current approval (1999 EIS and associated Consent R97/00029).

No threatened ecological communities would be directly impacted. The proposal may have a minor indirect impact on a nearby Coastal Upland Swamp, however this is unlikely to change the species composition of the community or reduce its extent given it is located about 50 m from the proposal site. The stand of Shale Sandstone Transition Forest located to the north of the existing landfill is unlikely to be impacted by the proposal given its distance from the proposal footprint and lack of any clearing in this area.

A total of 67 ramets of *Allocasuarina diminuta* subsp. *mimica* (that form part of an endangered population listed under the TSC Act would be removed from the proposal footprint.

The proposal would remove a very small proportion of available habitat resources for local populations of native fauna. Impacts would include the removal of:

- Up to 9.25 ha of potential foraging habitat for mobile threatened fauna species, including the Grey-headed Flying-fox, birds and microbats
- Up to 9.25 ha of potential foraging, shelter and nest or den sites for the Eastern Pygmy-possum and the Spotted-tailed Quoll
- Up to five hollow-bearing trees and two rock outcrops
- One artificial dam and a section of Mill Creek. Mill Creek would be realigned to allow continued flow.

The proposal would not affect any threatened biota listed under the *Fisheries Management Act 1994*.

A FBA assessment and credit calculations have been performed in accordance with the methodology (OEH 2014a) and using credit calculator Version 4.0. The FBA includes thresholds for assessing and offsetting impacts of development (see table 4 of OEH, 2014a). As noted above, the proposal would be constructed in two stages. As such, credit calculations have been undertaken for the initial work (construction of the GO facility) and for the later construction of the ARRT facility. This means that credits to offset the impacts on the endangered population of *Allocasuarina diminuta* subsp. *mimica* can be sourced at a later date as no ramets would be impacted by the construction of the GO facility. Impacts associated with the landfill have not been considered in the biobanking credit calculations as these impacts relate to the current approval. A summary of credits required and areas not required to be offset is provided in

Table 1 Summary of credits required for the project

Location	Area of native vegetation to be removed (ha)	Credits required
Landfill	100.9	None. SITA has current approval to construct and operate a landfill. Removal of regenerating vegetation and cleared land has not been included in this assessment.
GO facility	4.84	185 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014). 97 species credits for the Eastern Pygmy-possum. 1.25 ha of impacts for which the assessor is not required to determine an offset, comprising the removal of exotic grassland and cleared land.
ARRT facility	4.41	143 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014). 88 species credits for the Eastern Pygmy-possum. 5154 species credits for Allocasuarina diminuta subsp. mimica. 0.46 ha of impacts for which the assessor is not required to determine an offset, comprising the removal of exotic grassland and cleared land.

The Biodiversity Offset Strategy for the proposal would include the purchase and retirement of biodiversity credits as calculated in accordance with the FBA. In order to offset construction of the GO facility, credits would be purchased from the open market. This would enable construction of the GO facility to commence as soon as possible following project approval. Given the difficulty of securing credits for the *Allocasuarina diminuta* subsp. *mimica*, the construction of the ARRT facility would be delayed until these credits can be sourced. Where possible, credits for the ARRT facility would be sourced from within the Sutherland Shire.

To address potential impacts of the proposal on biodiversity, a series of mitigation and management measures have been identified, which would be implemented as part of the construction environmental management plan for the site. These include measures relating to:

- General management – including inductions and dust suppression measures
- Flora species – including collection of seeds / propagules / ramets of *Allocasuarina diminuta* subsp. *mimica* and the translocation of plants by the Menai Wildflower Group. SITA has long association with the Menai Wildflower Group who operates a native seedling nursery at the LHRRP. The Menai Wildflower Group has been in operation for 28 years and has been providing approximately 10,000 to 15,000 seedlings per year to schools, national parks and other community groups to propagate plants. The native seedling nursery was originally established to produce native plants for the rehabilitation of the New Illawarra Road landfill and is fully equipped with a glass house that has heated propagation beds plus an igloo and shade house with automated watering systems
- Vegetation clearing – including limiting disturbance of vegetation, vehicle washing, fencing, appropriate stockpiling during construction and sediment fences
- Weeds – including weed management actions/planning, weed propagule spread control measures and sediment control
- Fauna habitat – including hygiene protocol implementation, presence of an ecologist during clearing, staged vegetation clearining, removal of hollow-bearing trees and other habitat features, inspections and so forth
- Water quality and aquatic habitats – including erosion and sediment control measures, plans and suface stabilisation, dust control, spill kits and protocols, removal of large woody debris from the realigned creek and construction of new section of Mill Creek.

During operation there would be a minimal increase in existing impacts on native biodiversity values. Therefore, few additional mitigation measures are proposed, but these include:

- Ongoing management of noxious weeds according to legislative requirements.
- Ongoing suppression of dust within the landfill and ARRT and GO facilities.
- Ongoing water quality management.

This report addresses the Secretary’s Environmental Assessment Requirements and concludes that the proposal would meet the following objectives:

- No significant impacts on the natural environment and threatened biota
- Avoid or further reduce impacts on biodiversity values as far as is practicable
- Minimise the occurance of pests, vermin and noxious weeds

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Glossary

Term	Definition
ANSTO	Australian Nuclear Science and Technology Organisation.
BioBanking Assessment Methodology (BBAM)	The rules of BioBanking established under the TSC Act that determine credits created, credits required and the circumstances that improve or maintain biodiversity values.
BioBanking	The biodiversity banking and offsets scheme established under Part 7A of the TSC Act.
Biodiversity credit report	Specifies the number and type of biodiversity credits: required to offset the impacts of a development to obtain a Biobanking statement; or required to offset the impacts of a Major Project in accordance with the FBA; or that would be generated through conservation and management of a biobank site under a BioBanking agreement.
Biodiversity credit	A unit of biodiversity value to measure specific development impacts or conservation gains in accordance with the FBA or the BBAM. Includes ecosystem credits or species credits.
Biodiversity offsets	Specific measures that are put in place to compensate for impacts on biodiversity values.
Biodiversity values	The composition, structure and function of ecosystems including threatened species, populations and ecological communities, and their habitats.
Local Government Area	A spatial unit representing the geographic area that is under the responsibility of an incorporated Local Government Council
Ecosystem credit	A credit that relates to a vegetation type and the threatened species that are reliably predicted by that vegetation type (as a habitat surrogate).
DotE	Department of the Environment (previously Department of Sustainability, Environment, Water, Population and Communities - DEWHA)
DPI	Department of Primary Industries
EPBC Act	EPBC Act Environment Protection and Biodiversity Conservation Act 1999
EP&A Act	NSW *Environmental Planning and Assessment Act 1979.* The Act pertains to the core legislation relating to planning and development activities in NSW
FBA	The Framework for Biodiversity Assessment. The methodology to assess impacts on biodiversity that must be used by a proponent to assess all biodiversity values on the development site for a Major Project in accordance with The NSW Biodiversity Offsets Policy for Major Projects.
FM Act	*Fisheries Management Act 1994.* This Act provides the framework for the protection of fishery resources within NSW.
LHRRP	Lucas Heights Resource Recovery Park. Includes land owned by SITA and land owned by ANSTO.
Locality	The area within a 10 km radius of the proposal site.
Major project	Major projects include State Significant Development (SSD) and State Significant Infrastructure (SSI)
NW Act	The *Noxious Weeds Act 1993. This Act* provides for the declaration of noxious weeds by the Minister for Primary Industries.
OEH	Office of Environment and Heritage (previously Department of Environment and Climate Change – DECC).
PCT	Plant Community Type. A classification of vegetation types which is designed to be the NSW standard for community-level vegetation

Term	Definition
	mapping.
SEARs	Secretary's Environmental Assessment Requirements. These requirements set out the matters to be addressed in the EIS. This may include biodiversity impacts not considered by the FBA.
SICTA	Sydney International Clay Target Association. Located within the LHRRP.
SITA	SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.
Species credit	A credit that relates to an individual threatened species that cannot be reliably predicted based on habitat surrogates. Threatened species that require species credits are identified in the Threatened Species Profile Database.
SSC	Sutherland Shire Council.
SSD	State Significant Development
SSI	State Significant Infrastructure
Study area	The area that was subject to a site survey and assessed for indirect impacts arising from construction and operation of the proposal.
TSC Act	Threatened Species Conservation Act 1995. This Act provides the statutory framework for biota of conservation significance in NSW.

1. Introduction

1.1 Purpose of this report

SITA Australia (SITA)[1] is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights (referred to in this report as 'the proposal'). This report has been prepared by GHD Pty Ltd on behalf of SITA to provide an assessment of biodiversity associated with the proposal as an input to the environmental impact statement. Due to the existing operational arrangements at LHRRP, Sutherland Shire Council (SSC) is a joint applicant for the proposal. The environmental impact statement is being prepared by GHD in accordance with the requirements of Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (the EP&A Act).

The report addresses the requirements of the Secretary of the NSW Department of Planning and Environment (the Secretary's Environmental Assessment Requirements (SEARs No SSD-6835) dated 3 February 2015.

In addition to addressing the SEARs requirements, this report provides an assessment of how well the proposal meets SITA's objectives of having no significant impacts on the community or environment. Environmental management and mitigation measures related to biodiversity are proposed (where necessary) to mitigate potential impacts and ensure that they are managed in accordance with statutory requirements, regulations and community expectations.

1.2 Objectives

The following objectives have been identified:

- No significant impacts on the natural environment and threatened biota
- Avoid or further reduce impacts on biodiversity values as far as is practicable
- Minimise the occurance of pests, vermin and noxious weeds.

1.3 Proposal overview

The LHRRP consists of approximately 205 hectares (ha) in two ownerships: 89 ha,owned by SITA and 116 ha owned by Australian Nuclear Science and Technology Organisation (ANSTO) and leased to SITA for waste management or other agreed purposes. The following activities are proposed at the LHRRP and are collectively referred to as 'the proposal'. In addition to the proposal detailed below, SITA is committed to better environmental outcomes by the application of best practice prevention, mitigation and rectification measures:

- **Reprofiling of existing landfill areas to provide up to 8.3 million cubic metres of additional landfill airspace capacity.** This is equivalent to approximately 8.3 million tonnes of waste, assuming 1 tonne of waste utilises 1 cubic metre of waste disposal airspace. As the process of reprofiling would include removal and replacement of capping material over previously landfilled waste and augmentation of gas and leachate collection systems, the environmental performance of the site would be ultimately improved by reducing the infiltration of stormwater into the landfill (resulting in reduced landfill leachate in the longer term) and increase the overall amount of landfill gas recovered from the site.

[1] SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.

As part of the proposal, SITA is seeking permission to increase the approved quantity of waste landfilled at the site from 575,000 to 850,000 tonnes per year. This would enable the reprofiling of the site to be completed in 2037.

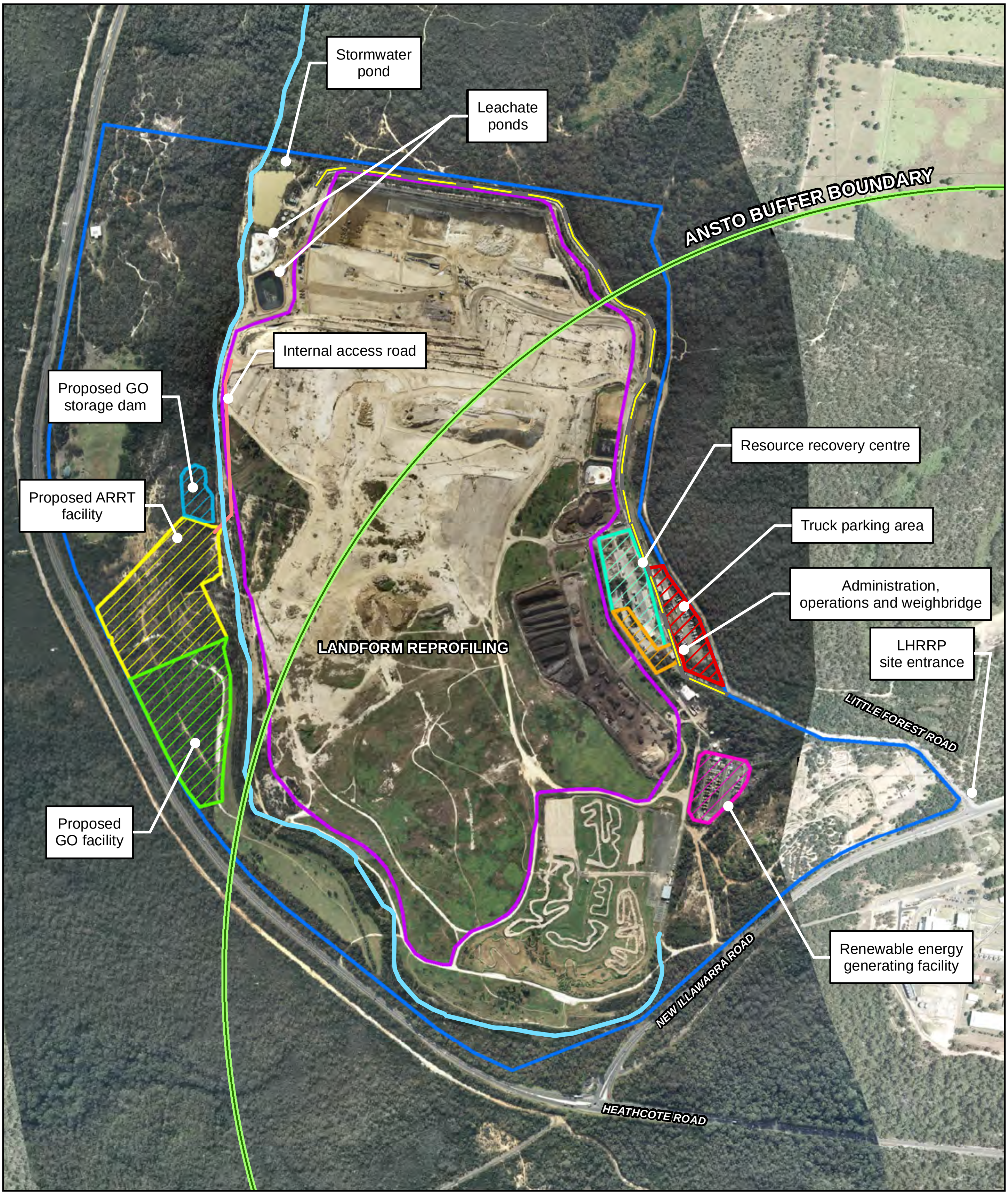
- **Relocation and expansion of the existing garden organics (GO) facility**. The existing garden organics facility would be relocated to the western side of the site adjacent to Heathcote Road. Approval is being sought to increase the approved capacity from 55,000 to 80,000 tonnes of green waste and garden waste received per year at the facility. The new facility would include the partial enclosure, active aeration and covering of the first four weeks of the active composting process, which coincides with the period of highest potential for odour generation, to enable more effective control of odour. Relocation of the facility would result in increased separation distances from the current nearest occupied land at ANSTO, existing residential areas and the proposed new residential area at West Menai. It is proposed that this facility would be constructed immediately following approval.
- **Construction and operation of a fully enclosed advanced resource recovery technology (ARRT) facility**. The ARRT would be located on the western side of the site adjacent to the GO facility and would process and recover valuable resources from up to 200,000 tonnes of general solid waste per year, reducing the amount of waste disposed to landfill to approximately 60,000 tonnes per year. This would divert up to 140,000 tonnes of waste per year from landfill. SSC and other councils would have the opportunity to have their municipal waste processed by the ARRT facility. Establishment of the ARRT facility would be dependent upon SITA securing a guaranteed, long-term waste supply to ensure that the substantial upfront investment is able to be recouped.
- **Community parkland**. The landfill reprofiling would increase the area available for future passive recreation following site closure from 124 ha (existing approved parkland) to 149 ha, an increase of approximately 25 ha. Landfilling would cease in 2037 after which time the site would be rehabilitated and converted to community parkland, with capping and landscaping to be completed and the site made available for community use in 2039.

As part of the proposal, SITA has committed to entering into an agreement with SCC in the form of a Voluntary Planning Agreement which includes ‘environmental undertakings’. In addition operational environmental management plans have been prepared for the landfill, GO facility, ARRT facility and post closure measures to manage potential environmental impacts, reflect regulatory requirements and provide guidance for site operators to undertake activities in an environmentally sound manner.

A Planning Proposal is being submitted in parallel with this State Significant Development Application. The Planning Proposal seeks to include new local provisions on the LHRRP site within the Sutherland Local Environmental Plan 2015 (SLEP), which would allow the proposal (a waste or resource management facility) to be undertaken on the proposal site.

The expansion of the LHRRP, which is outlined in this EIS, would permit the proposed future use of the land for recreational purposes, which is currently approved and would occur when the existing facility ceases operation in 2025. The proposal would however extend the timeframe for which the land would be unavailable for recreational purposes until 2037, due to the extension of operations at the proposed LHRRP.

These key components of the proposal are shown on Figure 1-1. The proposed final landform and preliminary masterplan for the parkland is shown in Figure 1-2.



LEGEND

- ANSTO buffer boundary
- Mill Creek
- Internal access road
- Existing access road
- Proposed GO facility
- Proposed ARRT facility
- Resource Recovery Centre
- Administration, operations and weighbridge
- Renewable energy generating facility
- Lucas Heights Resource Recovery Park boundary
- Landform reprofiling boundary
- Truck parking area

Paper Size A4
0 100 200 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

SITA Australia
Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision A
Date 28 May 2015

Key existing infrastructure and proposed facility layout

Figure 1.1

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z046_KeyProposedInfrastructure.mxd 15/133 Castlereagh Street Sydney NSW 2000 Australia T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

Aerial Imagery: ESRI, 2014. Works: GHD/SITA, 2014. Roads: NSW LPMA, 2012. Created by:jrichardson

Paper Size A4

NOT TO SCALE

SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	24 June 2015

Proposed parkland master plan

Figure 1.2

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z058_Parkland_Master.mxd

Data source: Taylor Brammer Landscape Architects Pty Ltd. Created by:jrichardson

1.4 Definitions

The following terms are used within this report when referring to the proposal site and surrounding areas:

- The 'LHRRP' refers to the entire Lucas Heights Resource Recovery Park. The boundary of the LHRRP is shown as the blue line on Figure 1.3
- The 'proposal site' refers to the areas where the activities described in Section 1.2 would be located. The boundary of the proposal site is shown as the red line on Figure 1.3

1.5 Location of the proposal

1.5.1 Existing

The proposal would be located within the boundary of the existing LHRRP. The LHRRP is located within the Sutherland local government area, approximately 30 kilometres (km) south west of the Sydney city centre. The site is bound to the west by Heathcote Road and by New Illawarra Road to the south.

Specifically, the proposal would be located on:

- Lot 101 DP 1009354
- Lot 3 DP 1032102
- Lot 2 DP 605077

It is noted that the proposal directly affects only a portion of each of these lots. There is minimal encroachment into the SICTA leased land (part of Lot 3 DP 1032102).

The proposal site, within the boundary of the LHRRP, is shown on Figure 1.3.

The site is currently accessed from Little Forest Road, off New Illawarra Road.

Current facilities at the LHRRP include:

- Landfill
- Resource recovery centre and waste collection point
- GO facility for processing garden organics
- Renewable energy production (operated by Energy Developments Ltd)
- Truck parking area
- Community use areas (mini bike area at the southern extent of the site run by the Sutherland Police Citizens Youth Club and the Sydney International Clay Target Association (SICTA) leased land on the north western side of the site)

There are also several ancillary buildings and structures (e.g. weighbridge, machinery workshop, administration offices, stormwater and leachate dams).

The following land uses are located in the immediate vicinity of the LHRRP:

- Bushland areas that form part of ANSTO's exclusion zone (to the east and south)
- ANSTO's facilities (to the east on the opposite side of New Illawarra Road)

Land uses in the surrounding area include:

- Holsworthy Military Reserve (to the west, northwest and southwest)

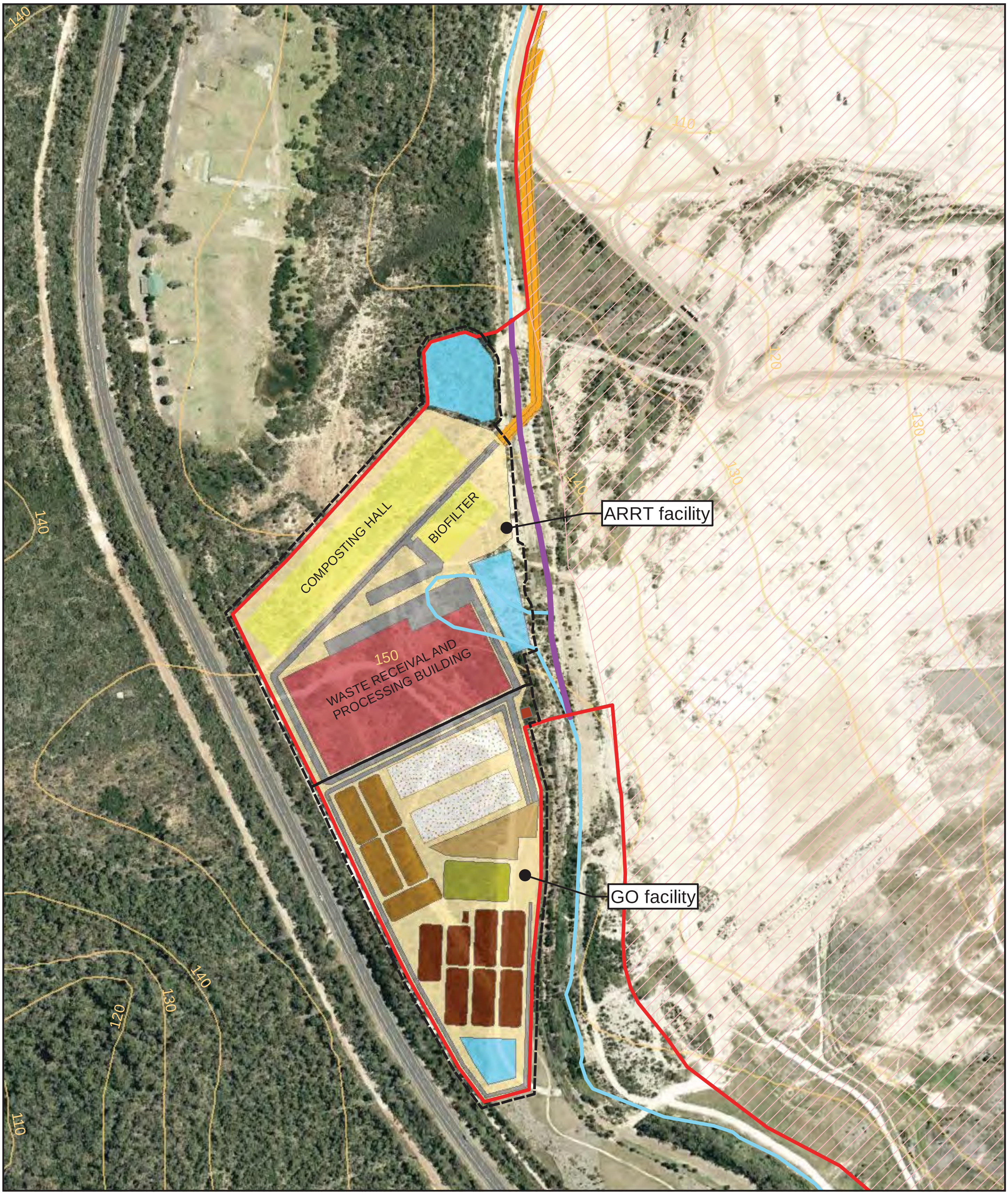
- The Ridge Sports Complex, a major regional sporting facility being developed on the site of the former Lucas Heights Waste and Recycling Centre (approximately 2.5 km to the north east)
- Lucas Heights Conservation Area (immediately to the north of the LHRRP)
- The suburbs of North Engadine (approximately 2 km to the east) and Barden Ridge (approximately 3 km to the north east)

Figure 1.4 shows these key areas.

1.5.2 Potential future surrounding land uses

The Gandangara Local Aboriginal Land Council (GALC) is proposing a development in the West Menai area. The West Menai State Significant Site contains 849 ha of mostly undeveloped land, covering parts of Menai, Barden Ridge and Lucas Heights.

The western boundary of the proposed development is Heathcote Road and the site extends east across Mill Creek to the edge of the existing Menai residential area close to New Illawarra Road. The location of the proposed West Menai State Significant Site is shown on Figure 1.4.



LEGEND

- Project footprint
- Landform reprofiling
- Mill Creek master alignment
- Internal access road
- Mill Creek

Paper Size A4
0 20 40 80 120 160
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

SITA Australia
Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision A
Date 04 May 2016

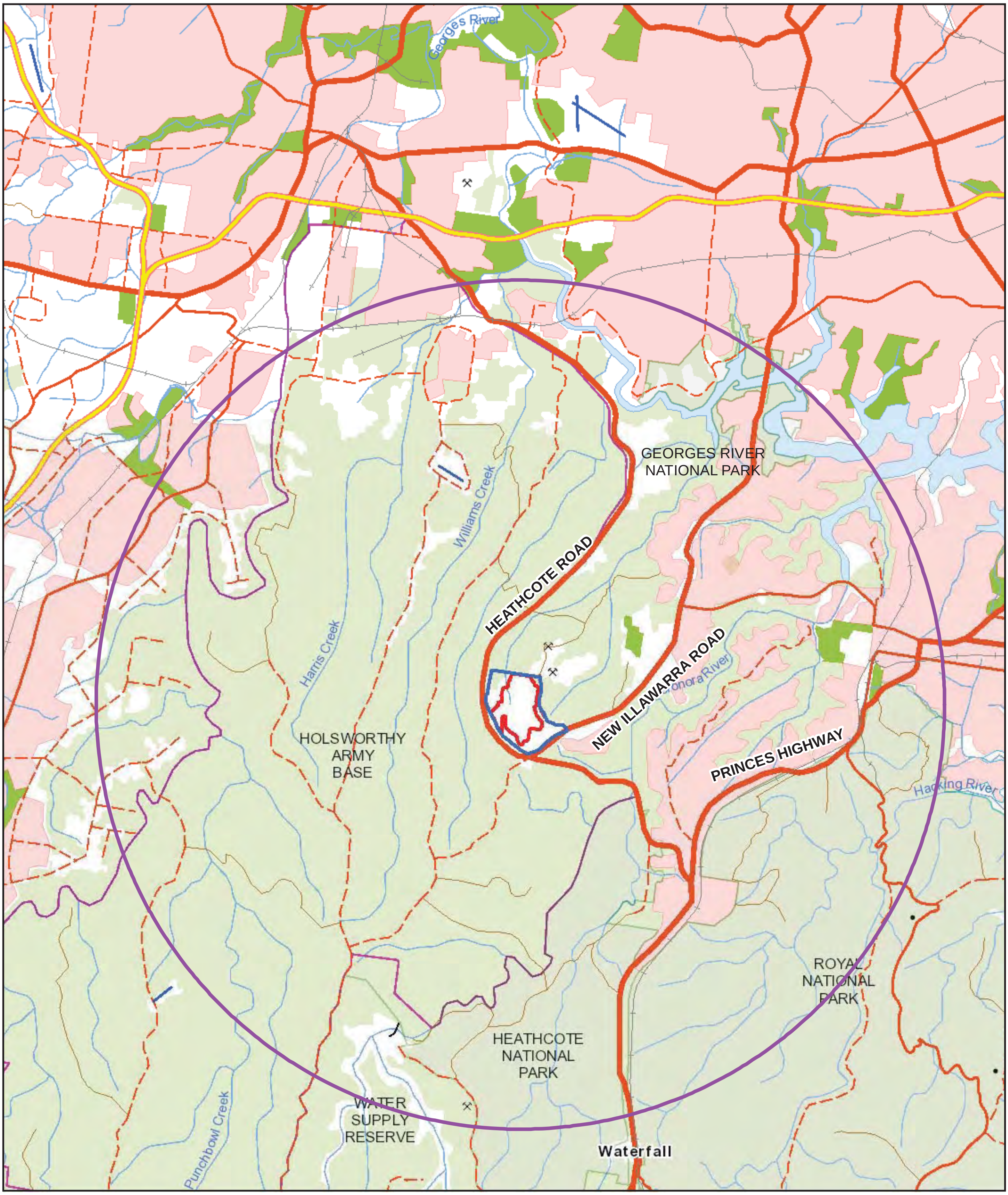
The proposal site

Figure 1-3

G:\21\23482\GIS\Maps\MXD\21-23482-Z043_Proposal.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by:apmiller



LEGEND

- Lucas Heights Resource Recovery Park boundary
- Project footprint
- 10Km locality boundary

Paper Size A4

0 0.5 1 2 3 4

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	04 May 2016

Surrounding land uses

Figure 1-4

G:\21\23482\GIS\Maps\MXD\21-23482-Z040_SiteLocationECOLOGY.mxd

15/133 Castlereagh Street Sydney NSW 2000 Australia T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

Aerial Imagery: Google, 2014. LHRRP Boundary: GHD, 2014. Roads/Suburbs: NSW LPMA 2012. Location Data: GEOSCIENCE AU 2014. Created by:apmiller

1.6 Secretary's Environmental Assessment Requirements and agency requirements

The specific SEARs and agency requirements addressed in this report are summarised in Table 1-1.

Table 1-1 Secretary's Environmental Assessment Requirements and agency requirements

Assessment requirements	Where addressed in report
Accurate estimates of any vegetation clearing associated with the project;	The methodology for identifying and mapping native vegetation is provided in section 3.3. Vegetation clearing calculations are provided in section 5.2.1.
A detailed assessment of the potential impacts of the project on any threatened species, populations, endangered ecological communities, groundwater dependent ecosystems or their habitats; and	Assessment of impacts on biodiversity values are provided in sections 5 and 7.
Where impacts cannot be avoided, detailed description of the measures that would be implemented to maintain or improve biodiversity values of the surrounding region in the medium to long term, including proposed biodiversity offset measures and details of the provisoin and protection of land for conservation purposes.	Mitigation measures are provided in section 6.3. Offset requirements have been calculated according to the Framework for Biodiversity Assessment (FBA) in section 7. A draft biodiversity offset strategy is provided in section 8.
Accurate estimates of any vegetation clearing associated with the project;	The methodology for identifying and mapping native vegetation is provided in section 3.3. Vegetation clearing calculations are provided in section 5.2.1.
Agency requirements	
Biodiversity impacts related to the proposed project are to be assessed and documented in accordance with the Framework for Biodiversity Assessment by a person accredited in accordance with s142B(1)(c) of the Threatened Species Conservation Act 1995.	This Biodviersity Assessment Report has been prepared in accordance with the Framework for Biodiversity Assessment (FBA). FBA calculations are detailed in section 7. Accreditation details of relevant staff are provided in Table 3-4.
Impacts on the following species, populations and ecological communities will require further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment: **Threatened ecological communities:** Shale Sandstone Transition Forest **Endangered Populations:** *Allocasuarina diminuta* subsp. *mimica* L.A.S.Johnson population in the Sutherland and Liverpool local government areas. *Prostanthera saxicola* population in Sutherland and Liverpool local government areas.	Further consideration of these threatened biota is provided with respect to the requirements of s9.2 of the FBA in section 7.6.3.
Biodiversity impacts related to the proposed project are to be assessed and documented in accordance with the Framework for Biodiversity Assessment by a person accredited in accordance with s142B(1)(c) of the Threatened Species Conservation Act 1995.	This Biodviersity Assessment Report has been prepared in accordance with the Framework for Biodiversity Assessment (FBA). FBA calculations are detailed in section 7. Accreditation details of relevant staff are provided in Table 3-4.

1.7 Scope and structure of the report

1.7.1 Scope of report

This Biodiversity Assessment Report has been prepared to describe the impacts of the proposal on biodiversity values using the FBA (OEH, 2014a).

The main components of the methodology for the biodiversity assessment were:

- Desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the proposal.
- Field survey to describe the biodiversity values of the proposal footprint and surrounding study area and determine the likelihood of threatened biota and their habitats occurring in the proposal footprint or being affected by the proposal.
- FBA calculations using the credit calculator v.2.1 to quantify the biodiversity impacts of the proposal and to determine the biodiversity credits that would be required to offset these impacts.

The biodiversity assessment and biodiversity credit calculations were performed by Kirsten Crosby in accordance with the FBA (Accredited Assessor number 160) and reviewed by Ben Harrington (Accredited Assessor number 0073).

Definitions

For the purposes of this assessment, the following definitions are employed:

Proposal footprint – this is the area to be directly affected by the proposed works as described above. In this case it encompasses the area proposed for the ARRT and GO facilities, the access road, realignment of Mill Creek and the reprofiling of the landfill.

Study area – the proposal footprint and adjacent areas that may be indirectly impacted by the proposal. This includes vegetation within 100 metres of the proposal boundary.

Locality – 10 kilometre radius of the proposal footprint.

IBRA subregion – the proposal is located within the Sydney Cataract subregion of the Sydney Basin bioregion, according to the Interim Biogeographical Regionalisation for Australia (IBRA) version 7 (Thackway and Cresswell 1995; DotE 2015).

1.7.2 Structure of report

This report includes:

- Legislative context (Chapter 2)
- Description of the method of assessment, site survey, FBA calculations, staff qualifications and assumptions and exclusions (Chapter 3)
- A review of the existing environment including site survey results and conservation significance (Chapter 4)
- As assessment of biodiversity impacts (Chapter 5)
- Proposed mitigation and management measures (Chapter 6)
- FBA calculations (Chapter 7)
- Draft biodiversity offset strategy (Chapter 8)
- Conclusions (Chapter 9)

- References (Chapter 10).

2. Legislative context

2.1 State legislation

2.1.1 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is the core legislation relating to planning and development activities in NSW. It is the principal law overseeing the assessment and determination of development proposals. All development in NSW is assessed in accordance with the provisions of the EP&A Act.

Part 4 of the EP&A Act

Part 4 of the EP&A Act provides for the control of development that requires development consent from a consent authority. Depending on the circumstances of the proposal, the consent authority may be the local Council or the Minister.

Part 4, Division 4.1 of the EP&A Act establishes an approval regime for development that is declared to be State significant development by either a State Environmental Planning Policy (SEPP) or Ministerial Order. In accordance with Section 89E of the EP&A Act, the Minister is the consent authority for State significant development (SSD). Pursuant to sub-section 78A(8A) of the EP&A Act, an environmental impact statement (EIS) is required to support a development application for SSD.

The NSW biodiversity offsets policy for major projects (the policy) applies to state significant development and state significant infrastructure. The policy is underpinned by the Framework for Biodiversity Assessment (FBA) which commenced in October 2014. It provides the methodology for assessing impacts and determining biodiversity offsets for major projects. The FBA is a modified form of the BioBanking methodology and includes increased flexibility in delivery of biodiversity offsets for Major Projects.

Under the policy, the SEARs for the proposal require SITA to apply the FBA to assess impacts on biodiversity values. The FBA has also been applied to the proposal to identify reasonable measures and strategies that can be taken to avoid and minimise impacts on biodiversity. This Biodiversity Assessment Report describes the biodiversity values present on the development site (the proposal footprint) and the impact of the proposal on these values. A draft Biodiversity Offset Strategy has also been prepared to outline how SITA proposes to offset the impacts of the proposal.

Approval process

SSD to which Division 4.1 of the EP&A Act applies is identified in the *State Environmental Planning Policy (State and Regional Development) 2011* (State and Regional Development SEPP) and in declarations made by the Minister. The proposal is considered to be SSD as it is of a type listed in Schedule 1 of the State and Regional Development SEPP.

The Minister is therefore the consent authority for the proposal and a development application is required to be lodged with the NSW Department of Planning and Environment, accompanied by an EIS. The EIS would be placed on public exhibition for a period of at least 30 days to allow public and agency submissions to be lodged, after which the proponent may be requested to respond to issues raised in the submissions.

2.1.2 Threatened Species Conservation Act 1995

The TSC Act provides the statutory framework for biota of conservation significance in NSW. The TSC Act aims to, inter alia, 'conserve biological diversity and promote ecologically sustainable project'. It provides for:

- The listing of threatened species, populations and ecological communities, with endangered species, populations and communities listed under Schedule 1, critically endangered species and communities listed under Schedule 1A, vulnerable species and communities listed under Schedule 2.
- The listing of Key Threatening Processes (under Schedule 3 of the TSC Act.)
- The preparation and implementation of Recovery Plans and Threat Abatement Plans.

The TSC Act has been addressed in the current assessment through:

- Desktop review to determine the threatened species, populations or ecological communities (threatened biota) listed under the TSC Act that have been previously recorded within the locality of the site and consequently could occur subject to the habitats present.
- Targeted field surveys for threatened biota.
- Identification of suitable impact mitigation and environmental management measures for threatened biota, where required.
- Assessment of potential impacts on threatened biota.
- Identification of offset requirements.

2.1.3 Fisheries Management Act 1994

The objects of the *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. It provides for:

- The listing of threatened species, populations and ecological communities, with endangered species, populations and communities listed under Schedule 4, critically endangered species and communities listed under Schedule 4A, vulnerable species and communities listed under Schedule 5.
- The listing of Key Threatening Processes (under Schedule 6).
- Diseases affecting fish and marine vegetation (under Schedule 6B).
- Noxious fish and noxious marine vegetation (under Schedule 6C).
- The preparation and implementation of Recovery Plans and Threat Abatement Plans.

The FM Act has been addressed in the current assessment through undertaking:

- A desktop review to determine the threatened species, populations or ecological communities that have been previously recorded within the locality of the site and consequently could occur subject to the habitats present.
- Assessment of aquatic habitats during terrestrial field surveys.
- Assessment of impacts on aquatic habitats and threatened aquatic biota.

2.1.4 Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* (NW Act), provides for the declaration of noxious weeds by the Minister for Primary Industries. Noxious weeds may be considered noxious on a National, State, Regional or Local scale. All private landowners, occupiers, public authorities and Councils are required to control noxious weeds on their land under Part 3 Division 1 of the NW Act. Noxious weeds have been identified in the study area (see Section 4.2.2). SITA currently manages weeds as per the controls in their existing Environmental Management Plan (EMP). If required, the EMP would be updated to include the control of any new noxious weeds identified during field surveys.

2.2 Commonwealth legislation

The purpose of the Commonwealth EPBC Act is to ensure that actions likely to cause a significant impact on matters of national environmental significance undergo an assessment and approval process. Under the EPBC Act, an action includes a project, undertaking, project or activity. An action that ‘has, will have or is likely to have a significant impact on a matter of national environmental significance’ is deemed to be a ‘controlled action’ and may not be undertaken without prior approval from the Commonwealth Minister for the Environment (the Minister).

The EPBC Act identifies matters of national environmental significance (MNES) as:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (Ramsar wetlands).
- Threatened species and ecological communities.
- Migratory species.
- Commonwealth marine areas.
- Nuclear actions (including uranium mining).
- A water resource, in relation to coal seam gas development and large coal mining development.

A referral for the proposal has been submitted to the Department of Environment (DotE).

3. Methodology

3.1 Approach

This Biodiversity Assessment Report has been prepared to describe the impacts of the proposal on biodiversity values using the FBA (OEH, 2014a).

The main components of the methodology for the biodiversity assessment were:

- Desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the proposal.
- Field survey to describe the biodiversity values of the proposal footprint and surrounding study area and determine the likelihood of threatened biota and their habitats occurring in the proposal footprint or being affected by the proposal.
- FBA calculations using the credit calculator v.2.1 to quantify the biodiversity impacts of the proposal and to determine the biodiversity credits that would be required to offset these impacts.

The biodiversity assessment and biodiversity credit calculations were performed by Kirsten Crosby in accordance with the FBA (Accredited Assessor number 160) and reviewed by Ben Harrington (Accredited Assessor number 0073).

3.2 Desktop assessment

3.2.1 Literature and database review

A desktop database review was undertaken to identify threatened flora and fauna species, populations and ecological communities (biota) listed under the TSC Act and FM Act, and MNES listed under the EPBC Act, that could be expected to occur in the locality, based on previous records, known distribution ranges, and habitats present Biodiversity resources pertaining to the proposal footprint and locality (i.e. within a 10 km radius of the site) that were reviewed prior to conducting field investigations included:

- The Commonwealth Department of the Environment (DotE) Protected Matters Search Tool (PMST), for MNES (threatened and migratory biota) known or predicted to occur in the locality (DotE, 2014a).
- DotE online species profiles and threats database (DotE, 2014b).
- OEH Wildlife Atlas database (licensed) for records of threatened species, populations and endangered ecological communities listed under the TSC Act that have been recorded within the locality of the proposal (OEH, 2014a).
- OEH threatened biota profiles for descriptions of the distribution and habitat requirements of threatened biota (OEH, 2014b). This resource was used to identify the suite of threatened ecological communities (TECs) that could potentially be affected by the proposal and to inform habitat assessments.
- The NSW vegetation types database (OEH, 2014c) to identify plant community types (PCTs) known or likely to occur in the study area as required by the FBA.
- Regional-scale vegetation mapping of the study area (Tozer *et. al.*, 2010).
- Mapping and descriptions of the NSW Mitchell landscapes (DECC 2008a, 2008b).

- DPI online protected species viewer for records of threatened aquatic species in the locality (DPI, 2014a).
- The NSW Department of Primary Industries (DPI) 'Threatened Fish and Marine Vegetation – Find a Species by Geographic Region' online search tool for Hawkesbury/Nepean (CMA) (DPI, 2014b).
- The list of species credit-type species identified by the FBA Credit Calculator based on the initial credit calculations.
- Aerial photographs and satellite imagery of the study area.

The threatened and migratory species identified in the desktop assessment are presented in Appendix B. Following collation of database records and threatened species and community profiles, a 'likelihood of occurrence' assessment was prepared for threatened and migratory species and ecological communities with reference to the broad vegetation types and habitats contained within the study area. This was further refined following field surveys and verification of vegetation types and identification and assessment of habitat present within the study area, or the species was found to occur in the proposal footprint. A likelihood of occurrence ranking was attributed to these biota based on this information (see Appendix B).

3.3 Site survey

3.3.1 Survey effort

A number of surveys have been conducted by GHD within the study area over recent years. These have included detailed surveys on land to the east of the landfill (GHD 2011), an ecological constraints assessment of the proposal footprint in November 2012, and detailed surveys for this proposal in December 2014 and January and March 2015.

Staged surveys of the development site were conducted with reference to the FBA and appropriate targeted survey guidelines were carried out in December 2014 and January and March 2015. Site surveys included:

- BioBanking plot/transect surveys.
- Vegetation mapping.
- Identification of flora species.
- Identification of potential habitat for threatened flora species.
- Fauna habitat assessment.
- Targeted frog surveys.
- Spotlighting, call playback and anabat surveys.
- Remote camera surveys.
- Opportunistic fauna surveys.
- Identification of potential habitat for threatened fauna species.

Survey effort that has directly contributed to this biodiversity assessment is summarised in Table 3-1 and is described below.

Table 3-1 Survey effort

Stage	Date	Survey Techniques
Previous surveys to the east of the landfill (eastern side of the study area) (GHD 2011)	June and November 2010	Vegetation mapping, quadrat surveys, targeted threatened flora searches, Koala spot assessments, diurnal bird surveys, mammal trapping (Elliot, cage and harp traps), spotlighting, call playback, anabat.
Constraints assessment within the area proposed for the ARRT and GO facilities (GHD 2012)	November 2012	Vegetation mapping, targeted threatened flora searches
Targeted threatened fauna surveys, opportunistic fauna surveys within the proposal footprint.	8, 9, 11, 15 December 2014	Three nights of Anabat recording; four nights of spotlighting and call playback; opportunistic fauna observations; fauna habitat assessment.
BioBanking plot/transect surveys, vegetation mapping, identification of flora species, fauna habitat assessment, opportunistic fauna surveys, aquatic habitat assessment within the proposal footprint.	22 January 2015	Vegetation survey and seven plot/transects. General fauna habitat assessment, diurnal bird surveys, Koala spot assessments, hollow-bearing tree searches. Aquatic habitat assessment and water quality.
Targeted flora searches, opportunistic fauna surveys within the proposal footprint, SICTA land and along Heathcote Road.	2 March 2015	One day targeted flora searches, opportunistic fauna surveys.

3.3.2 Previous surveys

Surveys to the east of the landfill

Detailed surveys were conducted to the east of the landfill to determine suitablility for the ARRT facility. Surveys included a preliminary three day survey in June 2010 followed by a detailed five day survey in November 2010. Flora surveys included vegetation mapping, 20x20m quadrats, and targeted threatened flora searches. Fauna surveys included diurnal bird surveys, mammal trapping, including harp nets, Elliot traps targeting Eastern Pygmy-possums (*Cercartetus nanus*), cage traps targeting Rosenberg's Goanna (*Varanus rosenbergi*), anabats, spotlighting, and call playback (GHD 2011). Development at this location was determined to be highly constrained due to the presence of two threatened ecological communities (Shale-Sandstone Transition Forest and Coastal Upland Swamp), and a large stand of *Eucalyptus camfieldii*, a threatened species listed under the TSC Act.

Constraints assessment for the current proposal

A constraints assessment was conducted by one ecologist for one day in the proposal footprint in November 2012. The focus of this survey was to identify vegetation types and determine if any threatened ecological communities were present in the area identified for the ARRT and GO facilities (current proposed location near Heathcote Road). Surveys for threatened flora species and potential habitat for threatened flora species were carried out. This survey focussed in particular on searches for *Acacia bynoeana, Eucalyptus camfieldii* and *Melaleuca deanei*, which are known to occur within or in close proximity to the proposal footprint. Searches for other threatened flora species that could potentially occur were also conducted.

3.3.3 Current surveys

Site stratification

Pre-existing vegetation mapping (eg Tozer 2010, NPWS 2002) and vegetation mapping from the constraints assessment (GHD 2012) were ground-truthed in the field via systematic walked transects across the entire proposal footprint and by walking the boundary of vegetation units. Necessary adjustments were made by hand on aerial photographs of the study area. The site was divided into relatively homogenous or discrete zones for assessment based on observed vegetation structure, species composition, soil type, landscape position and condition. Plot/transect and quadrat data was compared with Tozer (2010) diagnostic plant species lists to help confirm the presence of native vegetation and the identity of PCTs (OEH, 2014c). Native vegetation was divided into vegetation zones which represented a distinct PCT and broad condition state. Two native PCTs and two vegetation zones were identified in the proposal footprint as shown on Figure 4-1.

The remainder of the proposal footprint contains non-native vegetation that was divided into separate units based on observed structure and species composition.

Coastal Upland Swamp vegetation to the north of the proposed ARRT facility was also sampled as this vegetation type may be subject to indirect impacts.

Plot/transect surveys

Plot and transect surveys were conducted on site in accordance with the FBA to confirm vegetation types, assess site condition and where required to calculate biodiversity credits. The site value was determined by assessing ten site condition attributes against benchmark values. Benchmarks are quantitative measures of the range of variability in condition in vegetation with relatively little evidence of alteration, disturbance or modification by humans since European settlement. Cover abundance data was also collected for each species within the 20 metre x 20 metre portion of each plot/transect.

Plots were used to sample potential vegetation zones (i.e. PCTs and broad condition classes) based on the initial site stratification. Six plots were sampled within the proposal footprint and one outside the proposal footprint as shown on Figure 3-1. Plot/transects are shown on Figure 3-1 and summarised in Table 4-3.

Plot data was compared with Tozer (2010) diagnostic plant species lists using a modified version of a spreadsheet that has been provided to GHD by OEH in order to assign each vegetation type to the appropriate PCT.

Additional vegetation surveys

Additional vegetation survey effort was used to supplement the plot/transect surveys and help describe the vegetation of the study area. Area searches within both native vegetation and exotic grassland were conducted in the proposal footprint to compile a more exhaustive species list for proposal footprint.

Targeted threatened flora surveys

Threatened plant surveys were conducted throughout the proposal footprint during surveys in November 2012, January 2015 and March 2015. The suite of threatened plants potentially present was identified based on the desktop assessment results (see Appendix B) and the species credit-type species identified by preliminary FBA Credit Calculations (see Table 4-1). Habitat for these species was identified based on OEH threatened species profiles and the experience and judgement of GHD ecologists. The majority of the proposal footprint contains highly modified landforms such as embankments or cuttings that are dominated by exotic or planted native species. These areas feature very little native plant cover, do not contain natural soil profiles or soil seed banks and could be readily discounted as containing any threatened plant species. Areas of potential threatened plant habitat (i.e. near-intact native vegetation and areas with natural topsoil) were systematically traversed on foot and inspected for threatened plants.

The March 2015 surveys specifically targeted the endangered population of *Allocasuarina diminuta* subsp. *mimica* which had been recorded during the earlier survey. Surveys were carried out via a random meander within areas of potential habitat, mainly disturbed edges and open heathy woodland. Surveys also included searches for *Genoplesium baueri* and other orchids that flower in early autumn. This targeted survey was conducted within woodland and heath located in the proposal footprint, the SICTA land to the north of the proposed ARRT facility, and woodland within the road reserve of Heathcote Road adjacent to the proposal footprint.

Identification of groundwater dependent ecosystems

The NSW Groundwater Dependent Ecosystem (GDE) Policy defines GDEs as ecosystems, which have their species composition, and their natural ecological processes determined by groundwater (DLWC 2002). The Policy defines groundwater as the water beneath the earth's surface that has filtered down to the zone where the earth or rocks are fully saturated (DLWC 2002). Ecosystems vary dramatically in the degree of dependency of groundwater, from having no apparent dependence through to being entirely dependent on it (DLWC 2002). With the exception of the Great Artesian Basin's mound springs, the level of scientific understanding of the role that groundwater plays in maintaining ecosystems in Australia is generally low (DLWC 2002). Currently the approach for assessment of terrestrial groundwater dependent ecosystems is not well documented or understood.

The Australian Government Atlas of Groundwater Dependent Ecosystems was used to identify any previously mapped GDEs that occur in or near the study area. This atlas identifies GDEs reliant on surface groundwater (rivers, springs and wetlands) and subsurface groundwater (vegeation). The Atlas was reviewed to ascertain whether any GDEs are likely to occur in the study area.

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems – The Conceptual Framework* (Serov et. al., 2012) has recently been developed by the NSW Office of Water (NOW) and the OEH. This presents an approach to GDE identification, classification, ecological valuation, and ecological risk assessment for a given activity or potential impact on a groundwater source. This also details a series of steps to identify and infer the level of groundwater dependency and provides a summary of risk assessment guidelines for GDEs. This risk assessment has assigned probabilities of vegetation types in the Sydney Metro CMA being a GDE (Kuginis et al 2012).

Fauna habitat assesssment

The site survey methodology included relatively limited targeted fauna survey techniques (e.g. no trapping) because of the limited extent and quality of fauna habitat in the study area and because the FBA assesses the majority of threatened fauna species that could occur based on habitat surrogates.

An assessment was made of the type and quality of habitats present in the study area for native fauna. Habitat quality was based on the level of breeding, nesting, feeding and roosting resources available. The study area was searched for habitat features of particular relevance to threatened species, such as hollow-bearing trees, specific feed trees, termite mounds (breeding habitat for Rosenberg's Goanna), rock outcrops (potential den sites for the Spotted-tailed Quoll), and water bodies. Areas of planted trees that may provide habitat for fauna were inspected.

Habitat assessments included searches for and inspection of:

- rocks, logs, peeling bark and leaf litter for small reptiles
- winter-flowering eucalypts (important for the Swift Parrot (*Lathamus discolor*), and Grey-headed Flying-fox (*Pteropus poliocephalus*)) and feed trees of the Koala (*Phascolarctos cinereus*) and Glossy Black-cockatoo (*Calyptorhynchus lathami*)
- hollow-bearing trees and logs which provide refuge, nest and den sites for a range of threatened fauna species
- stags and other roost sites for raptors and owls
- termite mounds comprising potential habitat for Rosenberg's Goanna (*Varanus rosenbergi*)
- wetlands, moist grassland and other foraging habitat for waterbirds (including migratory birds) and frogs
- mammal scats at the base of trees or along tracks and runways
- tracks in soft substrate
- nest/den sites within logs, tree bases or tree trunks
- guano or moth remains at the base of hollow-bearing trees (diagnostic of the presence of tree-roosting bats)
- scratches on tree trunks (diagnostic of Koalas, gliders or goannas) and worn bark around tree hollows (diagnostic of active use of hollows)
- owl pellets, whitewash or animal remains beneath trees (diagnostic of owl or raptor roosts).

Searches for hollow-bearing trees were undertaken throughout the fauna habitat assessment and opportunistic fauna surveys. Positions of hollow-bearing trees were logged on a hand-held GPS, and details of tree species, height, diameter, and number, position and size of hollows recorded on a proforma.

Koala spot assessments

Koala spot assessments were carried out at four locations within the proposal footprint within patches of intact native vegetation. Spot assessments comprised searches for Koala scats at the base of up to 30 trees, centred on a secondary or supplemtentary feed tree identified within DECC (2008). In some areas, trees were very scattered or restricted in distribution, meaning that fewer than 30 trees were searched.

Targeted frog surveys

Giant Burrowing Frog surveys were completed following the Commonwealth Department of the Environment (DotE) survey guidelines for the species. These guidelines recommend targeted surveys for a minimum of four nights of survey within a week of >50mm of rain over seven days in warm weather (spring-autumn). Weather details for the survey period and the preceeding week is provided in Table 3-2.

Targeted surveys consisted of:

- nocturnal streamside searches along Mill Creek within the study area for signs and presence of this species
- nocturnal searches (walked and driven) along access tracks in the study area. No surveys were conducted along Heathcote Road or New Illawarra Road as these are very busy arterial roads
- call playback through a megaphone to illicit an audible response. A GPS was used to record the locations where call playback techniques were conducted
- visual searches for tadpoles.

Targeted Green and Golden Bell Frog and Red-crowned Toadlet surveys were conducted simultaneously with the nocturnal streamside searches and call playback surveys for the Giant Burrowing Frog described above.

Anabat surveys

Microbat ultrasonic echolocation call recordings (Anabat surveys) were undertaken at two locations in the study area on the nights of 8, 9 and 15 December 2014. Anabat detectors were placed in a flyway between native vegetation running parallel to Heathcote Road and also adjacent to the dam in the southern portion of the study area. The anabats were deployed about one hour before sunset and collected the following morning. Calls were identified using zero-crossing analysis and AnalookW software (version 3.8v, Chris Corben 2012). *The Bat calls of NSW: Region based guide to the echolocation calls of microchiropteran bats* (Pennay et al. 2004) was used to assist call analysis. Call identification was also assisted by consulting distribution information for possible species (Pennay et al 2011; Churchill 2008; van Dyck and Strahan 2008) and records from the Atlas of NSW Wildlife (OEH 2013a).

Spotlighting

Spotlighting for nocturnal fauna, including in particular the Eastern Pygmy Possum and Giant Burrowing Frog, was also carried out on all four nights of frog surveys. Spotlighting was conducted within the riparian vegetation of the creekline, around dams and drainage lines, and along tracks and in disturbed areas of native vegetation. Some areas of vegetation were very dense and spotlighting was not possible in these areas.

Remote cameras

Two infrared cameras were placed in the study area for a period of one week between 8th and 15th December 2014. One infra red camera was placed in a flyway between native vegetation running parallel to Heathcote Road, the other camera was placed in a patch of open vegetation adjacent to the boundary fence separating the gun club from the SITA land. A second camera was then set from 15th December 2014 to 22 January 2015. Cameras were set to take three pictures over one minute when triggered by movement, with at least five minutes between each set of photographs. Cameras were baited with chicken wings, targeting Spotted-tailed Quolls (*Dasyurus maculatus*) and Rosenberg's Goanna.

Opportunistic fauna surveys

Opportunistic and incidental observations of fauna species were recorded at all times during field surveys. Casual fauna observations were made in suitable areas of habitat throughout the course of the survey and while incidentally traversing the development site. This included visual inspection of trees and woody debris, active searches for small fauna and opportunistic observation of scats, tracks, burrows or other traces. Skeletal remains of mammals were identified by their dental and cranial anatomy and with reference to Triggs (1996).

Aquatic habitat assessment

Habitat descriptions were documented with reference to the NSW Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual (Turak *et al*, 2004), and included assessment of different instream habitat types, and the structure and condition of riparian vegetation. The information recorded was used to describe the nature of aquatic habitats present within the study area, and identify any areas of potential habitat for threatened aquatic fauna species.

Descriptions of aquatic habitat were based on visual estimates of characteristics such as streambed composition (percentage of total composition for each substrate category), aquatic and riparian vegetation cover, amount of in stream organic material, and area of aquatic habitat and canopy cover. Estimates of channel morphology characteristics were made including width (wetted width in metres), bank full width (mean width between top of banks), and estimated depth. Photographs of each site were taken as a further record of physical conditions observed at the time of assessment.

Given the lack of natural waterways within the study area, no fish trapping or electrofishing surveys were carried out. The condition of the waterway and potential habitat suitability for threatened fish were assessed during field surveys.

Macroinvertebrate sampling and identification

An aquatic ecology assessment was prepared to assess the curret state of Mill Creek within and downstream of the LHRRP (GHD 2015d). A copy of the report prepared as part of this assessment is contained in Appendix E. The principal aims of this survey were to assess the condition of aquatic and riparian habitat and the aquatic macroinvertebrate community within Mill Creek. Field sampling of marcoinvertebrates was undertaken at five monitoring locations (Figure 3-1) using Rapid Bioassessment (RBA) protocols in accordance with the NSW AUSRIVAS Sampling and Processing Manual (Turak et al., 2004). One monitoring location was located within the study area for this project and four sites were located downstream of the study area, in order to assess the potential impacts the existing LHRRP may be having on Mill Creek (GHD 2015d).

RBA sampling methods are described in detail in GHD (2015d). In summary, these involved sampling about 10 metres of the stream edge at each site using a sweep net. Macroinvertebrates collected were sorted in the field into taxonomic groups and preserved in 70% ethanol before being transported to the laboratory. Macroinvertebrates contained within the samples were examined in the laboratory using a microscope and identified using published taxonomic keys, unpublished working keys and an extensive specimen reference collection maintained by GHD following protocols identified in Hawking (2000).

Following identification of macroinvertebrates, a variety of data analyses were carried out. These are described in detail in GHD (2015d) These analyses provide indices allowing for a broad assessment of the condition or “health” of sites and allows a comparison between sites based upon community structure and defined habitat characteristics. Analyses conducted included:

- Taxa Richness Index – generally higher richness scores indicate better ecological health.
- EPT Taxa Index – the EPT taxa index refers to the proportional representation of key macroinvertebrate taxa belonging to the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) groups. These groups are generally recognised to be among the more pollution-sensitive macroinvertebrate taxa.
- SIGNAL 2 Taxa Richness Index – this is a biotic index based on pollution sensitivity values

- SIGNAL 2 Biotic Index (Chessman, 2003) - SIGNAL2 scores can be mapped on a biplot against taxa richness. High values of both SIGNAL2 scores and number of families indicates good habitat and chemically dilute water, low SIGNAL2 scores with high family diversity can indicate high salinity or nutrient levels, high SIGNAL2 and low diversity indicate toxic pollution or harsh physical conditions, and low SIGNAL2 scores and low taxa richness usually indicate urban, industrial or agricultural pollution.
- SIGNAL-SF (Sydney Families) – this is similar to that described above, but has been designed specifically for the Sydney region.
- NSW AUSRIVAS – Autumn Edge Model – this generates site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress. Sites are classified into bands depending on the ratio of expected to observed taxa.

In situ water quality

In situ physical and chemical parameters were measured at four locations along Mill Creek and within two dams located in the study area (see Figure 3-1). In addition, *in situ* physical and chemical parameters were measured at the five macroinvertebrate monitoring sites described in GHD (2015d). Parameters were measured using a Hydrolab MS5 water quality meter with the standard sensor suite. This meter was calibrated in accordance with GHD's Quality Assurance requirements and the manufacturer's specifications prior to its use in the field.

Water quality measurements were taken just below the water surface adjacent to the bank and included Temperature (°C), Conductivity (µS/cm), Dissolved Oxygen (mg/L and % saturation) and pH.

Survey conditions

Weather during the December nocturnal surveys was moderately warm with intermittent rain only occurring on the third night of surveys. Thunderstorm activity was present on the first night of nocturnal surveys. The neaby Holsworthy aerodrome weather station (~5 km from the study area) had received up to 46.4 mm of rain in the week before surveys commenced (BOM 2014), while Bankstown Airport (~14 km from the study area) had received 110.6 mm. Standing water was present within track ruts and low-lying depressions during the initial surveys. Weather conditions during the nocturnal surveys were approporiate for the detection of frogs, including for the detection of the threatened Giant Burrowing Frog. Rain may have hampered detection of birds, mammals and reptiles during these nocturnal surveys.

Table 3-2 Daily weather observations prior to and during the targeted frog surveys (December 2014)

Date	Holsworthy			Bankstown		
	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)
01/12/2014	17.7	31.7	3.0	18.1	31.5	3.8
02/12/2014	18.1	33.8	3.4	18.7	34.4	6.6
03/12/2014	19.6	34.3	2.4	20.8	34.9	0.6
04/12/2014	19.6	31.5	5.2	20.0	31.4	30.0
05/12/2014	18.7	29.6	10.6	18.5	30.2	28
06/12/2014	18.8	28.5	0.0	19.4	29.2	1.8
07/12/2014	17.7	29.1	21.8	17.6	29.5	39.8
08/12/2014	**17.3**	**29.5**	**2.2**	**18.3**	**30.5**	**3.8**
09/12/2014	**20.0**	**24.9**	**0.8**	**20.1**	**25.0**	**0.8**
11/12/2014	**19.7**	**21.6**	**4.4**	**20.3**	**21.8**	**13.0**

15/12/2014	**14.7**	**28.1**	**0.0**	**14.8**	**27.9**	**0.0**

Dates in bold are survey dates.

Weather during the vegetation surveys and fauna habitat assessment conducted in January was hot and humid, with temperatures reaching up to 29.8°C and 30.1°C in nearby Holsworthy and Bankstown aerodromes respectively. Conditions were appoporiate for reptile searches and opportunistic fauna observation.

Weather was warm and humid during the March survey. The warm and stormy summer preceeding the survey would have provided good growing conditions for autumn-flowering orchids, including potentially the threatened *Genoplesium baueri*.

Table 3-3 Daily weather observations prior to and during the January and March 2015 survey

Date	Holsworthy			Bankstown		
	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)	Minimum temp (° C)	Maximum temp (° C)	Rainfall (mm)
19/01/2015	19.0	20.6	0.0	19.9	22.2	0.0
20/01/2015	17.0	25.8	2.2	18.2	26.5	0.6
21/01/2015	18.6	28.8	2.4	19.1	29.8	2.8
22/01/2015	**20.0**	**29.8**	**0**	**19.9**	**30.1**	**0**
27/02/2015	16.7	27.1	0.2	18.1	28.3	0
28/02/2015	17.4	28.8	0	17.7	29.4	0
01/03/2015	17.6	35.5	0	17.8	36.9	0
02/13/2015	**15.0**	**23.5**	**8**	**16.6**	**24.0**	**2.4**

Dates in bold are survey dates.

3.3.4 Follow-up targeted flora surveys

Additional targeted surveys were conducted for the *Allocasuarina diminuta* subsp. *mimica* population within the proposal site on 23 March 2016 in the company of a qualified surveyor. The purpose of these surveys was to accurately map the location of the plants along the boundary fence, and to check potential access routes to the GO Facility for evidence or otherwise of this species. Individual ramets at each location were counted, and notes made regarding location inside and outside the boundary fence.

3.4 FBA calculations

The proposal was assessed according to the methodology presented in the FBA (OEH, 2014a), the Department of Environment and Climate Change (DECC, 2009) *BioBanking Assessment Methodology and Credit Calculator Operational Manual* and the *Draft Operational Manual for using the BioBanking Credit Calculator v2.0* (OEH, 2011). The credit calculator is a software application that is used to apply the FBA as well as BioBanking assessments. Data is entered into the credit calculator based on information collected in the desktop assessment, site surveys and from using GIS mapping software.

The FBA credit calculations were performed by Kirsten Crosby (assessor accreditation numner 160) and reviewed by Ben Harrington (assessor accreditation number 0073) using credit calculator Version 4.0. The credit calculations will be submitted to OEH. The biodiversity credit report is included Appendix A.

The data and assumptions used to perform the FBA credit calculations are summarised in Chapter 7.

3.5 Staff qualifications

Field surveys were conducted by Kirsten Crosby, Gary Leonard, Mal Weerakoon, Adrian Dickson and Ben Harrington of GHD Pty Ltd. Credit calculations were prepared by Kirsten Crosby and checked by Ben Harrington. The Biodiversity Assessment Report was prepared by Kirsten Crosby and peer reviewed by Jayne Tipping. Staff qualifications are presented in Table 3-4.

Table 3-4 Staff qualifications

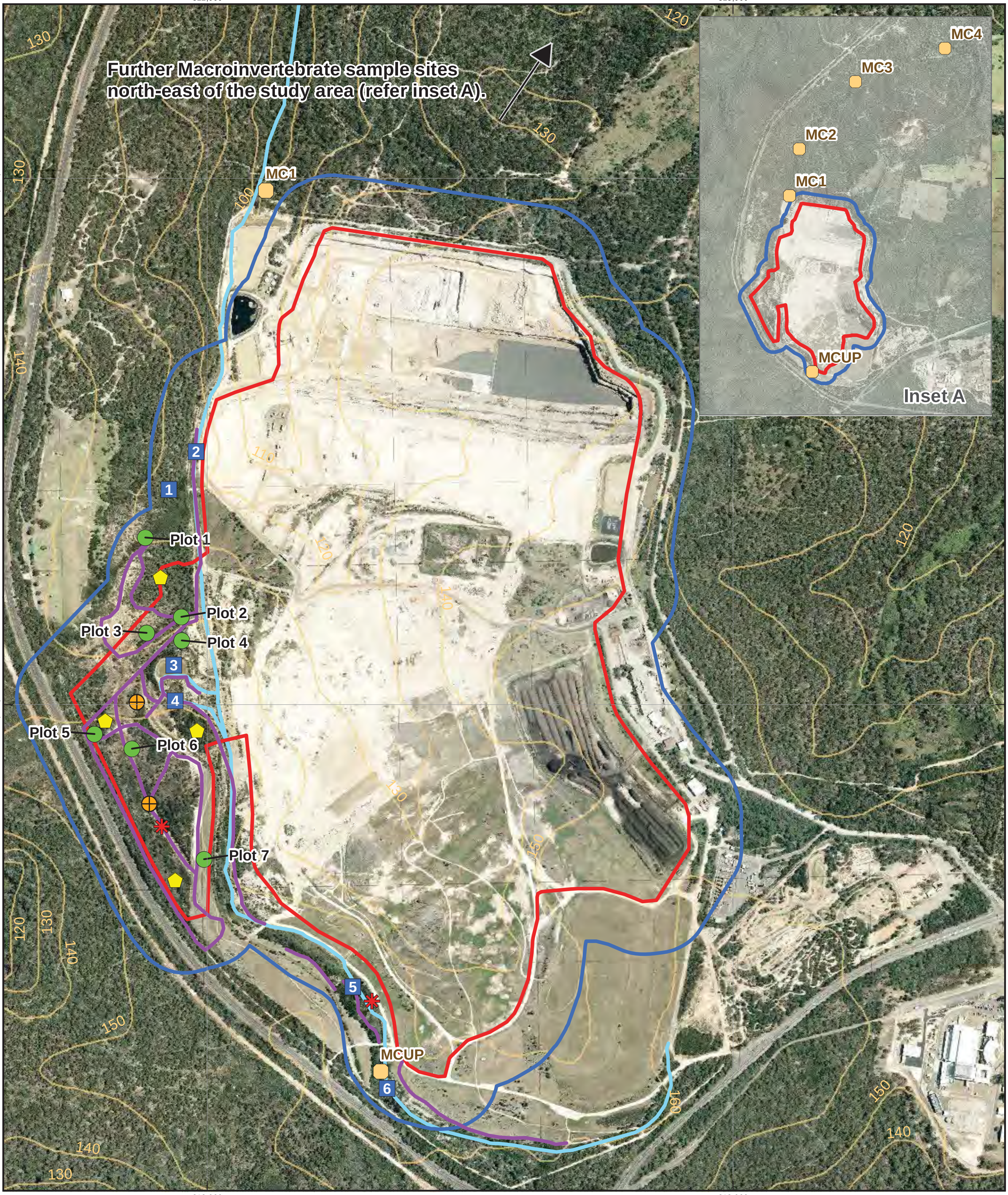
Name	Position / Proposal Role	Qualifications	Relevant Experience
Kirsten Crosby	Senior Ecologist / desktop assessment, site surveys, targeted frog surveys, reporting	BSc, PhD (Zoology) Accredited NSW BioBanking Assessor #0160	10+ years
Gary Leonard	Senior Ecologist / vegetation mapping, plot/transects, targeted threatened flora searches	DipHort HortCert DipEd	40+ years
Adrian Dickson	Environmental Scientist / aquatic habitat assessment	BSc (Freshwater Ecology) RBA and AUSRIVAS Certificate of Competency (Level 2), Environment Protection Authority, Victoria	10+ years
Malith Weerakoon	Graduate Ecologist / desktop assessment, targeted frog surveys, data processing.	BSc, MPhil. (Zoology)	2+ years
Ben Harrington	Senior Ecologist / targeted frog surveys, review of credit calculations	BSc, MSc (Physical Geography) Accredited NSW BioBanking Assessor 0073	10+ years
Daniel Williams	Principal Environmental Consultant Technical review of BOS	B. App. Sc. Cons Tech Accredited NSW BioBanking Assessor 0082	15+ years
Jayne Tipping	Principal Ecologist/Technical Review	BSc (Ecology), MEnvLaw	23+ years

3.6 Assumptions and exclusions

This Biodiversity Assessment Report has been prepared based on the proposal description and engineering drawings provided by the proponent. A ‘proposal footprint’ polygon (i.e. disturbance footprint) was prepared for the biodiversity assessment based on these inputs and confirmed in consultation with the proponent. It is assumed that the description and spatial data accurately represent the extent of direct impacts arising from the proposal and so these data have been used to calculate the extent of removal of vegetation and habitat arising from the proposal using

GIS. These calculations have in turn been relied upon in the FBA calculations and the determination of key thresholds such as whether the proposal would have a direct impact on a threatened species, whether biodiversity offsets are required for a particular impact and whether a particular impact is likely to be significant. The assessment conclusions may change as a result of the provision of an updated proposal design and/or spatial data.

A review has been undertaken which concludes that SITA has approval under the current consent (1999 EIS and associated Consent R97/00029) to clear vegetation on the batters of the existing landfill as it is not yet at final profile. Impacts associated with the clearing of regenerated/planted vegetation in these locations have therefore not been considered in the impact assessment and biobanking credit calculations.



LEGEND

- Study area
- Project footprint
- Mill Creek
- 10m Contour

Survey effort

- Koala spot assessment
- Camera
- Anabat
- Water quality
- Plot/transect
- Macroinvertebrate Sample Sites
- Spotlighting, call playback

Paper Size A4

0 50 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	04 May 2016

Survey effort

Figure 3-1

G:\21\23482\GIS\Maps\MXD\21-23482-Z052_SurveyEffort_ECOLOGY_A4.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 T 61 2 9239 7100 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by:apmiller

4. Existing environment

4.1 Site context

4.1.1 Surface water features

Most of the site lies within the Mill Creek catchment. Mill Creek originates from LHRRP and flows north along the western boundary towards Georges River. The gradients of the LHRRP are typical of a dissected plateau, with the slopes becoming steeper close to Mill Creek. Mill Creek itself has a slope of 2% as it travels through the site. Baseflow for the perennial rivers and streams are generally sourced from seeps and springs derived from groundwater.

The majority of the site, the landfilled portion, constitutes runoff to Mill Creek. An area around the administration facilities is a tributary to Bardens Creek.

There are a number of surface water management features currently in place at the site. Surface water diversion drainage is constructed around the rim of each active waste disposal cell to control surface water runoff flowing into or from the cells. The drainage typically comprises open channel drains on the outer edge of earthen bunds. Surface water is collected in drains, swales and ponds and diverted to sediment dams. The dams are designed to allow for settlement of suspended solids before discharging offsite following large rainfall events when stormwater has reached capacity.

Most of the LHRRP lies within the catchment area of Mill Creek, with the exception of the area bounded by New Illawarra Road and Little Forest Road in the south-east, which drains to Bardens Creek. Mill Creek originates from within the site and flows in a northerly direction through approximately the centre of the site, covering most of the length of the site. Towards the origin of the creek, the channel is not always clearly visible. Apart from small overflows, flooding is not expected to occur over the site because the gradients of the site allow good drainage.

4.1.2 Geology, soils and geomorphology

The geology of the area is known as the Woronora Plateau and Hawkesbury Sandstone, approximately 200 m thick, dominates the surface.

The LHRRP is located on the dissected Hawkesbury sandstone of the Woronora Plateau, which was uplifted during the Triassic Period such that it now dips downwards in a northerly direction and forms part of the Sydney Basin.

The dominant surface geology is made up of Hawkesbury Sandstone, which is approximately 200 m thick in the Lucas Heights region. It is a medium to coarse grained sandstone and consists of a series of lenticular (and therefore laterally discontinuous) beds of quartz sandstones. Although the dominant lithology is Hawkesbury Sandstone, the formation also includes significant minor components of Wianamatta Shale and siltstone. The shales and siltstones generally occur in relatively thin units frequently interbedded with sandstones.

The LHRRP is part of the Gymea Soil Landscape, with soils up to 150 cm deep. They are formed from sandstone and shale parent material, and consist of a surface layer of sand and subsurface layers of sandy clay and clay. The soils are highly permeable, with very low general fertility. Outcrops of Hawkesbury sandstone are found within the region. A small amount of sandstone bedrock is exposed within the site as a result of soil erosion.

4.1.3 Climate

Review of data from Bureau of Meteorology (BOM, 2014) and data from Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA, 2014) suggests that a warm temperate climate with strong maritime influence is experienced in the Lucas Heights area. Mean daily temperatures range from 26.0 0C to 17.0 0C in February and from 15.8 0C to 6.6 0C in July. Frost is not experienced in this area.

Seasonal variations occur in rainfall with a greater proportion being received during summer months. A generally even rainfall distribution is experienced over the region with a mean annual rainfall of 1015 millimetres (mm).

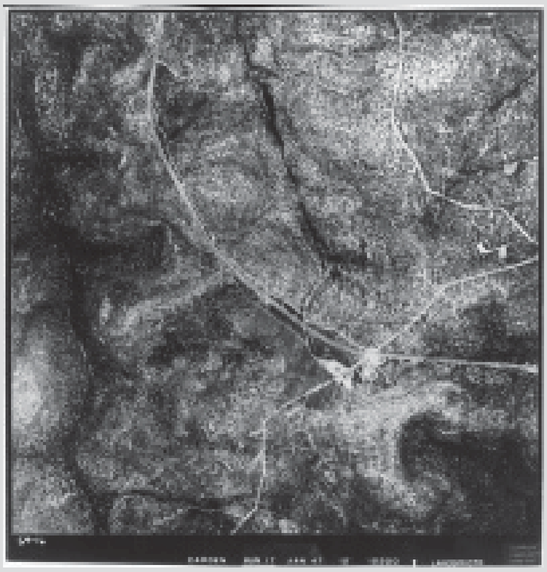
4.1.4 Disturbance

The LHRRP originally opened in 1987, based on a development consent received in 1985 permitting waste disposal operations. A development application was submitted and approved in 1999 which permitted the expansion of waste disposal operations and also the development of composting and other resource recovery operations at the site.

Historical aerial photographs show that the GO facility and ARRT facility area were vegetated in the earliest available photograph (1947) (Photograph 1) before being largely cleared of vegetation at some stage between 1947 and 1961 (Photograph 2). The GO facility and ARRT facility area remained predominantly cleared until the 1984 photograph where vegetation can be seen (Photograph 3, Photograph 4).

Mill Creek was previously located further to the east of the proposed GO facility and ARRT facility area, within the area currently occupied by the landfill. It was realigned to its present location in the late 1980s. Its original location shows up as a dark line running from south to north in the photographs.

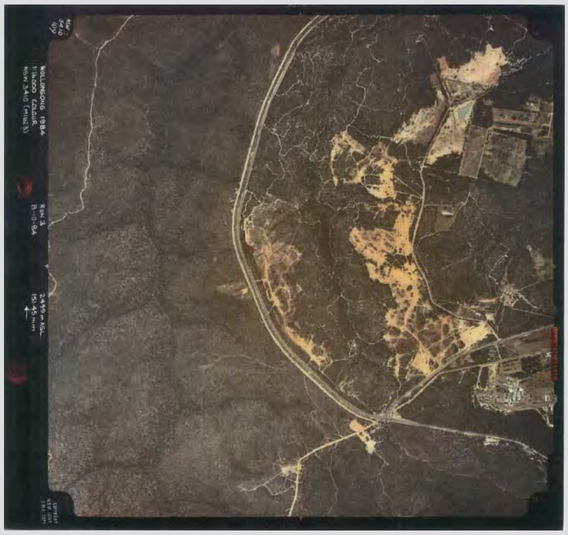
Aerial photographs are provided below.



Photograph 1: 1947 aerial photo

Photograph 2: 1961 aerial photo

Photograph 3: 1970 aerial photo



Photograph 4: 1984 aerial photo

4.1.5 Vegetation mapping

Vegetation mapping of the region by NPWS (2002) maps much the native vegetation in the study area and surrounds as MU34 Sandstone Heath-Woodland. This is equivalent to Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (ME014) in the NSW vegetation types database. A patch of *Eucalyptus squamosa* and *Eucalyptus paniculata* vegetation within the north-eastern portion of the study area is heritage listed under the Sutherland Local Environmental Plan 2006. This vegetation is commensurate with the Shale – Sandstone Transition Forest critically endangered ecological community (CEEC) listed under both the TSC Act and the EPBC Act. Previous vegetation surveys carried out to the east of the landfill identified an area of Coastal Upland Swamp (GHD 2011). Vegetation within the proposal footprint was ground-truthed during surveys (see section 4.2.2 for a description of vegetation types present).

4.1.6 Results of desktop review

The study area contains potential habitat for a number of threatened flora and fauna species. A search of the OEH Atlas of Wildlife database and DotE protected matters search indicated 34 threatened flora species or populations listed under the TSC Act and 27 threatened flora species listed under the EPBC Act that have been recorded or that are predicted to occur within 10 km of the study area. A total of 42 threatened fauna species listed under the TSC Act, one threatened fauna species listed under the FM Act and 20 threatened fauna species listed the EPBC Act have been recorded within 10 km of the study area or are predicted to occur. The likelihood of occurrence of these threatened biota are detailed in Appendix B.

In addition to the database review and the threatened biota likelihood of occurrence assessment for the study area, preliminary FBA credit calculations were performed to identify species credit-type species that may occur in the proposal footprint based on its geographic position and the PCTs and habitat resources present. Species-credit species that may occur in the proposal footprint based on the preliminary FBA credit calculations are listed in Table 4-1. A ‘survey/time matrix’ which shows the time of year that targeted surveys for each of these species can be conducted is included in Appendix C. The field surveys conducted by GHD match the required survey period for all species of relevance to the proposal (see Appendix B).

Table 4-1 Species-credit species that may occur in the proposal footprint

Scientific name	Common Name	TSC Act	EPBC Act
FLORA			
Acacia baueri subsp. *aspera*	-	V	
Acacia bynoeana	Bynoe's Wattle	E	V
Acacia prominens - endangered population	-	EP	
Acacia pubescens	Downy Wattle	V	V
Astrotricha crassifolia	Thick-leaf Star-hair	V	V
Caesia parviflora subsp. *minor*	Small Pale Grass-lily	E	
Caladenia tessellata	Thick Lip Spider Orchid	E	V
Callistemon linearifolius	Netted Bottle Brush	V	
Epacris purpurascens subsp. *purpurascens*	-	V	
Eucalyptus camfieldii	Camfield's Stringybark	V	V
Genoplesium baueri	Bauer's Midge Orchid	E	E
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V
Hibbertia puberula	-	E	
Hibbertia stricta subsp. *furcatula*	-	E	
Leucopogon exolasius	Woronora Beard-heath	V	V
Melaleuca deanei	Deane's Paperbark	V	V
Persoonia bargoensis	Bargo Geebung	E	V
Persoonia hirsuta	Hairy Geebung	E	E
Prostanthera densa	Villous Mint-bush	V	V
Pterostylis sp. Botany Bay	Botany Bay Bearded Orchid	E	E
Pultenaea aristata	Prickly Bush-pea	V	V
FAUNA			
Cercartetus nanus	Eastern Pygmy-possum	V	
Heleioporus australiacus	Giant Burrowing Frog	V	V
Isoodon obesulus subsp. *obesulus*	Southern Brown Bandicoot	E	E

Scientific name	Common Name	TSC Act	EPBC Act
Litoria aurea	Green and Golden Bell Frog	E	V
Phascolarctos cinereus	Koala	V	V
Pseudophryne australis	Red-crowned Toadlet	V	
Varanus rosenbergi	Rosenberg's Goanna	V	

* Note: E= endangered, V=vulnerable, EP=endangered population.

4.2 Survey results

4.2.1 Flora species

A total of 236 flora species from 56 families were recorded within the study area, comprising 183 native and 53 exotic species. Poaceae (grasses, 31 species, 17 native), Myrtaceae (flowering shrubs and trees, 30 species, all native), Fabaceae (28 species, 24 native) and Proteaceae (shrubs or trees, 27 species, all native) were the most diverse families recorded. The full list of species recorded is presented in Appendix D. Species recorded are discussed below in relation to the vegetation types occurring within the study area.

One endangered flora population was recorded in the proposal footprint: *Allocasuarina diminuta* subsp. *mimica*, listed as an endangered population under the TSC Act. This species is discussed in more detail in section 4.3.

4.2.2 Noxious and environmental weeds

A range of weed species occurs within the proposal footprint. Weeds of National Significance (Thorp and Lynch 1999) include Bitou Bush (*Chrysanthemoides monilifera* subsp. *rotundata*), Lantana (*Lantana camara*), and Fire Weed (*Senecio madagascariensis*). Noxious species for the Sutherland Local Government Area that are present include Ludwigia (*Ludwigia peruviana*), Pampas Grass (*Cortaderia selloana*), Lantana (*Lantana camara*) and Fireweed (*Senecio madagascariensis*). Control requirements for noxious weeds are detailed in Table 4-2.

A range of environmental weeds is also present. It is noted that weed species are more common in the section of Mill Creek, which flows along the western boundary of the ANSTO land, and evidence of weed management in the SITA land included harvested seed heads of *Juncus acutus* and poisoned clumps of African Lovegrass (*Eragrostis curvula*), Pampas Grass and Bitou Bush.

Table 4-2 Declared noxious weeds recorded in the study area

Scientific name	Common name	Control category	Legal requirements
Cortaderia selloana	Pampas Grass	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Ludwigia peruviana	Ludwigia	3	The plant must be fully and continuously suppressed and destroyed
Lantana camara	Lantana*	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread
Senecio madagascariensis	Fireweed*	4	The plant must not be sold, propagated or knowingly distributed

* also a Weed of National Significance.

4.2.3 Vegetation

Identification of Plant Community Types

Tozer *et. al*. (2010) and OEH (2013) vegetation mapping of the region were ground truthed by a GHD botanist. Necessary adjustments to regional vegetation mapping were made using a GPS tablet in the field. The site was divided into vegetation zones which represented distinct PCT and broad condition classes according to the FBA.

PCTs were classified according to vegetation structure, species composition, soil type and landscape position. PCTs were further split into broad condition classes with reference to the FBA to yield condition classes of the vegetation types as follows:

- 'Moderate condition', comprising Moderate/good or Moderate/good – moderate condition vegetation which featured over storey and mid storey vegetation at benchmark levels for the equivalent vegetation type.
- 'Poor condition', comprising Moderate/good – poor condition regenerating or planted vegetation with over storey and mid storey cover substantially below benchmark levels for the equivalent PCT but greater than 50% of the groundcover present was native species (i.e. derived native shrubland, scrub or low open woodland structure).
- Cleared land and exotic grassland, comprising Low or Cleared condition vegetation which featured native over storey and mid storey vegetation cover substantially below benchmark levels for the expected PCT and less than 50% of the groundcover present was native species or greater than 90% of the ground surface was bare earth or infrastructure.

Vegetation types in the study area are summarised in Table 4-3 and described below.

Plot/transect data from within the proposal footprint was compared with Tozer *et al* (2010) diagnostic species lists for equivalent vegetation map units to help confirm the identity of matching PCTs (OEH 2014c). This approach is endorsed by the NSW OEH for confirming the identity of floristically similar vegetation types and is particularly relevant for identifying vegetation that may comprise a particular threatened ecological community (Steenbeeke, G, OEH, pers. comm.). The results of comparisons with diagnostic species lists for the three closest matching Tozer *et al* (2010) vegetation map units and flora survey plots sampled in the proposal footprint are summarised in Table 4-4, Table 4-5 and Table 4-6.

There is a clear match between the species lists for plots 2, 3 and 5 and the diagnostic species list for Red Bloodwood - Scribbly Gum heathy woodland (ME014, Tozer DSFp131). Plots 2, 3 and 5 were sampled in the better condition patches of this PCT and each contain >100% of the required number of diagnostic species (see Table 4-4).

There is a clear match between the species lists for plot 4, which was sampled in a poor condition, planted or regenerating patch of vegetation and the diagnostic species list for Red Bloodwood - Scribbly Gum heathy woodland (ME014, Tozer DSFp131). Plot 6, also sampled in a poor condition patch of vegetation, had only 60% of the required diagnostic species for ME014/DSFp131. This is the best fit of any candidate PCTs. A shortfall in the required minimum number of positive diagnostic species is not unusual for degraded, modified or planted vegetation. The presence of confirmed patches of this PCT (i.e. surrounding plots 2, 3, 4 and 5) in connected vegetation with similar structure and in equivalent positions in the landscape further support the nominated PCT.

Plot 1, in the Needlebush - banksia wet heath (ME015, Tozer FrW129), has >100% of the required number of positive diagnostic species for the nominated PCT but also for

ME014/DSFp131 as sometimes happens with closely related PCTs. A closer look at the diagnostic statistics suggests that Needlebush - banksia wet heath is the better match. High cover abundance of species that are diagnostic of ME015/FrW129 only (*Baumea teretifolia*, *Leptocarpus tenax*, *Schoenus brevifolius*), geomorphic position and impeded drainage further support the nominated PCT.

Vegetation types outside of the proposal footprint were mapped according to the results of previous assessments (GHD, 2011).

Table 4-3 Vegetation in the study area

Vegetation Community	PCT / NSW Veg. Type ID (OEH, 2014d)	Condition	Location	Survey Effort	Conservation Significance
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux	ME014	Moderate to good (moderate)	Within proposal footprint	2 plot/transects	Native vegetation
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (regenerating and planted)	ME014	Moderate to good (poor)	Within proposal footprint	3 plot/transects	Native vegetation
Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin	ME015	Moderate to good (moderate)	Outside proposal footprint	1 plot/transect	Coastal Upland Swamps (endangered ecological community listed under the TSC Act and the EPBC Act.
Hairpin Banksia - Slender Tea-tree heath on coastal sandstone plateaux	ME013	Moderate to good	Outside proposal footprint	Identified during quadrat surveys by GHD (2011).	Coastal Upland Swamps (endangered ecological community listed under the TSC Act and the EPBC Act.
Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest	ME021	Moderate to good	Outside proposal footprint	Identified by Sutherland Council. Part of the patch verified during quadrat surveys by GHD (2011).	Shale-Sandstone Transition Forest (critically endangered ecological community listed under the TSC Act and the EPBC Act.
Exotic grassland	N/A	Low	Within proposal footprint	1 plot/transect	Not native vegetation
Cleared land	N/A		Within proposal footprint		Not native vegetation

Table 4-4 Comparison of vegetation survey plots in Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014) with Tozer (2010) diagnostic species lists

Attribute	Plot 2			Plot 3			Plot 5		
Vegetation map unit (Tozer 2010)	**DSFp131**	DSF p146	DSF p8	**DSFp131**	DSF p146	DSF p8	**DSFp131**	DSF p146	ME015
Equivalent PCT (OEH 2014c)	**ME014**	ME031	ME015	**ME014**	ME031	ME015	**ME014**	ME031	HN584
Total diagnostic species	**22**	15	5	**20**	12	8	**33**	20	11
Required minimum +ve diagnostic species	**20**	31	11	**20**	31	11	**20**	31	Yes
Achieved?	**Yes**	No	No	**Yes**	No	No	**Yes**	No	
No. by which required minimum +ve diagnostic spp. is exceeded?	**2**						**13**		100%
Ratio of actual : required +ve diagnostic species	**110%**	48%	45%	**100%**	39%	73%	**165%**	65%	45
Total native species	**25**	58	25	**27**	27	27	**45**	45	19
Required minimum total native species	**30**	42	19	**30**	42	19	**30**	42	Yes
Achieved?	**No**	Yes	Yes	**No**	No	Yes	**Yes**	Yes	24%
Ratio of +ve diagnostic species : total native species	**88%**	26%	20%	**74%**	44%	30%	**73%**	44%	ME015

Table 4-5 Comparison of vegetation survey plots in regenerating and planted Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014) with Tozer (2010) diagnostic species lists

Attribute	Plot 4			Plot 6		
Vegetation map unit (Tozer 2010)	**DSFp131**	DSF p146	DSF p8	**DSFp131**	DSF p146	DSF p8
Equivalent PCT (OEH 2014c)	**ME014**	ME031	ME015	**ME014**	ME031	ME015
Total diagnostic species	**22**	15	5	**12**	8	4
Required minimum +ve diagnostic species	**20**	31	11	**20**	31	11
Achieved?	**Yes**	No	No	**No**	No	No
No. by which required minimum +ve diagnostic spp. is exceeded?	**2**					
Ratio of actual : required +ve diagnostic species	**110%**	48%	45%	**60%**	26%	36%
Total native species	**33**	33	33	**12**	12	12
Required minimum total native species	**30**	42	19	**30**	42	19
Achieved?	**Yes**	No	Yes	**No**	No	No
Ratio of +ve diagnostic species : total native species	**67%**	45%	15%	**100%**	67%	33%

Table 4-6 Comparison of vegetation survey plot in Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin (ME015) with Tozer (2010) diagnostic species lists

Attribute	Plot 1		
Vegetation map unit (Tozer 2010)	**FrW129**	DSFp131	DSF p146
Equivalent PCT (OEH 2014c)	**ME015**	ME014	ME031
Total diagnostic species	**23**	29	15
Required minimum +ve diagnostic species	**11**	20	31
Achieved?	**Yes**	Yes	No
No. by which required minimum +ve diagnostic spp. is exceeded?	**12**	9	
Ratio of actual : required +ve diagnostic species	**209%**	145%	48%
Total native species	**58**	58	58
Required minimum total native species	**19**	30	42
Achieved?	**Yes**	Yes	Yes
Ratio of +ve diagnostic species : total native species	**40%**	50%	26%

Vegetation types in the study area

The majority of the vegetation in the proposal footprint and surrounding study area comprises cleared land or exotic grassland on highly modified landforms. Much of the area proposed to be developed as the ARRT facility and the GO facility has been previously disturbed and is currently vegetated with regrowth and, in several locations planted vegetation. Many tracks and trails pass through this area. Small patches of intact native vegetation are present in this area.

One native vegetation type is present in the proposal footprint: Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME 014). This vegetation type occurs as both moderate to good (medium) and moderate to good (poor) condition. This vegetation type also dominates the native vegetation in the study area. This vegetation type is not a threatened ecological community.

Three additional native vegetation types are present in the study area but not in the proposal footprint:

- Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin (ME015)
- Hairpin Banksia - Slender Tea-tree heath on coastal sandstone plateaux (ME013)
- Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (ME021).

All three vegetation types are commensurate with threatened ecological communities (see section 4.3.1).

Vegetation types present in the study area are detailed in Table 4-3 and described below.

Red Bloodwood - Scribbly Gum heathy woodland

Red Bloodwood - Scribbly Gum heathy woodland occurs in small patches in the western portion of the proposal footprint. A linear patch is present as a narrow strip along the boundary with Heathcote Road, extending into the SICTA land to the north (Photograph 5). A second patch is present along the boundary fence between SITA and SICTA. A small patch of this vegetation type is also present south of the nearby dam (Photograph 6). This vegetation type is also the dominant vegetation type surrounding the proposal footprint.

Canopy species are low and broadly spreading, varying in height from 6m to 14m. Trees are well-spaced (>5m apart) and rarely occur in thickets. Common canopy species include Red Bloodwood (*Corymbia gummifera*), Scribbly Gum species *Eucalyptus racemosa* subsp. *racemosa* at the northern end of the ARRT facility area and, less commonly *Eucalyptus haemastoma* at the southern end of the GO facility. Other canopy species include Sydney Peppermint (*Eucalyptus piperita*), Narrow-leaved Stringybark (*Eucalyptus oblonga*) and Scaly Bark (*Eucalyptus squamosa*). Over-mature, hollow-bearing trees are not present, and it is likely that most of the canopy species are less than 40 years old. A number of small hollows (~5 cm diameter) were observed in Scribbly Gums.

The shrub layer is variable in height and density, possibly in response to previous disturbances and fire. Common shrub species include Dwarf Apple (*Angophora hispida*), Banksia species (*Banksia ericifolia, B. spinulosa, B. marginata* and *B. serrata*), She-Oak species (*Allocasuarina littoralis* and *A. distyla*), Wattle species (*Acacia longifolia* subsp. *longifolia*, *A. myrtifolia*, and *A. suaveolens*), Mountain Devil (*Lambertia formosa*), Geebungs (*Persoonia lanceolata* and *P. levis*) and Grevillea species (*Grevillea sphacelata*, *G. sericea* subsp. *sericea* and *G. phylicoides*). Patches of the endangered population of *A. diminuta* subsp*. mimica* occur along the boundary fence adjacent to Heathcote Road (see Figure 4-1).

Groundcover is sparse, with only Lesser Flannel Flower (*Actinotus minor*) forming mats, while grasses, including *Anisopogon avenaceus, Entolasia stricta, Rytidosperma tenuous, Austrostipa pubescens, Poa sieberiana* and *Themeda australis,* generally occur as single clumps.

Photograph 5: Red Bloodwood - Scribbly Gum heathy woodland near the boundary fence alongside Heathcote Road

Photograph 6: Red Bloodwood - Scribbly Gum heathy woodland south of the dam

Red Bloodwood - Scribbly Gum heathy woodland (regenerating and planted)

Red Bloodwood - Scribbly Gum heathy woodland (regenerating and planted) occurs over much of the area proposed for the ARRT and GO facilities, as well as adjacent areas of the existing landfill, and along much of Mill Creek. This vegetation type varies from the self-recruiting sandstone heath-woodland described above in response to previous disturbance and supplementary planting (Photograph 7, Photograph 8). Planting was carried out historically around 15-20 years ago in the area near the dam by the Department of Lands. Provinence of these species is not known (L. Hedges, on-site nursery co-ordinator, pers. comm.). More recent planting has been carried out along the riparian corridor of Mill Creek, and has used specimens of local provinence (L. Hedges, on-site nursery co-ordinator, pers. comm.). The canopy is generally no more than 8 m in height and often less than 4 m. Trees may be spaced up to 10 m apart and the shrub layer is also sparse.

Species which are common in this vegetation include Dwarf Apple (*Angophora hispida*), Black She-Oak (*Allocasuarina littoralis*), Scrub She-oak (*Allocasuarina distyla*), *Allocasuarina diminuta* subsp. *diminuta*, Grey Gum (*Eucalyptus punctata*), Smooth-barked Apple (*Angophora costata*) and Bottlebrushes (*Callistemon citrinus* and *Callistemon linearis*). Within this vegetation type is one individual of an inter-generic hybrid *Corymbia gummifera* x *Angophora hispida*. Two individuals of the regionally rare Yellow-top Ash (*Eucalyptus luehmanniana*) occur in a patch of this community north-west of the dam, although it is likely that these specimens have been planted, along with several adjacent individuals of Grey Gum (*Eucalyptus punctata*). A small patch of the endangered population of *A. diminuta* subsp. *mimica* (listed under the TSC Act) occurs along a disturbed track margin in this community in the proposal footprint, as well as in a disturbed area in SICTA land to the north (see Figure 4-1).

Weed species occur in this vegetation type, particularly within constructed batters of Mill Creek. Noxious species include *Ludwigia peruviana*, Lantana (*Lantana camara*), Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*), Crofton Weed (*Ageratina adenophora*), Moth Vine (*Araujia sericifera*), Pampas Grass (*Cortaderia selloana*), Vasey Grass (*Paspalum urvillei*) and *Cyperus eragrostis*.

The patch of this vegetation type in the SICTA land (the northern portion of the proposed ARRT facility) is regularly trittered or partially cleared during shot vacuuming operations. Trees are scarce and are mostly < 20 years old. Black Oak (*Allocasuarina littoralis*) occurs in dense thickets throughout this area. Ground cover is sparse to absent.

Photograph 7: Red Bloodwood - Scribbly Gum heathy woodland (regenerating), with dense stand of *Allocasuarina* in background

Photograph 8: Red Bloodwood - Scribbly Gum heathy woodland (regenerating) on SICTA land

Needlebush – Banksia wet heath

Needlebush – Banksia wet heath is located to the north of the proposed ARRT facility within SICTA land. The vegetation type occurs in a narrow band which follows a drainage line from the formed access track around the existing infill area to a dam in the SICTA land (refer to Figure 4). The vegetation includes components of sedgeland, restioid heath and cyperoid heath in the drainage line bed, to sparse fringing eucalypt woodland and mallee-heath on the sandstone slopes above the drainage line.

The floristics and structure of the vegetation comply with descriptions of Upland Swamp (see NSW NPWS 2004 and Tozer et al. 2010). It is commensurate with the endangered ecological community Coastal Upland Swamp listed under the EPBC Act and the TSC Act.

The most commonly occurring tree species is Narrow-leaved Stringybark (*Eucalyptus oblonga*). Several seedlings of Red Bloodwood (*Corymbia gummifera*) also occur. Shrub species include oak species (*Allocasuarina* spp.), tea trees (*Leptospermum* spp.), *Banksia* species, Crimson Bottlebrush (*Callistemon citrinus*) and Tickbush (*Kunzea ambigua*). Species within the drainage bed include Slender Twine-rush (*Leptocarpus tenax*), Wire Rush (*Empodisma minus*), *Eurychorda complanatus, Baumea teretifolia* and *Schoenus paludosus*. One fern species, Swamp Water Fern (*Blechnum indicum*), was an uncommon occurrence and mainly restricted to a pond adjacent to the dam.

Large quantities of lead shot are scattered throughout this vegetation type, with dense concentrations in depressions. These can be seen as grey deposits in Photograph 9. Lead shot was observed in the northern portion of the proposed AART facility, within the land currently leased by SICTA.

Photograph 9: Needlebush – Banksia wet heath showing lead shot

Photograph 10: Hairpin Banksia – Slender Tea-tree heath

Hairpin Banksia – Slender Tea-tree heath

Hairpin Banksia – Slender Tea-tree heath (Photograph 10) is located to the east of the existing landfill where it intergrades with the Red Bloodwood–Scribbly Gum heathy woodland. It occurs on shallow, damp Hawkesbury Sandstone derived soils, on a ridge top, with very slight cross-slopes and impeded drainage.

The floristics and structure of the vegetation comply with descriptions of Upland Swamp (see NSW NPWS 2004 and Tozer et al. 2010). It is commensurate with the endangered ecological community Coastal Upland Swamp listed under the EPBC Act and the TSC Act.

This community is a closed heath (Specht, 1970) of sclerophyllous shrubs to 2m tall with very occasional small trees, including Red Bloodwood (*Corymbia gummifera*), Dwarf Apple (*Angophora hispida*) and mallee-form Narrow-leaved Stringybark (*Eucalyptus oblonga*).

There is a very dense, near continuous cover of tall shrubs, including Slender Tea-tree (*Leptospermum trinervium*), Broad-leaf Drumsticks (*Isopogon anemonifolius*), Heath-leaved Banksia (*Banksia ericifolia*), Mountain Devil (*Lambertia formosa*), Lance Leaf Geebung (*Persoonia lanceolata*) and Needlebush (*Hakea sericea*). There is a very diverse assemblage of smaller shrubs, including Coast Coral Heath (*Epacris microphylla*), Pink Spider Flower (*Grevillea sericea*), Fern-leaved Banksia (*Banksia oblongifolia*), Heathy Mirbelia (*Mirbelia rubiifolia*) and Wreath Bush-pea (*Pultenaea tuberculata*).

The groundcover is dense, species rich and variable and includes: herbs such as Purple Fan-flower (*Scaevola ramosissima*), Lesser Flannel Flower (*Actinotus minor*), Germander Raspwort (*Gonocarpus teucrioides*) and Silky Purple-Flag (*Patersonia sericea*); grasses, including *Entolasia stricta* and *Lomandra obliqua*; the fern *Lindsaea linearis*; and a diverse suite of sedges.

Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest

This community is located as a narrow strip to the northeast of the existing landfill, outside the proposal footprint (Photograph 11). A large patch extends out of the study area to the east (see Figure 4-1).

Ironbark – White Stringybark open forest is an open forest (Specht, 1970) with a grassy understorey and a canopy of Broad-leaved Ironbark (*Eucalyptus fibrosa*), White Stringybark (*Eucalyptus globoidea*), Thin-leaved Stringybark (*Eucalyptus eugenioides*), Turpentine (*Syncarpia glomulifera*) and occasional Grey Gum (*Eucalyptus punctata*). It occurs on deep, free draining clay loam soils on a dry ridge.

There is a sparse small tree layer of Black Oak (*Allocasuarina littoralis*), Forest Oak (*Allocasuarina torulosa*), *Persoonia linearis* and Cherry Ballart (*Exocarpos cupressiformis*). This community features occasional dense patches of the shrubs *Pultenaea villosa* and Blackthorn (*Bursaria spinosa* subsp. *spinosa*) though the shrub layer is generally open with occasional Ozothamnus diosmifolius and Hibbertia aspera.

There is a dense, grassy groundcover dominated by Kangaroo Grass (*Themeda australis*), Three-awn Speargrass (*Aristida vagans*) and Wallaby Grass (*Microlaena stipoides* var. *stipoides*). The understorey also features a diverse assemblage of forbs including Whiteroot (*Pratia purpurascens*), *Lomandra multiflora*, Solenogyne (*Solenogyne bellioides*), Kidney Weed (*Dichondra repens*), Small-leaf Glycine (*Glycine microphylla*) and Apple-dumplings (*Billardiera scandens*).

The mix of species in this community is indicative of transitional shale-sandstone soils around the edge of the Cumberland Plain at altitudes up to 350m (DECCW, 2010c). This vegetation type is commensurate with the critically endangered ecological community Shale-Sandstone Transition Forest listed under the TSC Act and the EPBC Act.

Photograph 11: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest

Photograph 12: Exotic grassland

Exotic grassland

This vegetation type mainly consists of a dense groundcover of mostly exotic grasses and forbs (Photograph 12). Dominant species include Paspalum (*Paspalum dilatatum*), Kikuyu (*Pennisetum cladestinum*), Brome Grass (*Bromus* spp.), Whisky Grass (*Andropogon virginicus*), Fireweed (*Senecio madagascariensis*), Cotton weed (*Gomphocarpus fruticosus*) and Thistle (*Cirsium vulgare*).There are also occasional plantings of trees, including River Oak (*Casuarina cunninghamiana*) and Sydney Blue Gum (*Eucalyptus saligna*).

This vegetation does not constitute a native vegetation type.

Cleared land

Areas of cleared land, including the landfill, roads and buildings are also present. These include some areas of planted vegetation, particularly near the existing site buildings. These do no constitute a native vegetation type. Cleared land provides minimal habitat for native biota.

4.2.4 Groundwater dependent ecosystems

Seven broad GDEs have been identified in Australia, including three types of subsurface ecosystems and four types of above-ground ecosystems (Serov et al 2012). No subsurface

GDEs are likely to be present in the study area. Two surface GDEs, groundwater dependent wetlands and groundwater dependent terrestrial ecosystems, may be present.

Groundwater dependent wetlands are defined as land permanently or temporarily under water or waterlogged with a known or likely component of groundwater discharge in their hydrologic cycle. Examples of groundwater dependant wetland ecosystems include upland swamps, paperbark swamp forests and woodlands (found on coastal dunes and coastal and river floodplains), swamp sclerophyll forests and woodlands (along riparian corridors of ephemeral or base flow dependent streams), swamp scrubs and heaths (coastal dunes and swampy areas) and swamp shrub lands, sedge lands (coastal, floodplain and valley floor environments) (Serov et al 2012).

Forests and woodlands can rely on groundwater for survival, particularly in areas of shallow groundwater. Groundwater dependency can range from total reliance to a proportional, opportunistic use of groundwater (Serov et al 2012).

Groundwater data for wells close to Mill Creek (i.e. MB116) suggest groundwater elevations may be very shallow in places and thus provide an environment for GDEs to exist (GHD 2015).

A literature review found conflicting information on the likelihood of GDEs being present in the study area. The Atlas of Groundwater Dependent Ecosystems maps vegetation in most of the study area as having no or low potential for groundwater interaction. Conversely, the vegetation types present are likely to be GDEs according to Kuginis et al (2012). According to that study, groundwater dependency can be inferred for many parts of the landscape as there is a strong association between floristic composition, topography and groundwater. Coastal Sandstone Ridgetop Woodland (with which Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux is commensurate), Shale Sandstone Transition Forest and Coastal Upland Swamps are all identified as having a high probability of being a GDE (Kuginis et al 2012). These three vegetation types are present in the study area. As such, and as a precaution, it is assumed that all native vegetation types in the study area are groundwater dependent to some degree. Further downstream, outside the project footprint, vegetation in the Mill Creek gully is mapped in the Atlas of Groundwater Dependent Ecosystems as having been identified in a previous study as a GDE.

Mill Creek is not mapped by the Atlas of Groundwater Dependent Ecosystems as being groundwater dependent. The only waterway in the vicinity of the proposal with potential dependence on groundwater is the Woronora River. Given its position near the top of the ridge, much of the water flow in Mill Creek is likely to be dependent on rainfall within the immediate area. As such, Mill Creek in the project footprint is not likely to be a groundwater inflow dependent ecosystem.

Downslope of the dam, flows were generally absent, but intermittent pools were present. This suggests that groundwater inputs into Mill Creek may be negligible, however, as a precaution for the purposes of this study, aquatic flora and fauna in Mill Creek downslope of the study area are considered to be potentially dependent on groundwater inflow.

4.2.5 Fauna species

A moderate diversity of fauna species were recorded in the proposal footprint, likely due in part to the presence of impacts from a highly modified environment arising from the landfill works and historical clearing. A total of 54 native species were recorded, which included 33 bird species, eight mammal species, seven reptile species and six frog species. The full list of species is included in Appendix D.

No threatened species have been positively recorded in the proposal footprint. One threatened species, the Greater Broad-nosed Bat (*Scoteanax rueppellii*) was possibly recorded during anabat surveys. The calls of this species overlap with those of the common Gould's Wattled Bat (*Chalinolobus gouldii*), which was also positively identified in the study area by analysis of calls. The calls of these species are difficult to distinguish if call quality is not good. There are a small number of records of the Greater Broad-nosed Bat in the locality, and it could occur in the study area.

A higher diversity of fauna species was recorded in the good quality woodland and forest habtiats to the east of the proposal footprint sureyed in 2010 (GHD 2011). This included an additional 49 species. Of thesefour threatened fauna species were recorded the Black-chinned Honeyeater (*Melithreptus gularis*), Scarlet Robin (*Petroica boodang*), Grey-headed Flying-fox (*Pteropus poliocephalus*) and Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), all of which are listed as 'Vulnerable' under the TSC Act. The Grey-headed Flying-fox (*Pteropus poliocephalus*) is also listed as a vulnerable species under the EPBC Act. These threatened species could occur within the proposal footprint on occasion.

Threatened fauna species are discussed in more detail in section 4.3.

Feral species observed in the study area include Red Foxes (*Vulpes vulpes*), Feral Cats (*Catus familiaris*), European Rabbits (*Oryctolagus cuniculus*) and House Mice (*Mus musculus*). Fox numbers are controlled by Sutherland Shire Council with shooting and baiting.

4.2.6 Fauna habitats

Four broad fauna habitats were recorded within the study area:

- Grassland on landfill
- Native woodland, including regrowth
- Upland Swamps
- Dams and creeks

Grassland on landfill

Exotic grassland within the study area occurs across much of the southern portion of the landfill, and alongside an access track within the area proposed for the ARRT and GO facilities. The exotic grassland did not contain any mid-storey or canopy species.

Exotic grasses and weeds within the study area provide foraging resources for opportunistic insectivorous and granivorous bird species typical of open grassland. Such species recorded during the survey include the Australian White Ibis (*Threskiornis molucca*), Australian Raven (*Corvus coronoides*), Australian Magpie (*Cracticus tibicen*), Australian Pipit (*Anthus novaeseelandiae*), Welcome Swallow (*Hirundo neoxena*) and Masked Lapwing (*Vanellus miles*). Larger predatory raptor species such as the Black-shouldered Kite (*Elanus axillaris*) were also recorded foraging over this habitat type. Some threatened microbats (such as the Eastern Bentwing Bat) may forage over these areas, as may threatened birds such as the Little Eagle (*Hieraaetus morphnoides*) and Masked Owl (*Tyto novaehollandiae*).

Exotic grassland provides habitat for small mammals and the House Mouse (*Mus musculus*) was recorded. Eastern Grey Kangaroos (*Macropus giganteus*) were regularly observed foraging in these areas. The European Rabbit (*Oryctolagus cuniculus*) was also observed in exotic grassland throughout the study area. Threatened microbats such as the Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*) and Greater Broad-nosed Bat (*Scoteanax ruepellii*) may forage over these areas on occasion.

Grassland is also likely to provide habitat for a range of reptile species, including snakes and small lizards. Common Eastern Froglets (*Crinia signifera*) were heard calling from small soaks in grassland areas.

Woodland

Native woodland comprises a mix of heathy woodland of varying structural complexity dependant on past disturbance history such as clearing, planting and even fire events. A moderate diversity of species is expected to utilise this habitat type given the varied structural complexity.

Myrtaceous trees provide foraging resources for a range of birds, including cockatoos, parrots and honeyeaters, and arboreal mammals. The Common Ringtail Possum (*Pseudocheirus peregrinus*) was observed in a number of locations within this vegetation during spotlighting surveys. Sugar Gliders (*Petaurus breviceps*) were observed in vegetation to the east of the landfill during previous surevys (GHD 2011). Nectivorous birds such as Lewin's Honeyeater (*Meliphaga lewinii*), the Little Wattlebird (*Anthochaera chrysoptera*), Noisy Friarbird (*Philemon corniculatus*) and Yellow-faced Honeyeater (*Lichenostomus chrysops*) were recorded foraging within the canopies of this vegetation type. Smaller gregarious bird species such as the Brown Thornbill (*Acanthiza pusilla*), Buff-rumped Thornbill (*Acanthiza reguloides*) and Red-browed Finch (*Neochmia temporalis*) were also recorded in this habitat type.

Dominant canopy species such as Red Bloodwood (*Corymbia gummifera*), may provide winter foraging habitat for the threatened Swift Parrot (*Lathamus discolor*) and Grey-headed Flying Fox (*Petropus poliocephalus*). Additional myrtaceous species such as Coast Banksia (*Banksia integrifolia*), Old-man Banksia (*Banksia serrata*) and planted Grey Gum (*Eucalyptus punctata*) may also provide foraging habitat for the Grey-headed Flying-fox.

The Koala (*Phascolarctos cinereus*) is known to occur in Heathcote National Park and Holsworthy army base which occur adjacent to the study area. Only limited, poor quality, foraging habitat for this species is present in the proposal footprint. Much of the native vegetation comprises recent regrowth and plantings dominated by *Allocasuarina* species, following clearing between 1947 and 1961. No preferred feed trees listed for the 'Central Coast Koala Management Area' (DECC 2008) are present in the proposal footprint. One secondary species (DECC 2008), the Grey Gum (*Eucalyptus punctata*), has been planted near the large northern dam (western sediment control and water reuse basin) near the gun club boundary. Narrow-leaved Stringybark (*Eucalyptus oblonga*), a supplementary feed tree species, is present in low numbers. Broad-leaved Scribbly Gum (*Eucalyptus haemostoma*), a feed tree listed under NSW State Environmental Planning Policy 44 (Koala habitat protection), occurs in very low densities in the southern portion of the proposal footprint, near Heathcote Road. This species is not listed as a feed tree for the 'Central Coast Koala Management Area' (DECC 2008).

The habitat in the proposal footprint is not considered habitat critical to the survival of the Koala according to the referral guidelines (DotE 2014). Impact areas that score five or more using the habitat assessment tool for the Koala contain habitat critical to the survival of the species. Impact areas that score four or less using the Koala habitat assessment tool do not contain habitat critical to the survival of the species. Habitat within the proposal footprint scored 3 (see Table 4-7).

Table 4-7 Assessment of Koala habitat in the proposal footprint

Attribute	Score	Habitat appraisal	
Koala occurrence	+0	Desktop	EPBC PMST report identified the koala as ‘known to occur’ in the study area. There are no records of Koalas within 2 km of the proposal footprint from the last 5 years (OEH 2014b).
		On-ground	Nocturnal spotlighting and scat surveys were carried out in the impact area over four days in December 2014 and January 2014, covering approximately 13 ha. No Koala scats or Koalas were recorded.
Vegetation structure and composition	+1	Desktop	Vegetation mapping by Tozer et al (2010) identifies Coastal Sandstone Ridgetop Woodland in the proposal footprint. No primary or secondary feed trees identified for the Central Coast Managementa Area in DECC (2008) are listed as occurring in this community. A number of stringybarks that aresupplementary feed trees do occur in this community.
		On-ground	Vegetation surveys identified a low incidence of supplementary feed trees within the proposal footprint. A small number of planted Grey Gums (secondary feed trees) are planted in one localised area.
Habitat connectivity	+1	The proposal footprint is part of a mostly contiguous landscape. A three lane, 100 km/hr road is located immediately to the west of the proposal, and an 80 km/hr two lane road is located to the south of the proposal footprint.	
Key existing threats	+1	Koalas are known to be killed by vehicle strike along Heathcote Road on occasion.	
Recovery value	0	Vegetation in the proposal footprint is unlikely to be important for achieving recovery objectives. No primary feed trees are present. A low number of planted secondary feed trees are present. Supplementary food trees have a low incidence. Large areas of connected habitat occur near the proposal footprint and are likely to support better quality habitat for the species.	
Total	3	Decision: The total habitat score for the proposal footprint is 3 and therefore the habitat is not critical to the survival of the koala.	

Given the above points, the Koala is considered unlikely to be present in the development site, and no further assessment of impacts on this species with respect to the FBA are required (see section7.4).

Extensive stands of *Allocasuarina* spp. occur throughout the study area in native woodland and generally occur in regrowth. The Glossy Black-cockatoo (*Calyptorhynchus lathami*) is likely to forage in Black Oak (*Allocasuarina littoralis*) where they are fruiting or have cones. No chewed cones were observed during surveys, despite the large quantities of fallen cones present in the proposal area.

The native woodland provides foraging habitat for a variety of microchiropteran bat species. This includes common species such as Gould’s Wattled Bat (*Chalinolobus gouldii*) and the White-striped Freetail Bat (*Tadarida australis*). Long-eared bats (*Nyctophilus* spp.), forest bats (*Vespadelus* spp.) and possibly also the Eastern Freetail Bat (*Mormopterus ridei*) and the threatened Greater Broad-nosed Bat (*Scoteanax rueppellii*) were also recorded, however calls of these species were not of a quality to accurately assign to a particular species. The threatened Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*) was recorded to the east of the proposal footprint during previous surveys (GHD 2011), and would also likely forage in the proposal footprint on occasion.

The absence of senescent or mature trees within the native woodland reduces the number of hollow-bearing trees and fissure-bearing trees available for nesting or denning by fauna. Around 300 vertebrate species use tree hollows and shedding bark in Australia, and the shelter provided by these habitat features is essential for the survival of many of these species (Gibbons & Lindenmayer 2002). Only five hollow-bearing trees were recorded in the proposal footprint, and these only contained small hollows potentially suitable for species such as the Eastern Pygmy Possum and Sugar Glider. No hollows suitable for larger species such as Brush-tailed Possums (*Trichosurus vulpecula*), owls or cockatoos were recorded in the proposal footprint. The small size of the hollows present also reduces the likelihood of microbats using them for roosting, as these species often roost in colonies in larger hollows.

Terrestrial mammals observed in woodland in the study area included the Swamp Wallaby (*Wallabia bicolor*) and Eastern Grey Kangaroo (*Macropus giganteus*). These species would shelter in the woodland and forage in the adjacent grassland. Diggings and a jaw bone of the Long-nosed Bandicoot (*Perameles nasuta*) were observed in woodland areas, with diggings observed particularly in areas dominated by *Allocasuarina* trees. A Bush Rat (*Rattus fuscipes*) was recorded to the east of the landfill during previous surveys, and the skull of a rat, possibly either this species or the introduced Black Rat (*Rattus rattus*) was found near a rock outcrop in the proposal footprint.

Two rock outcrops containing many crevices are present within the isolated patch of intact vegetation south of the western sediment control and water reuse basin. Many fauna carcasses were observed near these rock outcrops, including those of the Australian White Ibis, Australian Raven, European Rabbit, macropods, Common Ringtail Possum, Red Fox and the rat noted above. These are likely to be or have been fox dens, given the presence of these carcasses. These rock outcrops are also potential den habitat for the threatened Spotted-tailed Quoll (*Dasyurus maculatus*) however the presence of foxes is likely to make these unsuitable for this species. Spotted-tailed Quolls tend to prefer mature wet forests and gullies (Belcher 2000), and habitat in the study area is thus not optimal for the species.

A number of termite mounds were observed within the proposal footprint. These showed some evidence of disturbance, most likely from Echidnas (*Tachyglossus aculeatus*) as disturbance was generally on the surface only, and no deep holes were observed. Termite mounds can provide nesting habitat for the threatened Rosenberg's Goanna (*Varanus rosenbergi*). No evidence of this species was recorded during camera surveys in the proposal footprint or during previous cage trapping surveys to the east of the landfill. The common Lace Monitor (*Varanus varanus*) was recorded in the proposal area.

Groundcover within the native woodland varies, with some patches of woodland high in floristic diversity where *Allocasuarina* species were less dominant. Fallen debris and leaf litter is present in the less disturbed areas of the proposal footprint. Dark-flecked Garden Sunskinks (*Lampropholis delicata*) were regularly observed in the leaf litter. Eastern Water Skinks (*Eulamprus quoyii*) were observed basking on fallen timber and rocky outcrops. Diggings of a bandicoot (most likely the Long-nosed Bandicoot *Perameles nasuta*) were observed throughout this habitat type and a jaw of this species was also recovered. The threatened Giant Burrowing Frog (*Heleioporus australiacus*) could forage and shelter in this vegetation. This species is known to travel more than 500 metres from water (Lemckert and Brassil 2003). The Mountain Dragon (*Rankinia diemensis*) was observed basking in rocky habitat within the disturbed vegetation.

Upland Swamp

Upland swamp habitat occurs in the north-west of the study area and contains small semi-permanant pools among a thick sedge understorey cover. A heathy midstorey is present in some areas of the outlying swamp habitat and provides foraging resources when flowering for species such as the New Holland Honeyeater (*Phylidonyris novaehollandiae*) and Noisy Friarbird (*Philemon corniculatus*). A Brown Goshawk (*Accipiter fasciatus*) was observed foraging above the swamp during the survey.

The Brown Striped Frog (*Limnodynastes peronii*) and Common Eastern Froglet were heard calling during surveys at the Needlebush - Banksia wet heath. No other frogs were heard or observed at this location. Potential habitat for the threatened Giant Burrowing Frog (*Heleioporus australiacus*) and Red-crowned Toadlet (*Pseudophryne australis*) is present at this swamp, although neither species was recorded during targeted surveys in appropriate conditions. Red-crowned Toadlets require a pH range between 5.5 and 6.5. The recorded pH was 5.87 meaning that the species could potentially ustilise the ephemeral waterbodies in this swamp.

Existing and prevous disturbance may reduce habitat quality for these frog species. High levels of lead shot from the adjacent clay target club are present within the swamp and surrounding area. Lead concentrations from lead shot in soil are particularly high in skeet and shooting ranges, where lead concentrations within the soil and surface water recorded up to 1000 fold higher than at control sites (Stansley and Roscoe 1996). When lead shot is deposited on the soil, lead compounds are oxidised and released into the soil (Jorgensen and Willems 1987), where they become bioavailable for a range of flora and fauna within the ecosystem (Ma 1989). The effects of lead intake on fauna can result in histopathological indications of lead poisoning, and reduced haemoglobin levels (Stansley and Roscoe 1996). Lead uptake in frogs has been poorly researched, but elevated levels of lead have been recorded in a number of frog species outside Australia (Stansley and Roscoe 1996, Niethammer et al.1985, Stansley et al 1997). An elevated lead level in frogs is known to significantly affect the mortality of some species (Stansley et al 1997) and can inhibit the growth and development of frogs (Power et al 1989). The effect of lead on the Giant Burrowing Frog and Red-crowned Toadlet is not known, however could reduce the habitat quality present at this swamp.

4.2.7 Aquatic habitats and species

Dams

Two dams are located along the previously realigned Mill Creek. The dam in the south (outside the proposal footprint) is heavily vegetated at its southern end with a dense patch of Broad-leaved Cumbungi (*Typha orientalis*). The dam in the area proposed for the ARRT facility has no emergent vegetation, but does contain extensive beds of opportunistic submerged and emergent macrophytes. Fringing vegetation includes *Allocasuarina* and eucalypts, as well as grasses.

Typical common wetland bird species such as the Pacific Black Duck (*Anas superciliosa*), Dusky Moorhen (*Gallinula tenebrosa*) and Chestnut Teal (*Anas castanea*) were observedon open water in these dams. Semi aquatic species such as the Eastern Water Dragon (*Physignathus lesueurii*) are present, and dam habitat and is also likely to be used by the Red-bellied Black Snake (*Pseudechis porphyriacus*).

Common frogs such as the Eastern Dwarf Tree Frog (*Litoria fallax*), Peron's Tree Frog (*Litoria peronii*) and Smooth Toadlet (*Uperoleia laevigata*) were heard calling in these dams. The Broad-palmed Frog (*Litoria latopalmata*), was heard and observed at the dam within the area proposed for the ARRT facility. These two dams provide breeding habitat for these frog species.

Common families of dragonfly (Aeshnidae, Libuliidae) and damselfly (Coenagrionidae, Megapodagrionidae) were observed flying above Mill Creek and the artificial dams.

Mill Creek in the study area

Mill Creek in the proposal footprint is a first order stream. As noted elsewhere, Mill Creek has previously been realigned within the study area and does not follow its natural course. The creek width varies between about 1-2 metres wide along much of its length. In the southern portion of the study area, the creek has a generally natural form, with planted vegetation present in the riparian zone (Photograph 13). This includes a range of eucalypts and dense thickets of tea-tree (*Leptospermum* spp.). Leaf litter is present in the riparian zone in this area. Occasional patches of emergent vegetation including *Typha* are present. Much of the creek habitat has overhanging vegetation in the form of native shrubs and low trees which provide a great deal of organic matter input to the creek. The Dusky Moorhen and Eastern Water Dragon were observed in larger pools in this section of the creek. The aquatic habitat generally resembles an upland ephemeral waterway with some persistant waterholes that are likely to provide habitat for a moderately diverse aquatic fauna.

In the proposal footprint (near the proposed ARRT and GO facilities), Mill Creek typically occurs over sandstone bedrock with a number of small, shallow pools present. Steep banks occur between the creek and the adjacent landfill at this location (Photograph 14). Adjacent vegetation includes Allocasuarinas and heathy shrubs and there is limited leaf litter. Occasional patches of emergent vegetation were observed. The aquatic habitats present in the proposal footprint are dominated by shallow pools over bedrock, with overlaying sand and clay/silt sediments. Eastern Water Skinks were observed on exposed bedrock at this location.

Photograph 13: Mill Creek upstream of the proposed GO facility

Photograph 14: Mill Creek within the proposal footprint

Near the northern border of the proposed ARRT facility Mill Creek is located in an artificial drain, and travels through short pipes in some locations. Emergent vegetation is often present at the interface between the drain and the pipes (Photograph 15). Common Eastern Froglets (*Crinia signifera*) and Brown-striped Frogs (*Limnodynastes tasmaniensis*) were heard calling in these areas. Further downstream, the dirty water drain is located adjacent to Mill Creek (Photograph 16). This drain directs dirty water away from Mill Creek.

Photograph 15: Mill Creek downstream of the proposed ARRT facility, showing the unnatural creek bed and banks

Photograph 16: Mill Creek (on the left) downstream of the proposed ARRT facility, with the dirty water drain on the right (area with black plastic)

A previous record of the Giant Burrowing Frog exists along the southern section of Mill Creek in the study area. This species could forage and shelter in the riparian leaf litter, and also potentially breed in ephemeral ponds. The species may use Mill Creek and adjacent vegetation to disperse between better quality vegetation to the south and north, although the unnatural stream bed to the north of the proposed ARRT facility is likely to limit the movement of the species in this location. Preferred breeding habitat includes ephemeral pools and soaks formed in eroded sandstone drainage lines, and is rarely associated with permanent ponds or streams (Mahony 1993, Watson & Martin 1973). Tadpoles have been recorded in clear water with a pH 4.3–6.5 (Recsei 1997). Measurements of pH in the study area found the pH in Mill Creek and the two dams to range between pH 6.87-9.7, averaging around pH 8. Not including the dams, the pH of Mill Creek averaged at 7.19. This may mean that Mill Creek is unsuitable for breeding for the Giant Burrowing Frog.

The Red-crowned Toadlet breeds in ephemeral feeder creeks or flooded depressions, requiring unpolluted water between 5.5 and 6.5 pH. The pH levels recorded along Mill Creek make this waterway unsuitable for this species. Given the disturbance of vegetation in the study area, high pH levels recorded, and lack of evidence of the species during targeted surveys, this species is unlikely to occur in the proposal footprint.

Common families of dragonfly (Aeshnidae, Libuliidae) and damselfly (Coenagrionidae, Megapodagrionidae) were observed flying above Mill Creek. In addition, adult Mayflies (Ephemeroptera) were observed, although less commonly. Hemipteran water bugs were commonly present where standing water occurred including families such as Gerridae and Veliidae (Water Striders) and the diving taxa such as Notonectidae and Corixidae (Backswimmers and Water Boatmen). These are all common taxa found in surface waters across NSW and are taxa generally tolerant of changes in water and habitat quality.

Macroinvertebrates were collected at one site (MCUP) within the study area as part of the aquatic ecosystem investigation (GHD 2015d). This site is located at water quality site 6 as mapped on Figure 3-1. A total of 24 macroinvertebrate taxa were collected at this site. SIGNAL 2 scores for this site suggest elevated salinity or nutrient levels, however the site’s physical conditions are sufficient to support diverse macroinvertebrate life. The AUSRIVAS results suggest that this site is in good condition (GHD 2015d). As this site is above much of the LHRRP and near the top of the ridge, this is to be expected, as there are likely to be less disturbance or pollutants at this location.

The realigned creek and artificial dams are not likely to be potential habitat for Adam's Emerald Dragonfly (*Archaeophya adamsi*), listed as endangered under the FM Act. This species is known only from four locations in the Sydney Basin, none being in southern Sydney. Preferred habitat for this species includes small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian vegetation. No riffle habitats were present at any of the surveyed sites during the survey, and if they became present during higher rainfall/surface flow events, they would be highly unlikely to persist for a period of time long enough for colonisation by this species.

No habitat for the Sydney Hawk Dragonfly (*Austrocordulia leonardi*), listed as endangered under the FM Act, is present in the study area. This species has specific habitat requirements, and has only ever been collected from deep and shady riverine pools with cooler water. While the species has been collected from the nearby Woronora River, their habitat preference suggests larger, cooler waters of higher order streams, than those present within Mill Creek. The current known distribution of the Sydney Hawk Dragonfly may include areas adjacent to the SITA Mill Creek sites although the habitat required by this species is highly unlikely to occur and persist, sufficient for colonisation.

No habitat for threatened fish species predicted to occur in the Sydney Metro CMA is present in the study area. Threatened fish species predicted to occur in the CMA include marine and estuarine species only (DPI 2015a). Mill Creek in the study area is not mapped as key fish habitat.

Water Quality

provides the results of the water quality sampling along Mill Creek and the two online dams in the study area. Conditions outside the ANZECC (2000) Guidelines, 95% protection levels for slightly disturbed lowland ecosystems of south-east Australia, are highlighted. Although portions of the Mill Creek catchment are at an altitude above 150 m, the majority is below 150 m, therefore the ANZECC guidelines applied were for lowland ecosystems.

Table 4-8 *In situ* water quality observed at sites where surface water was present during the field survey in January 2015

Site No.	Site name	Time	Temperature (°C)	Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%sat)
1	MC-Swamp	9:20	20.04	505	5.87	3.34	36.5
2	MC-AE1	9:50	23.11	696	6.87	5.64	65.9
3	MC-Dam1	10:05	26.42	320	9.7	14.06	175.2
4	MC-AE2	10:20	22.72	533	7.68	6.92	80.2
5	MC-Dam2	10:35	26.63	248	8.94	13.67	171.2
6	MC-AE3	10:50	23.71	448	7.03	1.63	19.0
	Guideline	**N/A**	**N/A**	**2200**	**6.5-8.0**	**N/A**	**85-110**

The water quality results indicate that water quality conditions across the site are highly variable, particularly pH and dissolved oxygen levels. The measured pH ranged from a low of 5.87 at the swamp site to a high of 9.7 at the dam where the ARRT facility is proposed. Sites which were generally in a more natural riverine state (sites 2, 4 and 6) were within the pH guideline limits, while the two dam sites were above the upper limit.There was no apparent trend in pH conditions across an altitudinal gradient.

Dissolved oxygen (DO) values varied across the sites with the lowest value of 19% occurring at site 6, the most upstream site sampled, and the highest value of 175% occurring at the dam where the ARRT facility is proposed. While there were no obvious trends in DO with increasing distance upstream, the two dam sites observed high levels suggesting excessive chemical or biological activity in these constructed water bodies. High cover of algae and macrophytes were obsereved at these two sites which may be contributing factors, however the levels observed imply irregular conditions may be occurring. Furthermore, the cause of the fluctuating DO values may be attributable to leachate entering the surface water and/or the oxidation of iron species in the groundwater which are naturally occurring in the groundwater which is entering the surface water as baseflow. Ongoing monitoring of leachate indicators (as currently occurs and will continue) will provide a suitable basis for assessing whether the DO variation is due to the landfilling of waste at the site.

Mill Creek below the LHRRP

All sites downstream of the LHRRP assessed for the aquatic ecosystem investigation (GHD2015d) had a mostly natural and continuous riparian vegetation zone almost completely dominated by native species. A healthy mix of ground cover, shrub layer and over story trees was present at all sites. The macrophytes in the riparian zone were generally emergent forms and were predominantly natives with cover ranging between 5-20% of the available habitat across the sites.

The geomorphic nature of the sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. The active channel was well defined. Substrates were a mix of bedrock, boulder, gravel, sand and clay/silt, but predominantly bedrock and clay/silt. Flow habitat types were generally half pool and half run with some riffle occurring at the site furthest downstream (MC4) (GHD 2015d).

Disturbance to the ground surface associated with recreational vehicle activities was observed at MC3. These activities appear to be causing an influence on the integrity of the stream banks and causing increased levels of sediment deposition (eroded from unsealed dirt tracks) in close proximity to this monitoring location. The general habitat condition at this site was rated as good. Other monitoring sites below the LHRRP were in excellent (MC4) or very good condition (MC 1 and MC2).

A total of 46 macroinvertebrate taxa were identified across the five monitoring locations assessed for the aquatic ecosystem investigation (GHD2015d). Site MCUP is the site located upstream of the proposed ARRT and GO facilities (described above). The other four sites are located downstream of the LHRRP. A full discussion of macroinvertebrate results is provided in GHD (2015d), however a summary is provided here:

- Lower taxa richness and SIGNAL 2 richness were observed at sites MC 3 and MC 4, located furthest from the LHRRP, suggesting some impact from the LHRRP or other disturbance (eg pollutants from Heathcote Road).
- SIGNAL 2 biotic index scores indicated that all sites are subject to elevated salinity or nutrient levels. These elevated levels may occur naturally or as a result of human activities. Whatever the source, the relatively high number of macroinvertebrate taxa identified across the monitored locations suggests that physical conditions are sufficient to support diverse macroinvertebrate life.
- The Signal 2 taxa richness scores for the three monitoring locations closest to the LHRRP are higher than those for the two locations furthest away from the LHRRP, but the SIGNAL 2 Biotic Index scores were higher at the downstream sites. This demonstrates that the sensitivity to pollution of the taxa at the sites closer to the LHRRP is lower than those further downstream. This suggests that while some nutrient enrichment may be occurring at the higher elevation sites near the LHRRP, it could be reducing by dilution downstream.

- Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present. While this may seem a cause for concern these ratings are relatively good. Recent studies of the Georges River catchment found that urban streams throughout the catchment contain macroinvertebrate communities dominated by pollution tolerant species with little or no pollution sensitive species present (Tippler *et al.*, 2014). This suggests that macroinvertebrate communities present at the monitoring locations were generally in a healthy condition given the extent of catchment disturbance associated with a development such as the LHRRP.
- AUSRIVAS assessment of macroinvertebrate communities' rated MCUP as in 'Reference condition' (Band A), MC3 as 'Severely impaired' (Band C) and the remainder as 'Significantly impaired' (Band B). The decline from Band A to Band B immediately downstream of the LHRRP (MC1) is not unexpected given the change in catchment landuse associated with the LHRRP. The decline to Band C at MC3 is likely due to a decline in taxonomic diversity, also displayed in the richness results discussed above. This may be attributed to several factors but is likely due to the decline in aquatic and riparian habitat condition that may be linked to nearby recreational vehicle use. Condition improves again at MC4, which is furthest from the LHRRP. Note that MC1, 2 and 4 were all in the upper levels of Band B, close to Band A (reference condition).

No dragonflies of the family Corduliidae (the family in which the threatened Sydney Hawk Dragonfly and Adam's Emerald Dragonfly are placed) or Petaluriidae (the family in which the threatened Giant Dragonfly is placed) were recorded during the macroinvertebrate surveys (GHD 2015d).

4.2.8 Habitat connectivity

Assessment of habitat connectivity and the proposal's impacts on habitat connectivity is provided in the assessment of landscape value according to the FBA that is provided in Section 7.2.

4.3 Conservation significance

4.3.1 Threatened ecological communities

No TECs have been identified within the proposal footprint. Two TECs have been recorded in or near the study area:

- Coastal Upland Swamp: Needlebush - Banksia wet heath on sandstone plateaux (ME015) and Hairpin Banksia - Slender Tea-tree heath (ME013) are commensurate with Coastal Upland Swamps in the Sydney Basin Bioregion, listed as an endangered ecological community under the TSC Act and EPBC Act. This community is located about 50 m downslope of the proposed detention pond that will be located north of the ARRT facility, and about 70 m to the east of the existing landfill (see Figure 4-1).
- Shale-Sandstone Transition Forest: Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest (ME021) is commensurate with this critically endangered ecological community CEEC. A narrow strip of this CEEC is located to the north-east of the existing landfill, outside the proposal footprint. This extends into a large stand further to the east of the proposal footprint. A second stand is mapped by SCC to the north of this stand (see Figure 4-1).

4.3.2 Threatened flora species

The Protected Matters Search predicts 25 threatened flora species that may occur in the locality. Of these, 11 species have been previously recorded in the locality (OEH 2014a).

One threatened flora species was previously recorded in the proposal footprint during surveys:

- *Acacia bynoeana,* listed as an endangered species under the TSC Act and a vulnerable species under the EPBC Act. One individual was recorded alongside the boundary track in the area proposed as the GO facility during the constraints surveys in 2014. This specimen was protected by wooden posts and tape. This species appears to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches (OEH 2015b). During the March 2015 survey it was noted that the individual was in poor condition compared to the earlier survey. In the March 2016 survey, no evidence of the individual could be found at the marked location. Given the lack of any evidence, it is thought that the individual died about six months prior. No other individuals have been recorded in the proposal footprint, and none were recorded in the adjacent SICTA land during vegetation mapping surveys conducted in February 2016. *Acacia bynoeana* has previously been recorded between 3 and 5 km to the north-east of the study area (Cumberland Ecology 2012), in the land proposed as the Menai Ridge development.

Three threatened flora species occur near the study area. These comprise:

- *Eucalyptus camfieldii* (listed as a vulnerable species under the TSC Act and EPBC Act). A stand of *E. camfieldii* (including hybrid specimens) was identified about 100 metres to the east of the proposal footprint during surveys in this area in 2010 (GHD 2011) (see Figure 4-1). This species was identified within Hairpin Banksia - Slender Tea-tree heath. No individuals of this species have been recorded in the proposal footprint.
- *Melaleuca deanei* (listed as a vulnerable species under the TSC Act and EPBC Act). Two *M. deanei* were recorded about 200 metres to the east of the proposal footprint during surveys in this area in 2010 (GHD 2011). One individual was recorded about 200 metres to the south of the proposal footprint near Heathcote Road (GHD 2012) and one idividual was recorded during the March 2015 survey on the western side of Heathcote Road approximately 400m to the north-west of the intersection with New Illawarra Road. All records are located in areas of Red Bloodwood - Scribbly Gum heathy woodland. This species has also previously been recorded within 500 metres of the proposal footprint to the north and to the south (OEH 2014a). No individuals of this species have been recorded in the proposal footprint.
- *Melaleuca biconvexa (*listed as a vulnerable species under the TSC Act and EPBC Act). One individual was recorded during the March 2015 survey on the eastern side of Heathcote Road, on slopes leading down to a culvert and a tributary of Mill Creek. This individual is growing on a section of road reserve within occasionally mown grassland, adjacent to a dense patch of *Allocasuarina littoralis*.

During the March 2015 survey, incidental searches were carried out for appropriate habitat for the threatened terrestrial orchid *Genoplesium baueri* (Brittle Midge Orchid). The Brittle Midge Orchid occurs in heathy eucalypt forests and in "…moss gardens in sandy soils on sandstone…" (Bishop 2000). The flowering time for this species is February to May, and because there has been adequate rainfall over the previous summer, it may be assumed that if this species were present on the site, some individuals would be visible in March. No flowering terrestrial orchids, and no *Genoplesium* species were recorded on the subject site during the March 2015 survey.

The study area and proposal footprint contain broadly suitable habitat for a number of other threatened plants that are known or predicted to occur in the locality based on the results of the desktop assessment (see Appendix B) and/or the FBA credit calculations (see Table 4-1). Based on the historical clearing, small area of native vegetation and natural soil profiles that could comprise threatened plant habitat in the proposal footprint, and the survey effort employed, these species can be reliably discounted as occurring in the proposal footprint or being affected by the proposal.

4.3.3 Threatened flora populations

Allocasuarina diminuta subsp. mimica

One endangered flora population listed under the TSC Act has been identified within the proposal footprint: *Allocasuarina diminuta* subsp*. mimica* L.A.S.Johnson population in the Sutherland and Liverpool local government areas. Most of the population records occur in land alongside Heathcote Road (OEH 2015b).

Many ramets of *Allocasuarina diminuta* subsp. *mimica* were recorded during the March 2015 taregeted survey for the species both within the proposal site and outside the proposal site, mainly in the road reserve of Heathcote Road. The stems of *Allocasuarina diminuta* subsp. *mimica* are described as ramets, because it is possible that many of the stems have reproduced apomyctically after damage to the roots and stems of the original plants. Because some ramets were recorded along the fence between the proposal footprint and Heathcote Road, surveys were also carried out along both sides of a section of road reserve adjacent to the proposal footprint.

All ramets recorded within the SITA land were recorded along the access track along the western and northern boundary fence. Additional ramets were recorded in the SICTA land to the north in regenerating woodland. A follow-up survey was conducted in the company of a qualified surveyor in March 2016 to accurately map the location of the ramets with respect to the layout of the GO and ARRT facilities, and to refine the layout of these facilities in order to minimise impacts on the endangered population. Due to redesign of the GO facility, no *Allocasuarina diminuta* subsp. *mimica* ramets are present with the GO facility footprint. A total of about 67 ramets are within the ARRT facility footprint (66 along the track margin between SITA and SICTA land), and one in regenerating woodland in SICTA land. 62 ramets within the ARRT footprint appear to be hybrids with the common *Allocasuarina littoralis*, with which the endangered population is growing. Specimens have been forwarded to the National Herbarium of NSW for further analysis.

A total of 137 ramets were counted outside the proposal footprint, both along Heathcote Road and within SICTA land during the March 2015 survey. At least 12 ramets were recorded on the eastern side of Heathcote Road, and 101 in the drainage line and slopes along the western road reserve. About 24 ramets were recorded in disturbed vegetation immediately to the north of the proposal footprint in SICTA land.

Ramets were recounted along the boundary fence during the March 2016 survey. A total of 89 ramets were counted within SITA land along the western access track (outside the proposal footprint). Additional individuals were observed on the road reserve side of the fence. The number of ramets recorded within the boundary fence has increased between the two targeted surveys, likely as a result of further disturbance (eg access track maintenance). It is recommended that further surveys be conducted to accurately quantify the number of ramets present in the ARRT facility closer to the time of construction.

Female flowers were recorded on several stems and cones were common on stems within most patches of this species, therefore it is possible that viable seed has been produced. It was noted however that some cones were beginning to open during the survey. Seed collection by the on-site nursery volunteers was recommended and preliminary seed collection was undertaken in 2015 (see section 6.3).

A more detailed description of the occurrence of this endangered population is provided in section 7.6.3.

Prostanthera saxicola

The SEARs highlighted the *Prostanthera saxicola* endangered population in the Sutherland and Liverpool LGAs as an endangered population of possible concern for the proposal. This population occurs mainly between Holsworthy station and Sutherland station, north from Lucas Heights and south of the Georges River. It grows primarily in eucalypt forest, heath and low shrubland, often in damp or moist sites. Woodland in the proposal footprint has been heavily disturbed, with much of it being regrowth on skeletal soils. Intact vegetation is dry, with few, if any, damp or moist sites. This species was not recorded during surveys in the proposal footprint and adjacent areas. No individuals of this species have been observed in the study area by the nursery volunteers. Given the lack of preferred habitat and lack of any evidence of its occurrence, this population is unlikely to be present in the proposal footprint. An expert report is provided in Appendix E.

4.3.4 Threatened fauna species

Only one threatened fauna species was possibly recorded during the field surveys:

- The Greater Broad-nosed Bat (*Scoteanax rueppellii*), listed as a vulnerable species under the TSC Act, was possibly recorded during anabat surveys (see section 4.2.4). The calls of this species are similar to those of Gould's Wattled bat (*Chalinolobus gouldii*) which was definitiely recorded on site. Call characteristics overlap making it too difficult to distinguish between species if call quality is not good, or if enough calls are not recorded. There are a small number of records of the Greater Broad-nosed Bat in the locality, and it could occur in the study area. This species is known from a wide variety of habtiats, including open woodland and tree-lined creeks in open areas (Churchill 2008).

Four threatened species have been recorded to the east of the study area during previous surveys (GHD 2011), and could occur on occasion in the proposal footprint:

- Grey-headed Flying-fox (*Pteropus poliocephalus*), listed as a vulnerable species under the TSC Act and the EPBC Act, was recorded flying over the study area. This species could forage in flowering myrtaceous trees in the study area on occasion. There are no roost camps in the proposal footprint or broader study area.
- Black-chinned Honeyeater (*Melithreptus gularis*), listed as a vulnerable species under the TSC Act, was recorded in Red Bloodwood – Scribbly Gum heathy woodland east of the proposal footprint and could forage in the proposal footprint on occasion. Breeding is unlikely in the proposal footprint due to the generally disturbed nature of the vegetation.
- Scarlet Robin (*Petroica boodang*), listed as a vulnerable species under the TSC Act, was recorded in woodland east of the proposal footprint and could forage in the proposal footprint on occasion. Breeding is unlikely in the proposal footprint due to the generally disturbed nature of the vegetation.
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), listed as a vulnerable species under the TSC Act, was recorded near a dam to the east of the proposal footprint. This species could forage above the proposal footprint on occasion. No breeding habitat (maternity caves) is present.

The study area contains suitable habitat for a number of additional fauna species that have been recorded in the locality within the last 20 years. Threatened fauna species that are known or have the potential to occur in the study area based on the habitat resources present and recent records in the locality are listed in Table 4-9. Species with potential habitat present but considered unlikely to occur are also listed in Table 4-9.

No suitable habitat is present for threatened aquatic fauna species listed under the FM Act (see section 4.2.7).

Table 4-9 Likelihood of occurrence of threatened fauna species in the proposal footprint

Common Name	Scientific Name	TSC Act Status	EPBC Act Status	Liklelihood of Occurrence/Habitat in the proposal footprint
MAMMALS				
Eastern Pygmy-possum	*Cercartetus nanus*	V		Likely. Suitable foraging and nesting habitat present in native vegetation in the proposal footprint.
Koala	*Phascolarctos cinereus*	V	V	Unlikely. Poor quality foraging habitat present only. No primary feed trees present. Occasional secondary feed trees are present. May forage in the proposal footprint on occasion when moving between other areas of better quality habitat. Unlikely to breed in the proposal footprint. Proposal footprint is not considered an important habitat area for the Koala. No habitat critical for the survival of the species is present in the proposal footprint.
Spotted-tailed Quoll	*Dasyurus maculatus*	V	E	Possible. May utilise the project footprint for dispersal and foraging. Two small rock outcrops and fallen timber are present, representing potential den habitat. The rock outcrops appear to be currently used by foxes and are thus unlikely to be den sites for the Spotted-tailed Quoll. Tree hollows present are very small (~5cm diameter) and are not suitable denning habitat. No moist forest (preferred habitat) present. A range of prey species, including the Common Ringatil Possum, are present.
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	Likely. Would forage in flowering eucalypts on occasion.
Eastern Bentwing Bat	*Miniopterus schreibersii oceanensis*	V		Possibly recorded. Could forage in native vegetation and cleared areas within the proposal footprint. Suitable roosting habitat not present. Preferred breeding habitat includes caves, culverts and buildings.
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V		Possible. May forage on occasion in native vegetation within the proposal footprint. No suitable roosting habitat present. Prefers tall moist forest for foraging and breeding which is not present in the proposal footprint.
Eastern Freetail-bat	*Mormopterus norfolkensis*	V		Likely. May forage on occasion in native vegetation within the proposal footprint. May roost/breed in hollow-bearing trees in the study area, although hollows present are very small.
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V		Likely. Could forage in native vegetation and cleared areas within the proposal footprint. May roost/breed in hollow-bearing trees in the study area, although hollows present are very small.
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	V	Possible. Limited suitable forested foraging habitat present. No breeding habitat (sandstone caves and crevices) present.

Common Name	Scientific Name	TSC Act Status	EPBC Act Status	Liklelihood of Occurrence/Habitat in the proposal footprint
Large-footed Myotis	*Myotis macropus*	V		Likely. May forage above dams and Mill Creek on occasion. Suitable roosting habitat not present. Preferred roosting habitat includes caves, culverts and bridges.
Little Bentwing Bat	*Miniopterus australis*	V		Likely. May forage on occasion in native vegetation within the proposal footprint. No suitable roosting habitat present. Preferred roosting habitat includes caves, culverts and buildings.
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V		Likely. Could forage in native vegetation and cleared areas within the proposal footprint. May roost/breed in hollow-bearing trees in the study area, although hollows present are very small.
BIRDS				
Black-chinned Honeyeater	*Melithreptus gularis gularis*	V		Likely. May forage on occasion in the proposal footprint. Unlikely to breed in the proposal footprint due to disturbed nature of the vegetation.
Flame Robin	*Petroica phoenicea*	V		Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.
Gang-gang Cockatoo	*Callocephalon fimbriatum*	V		Likely. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V		Likely. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.
Little Eagle	*Hieraaetus morphnoides*	V		Possible. May forage on occasion in the study area. No breeding habitat (tall trees) present ij the proposal footprint.
Little Lorikeet	*Glossopsitta pusilla*	V		Possible. May occur on occasion, although previous clearing may have reduced structural complexity required for this species. Good quality habitat present in adjacent areas. No breeding habitat present in the proposal footprint.
Masked Owl	*Tyto novaehollandiae*			Possible. May forage on occasion in the study area. No breeding habitat present.
Powerful Owl	*Ninox strenua*	V		Likely. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.
Scarlet Robin	*Petroica boodang*	V		Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.
Square-tailed Kite	*Lophoictinia isura*	V		Possible. May forage on occasion in the study area. No breeding habitat (tall trees) present ij the proposal footprint.
Swift Parrot	*Lathamus discolor*	V		Possible. May forage on occasion in the study area. *Corymbia gummifera*, a preferred forage species, is the dominant eucalypt in the

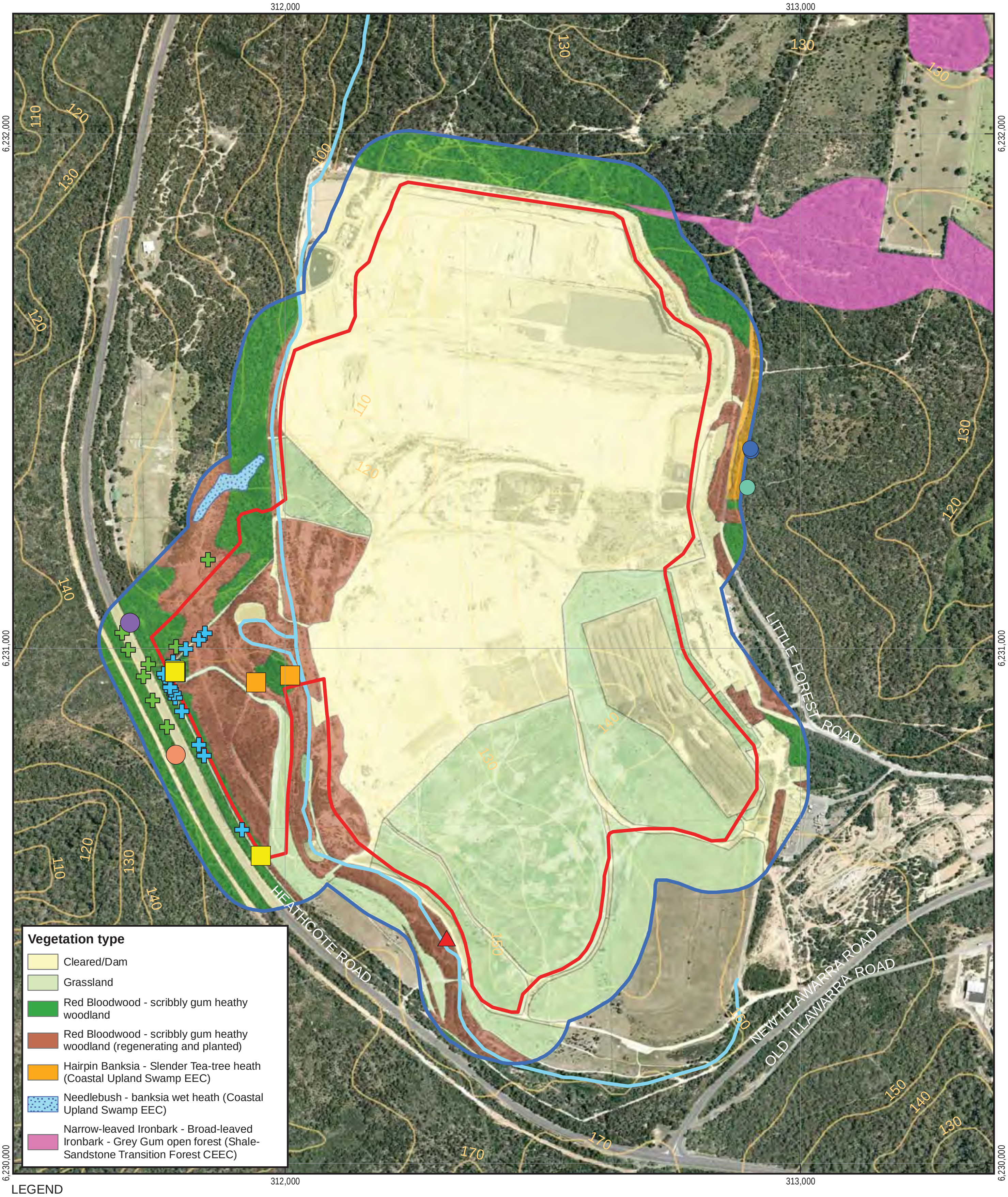
Common Name	Scientific Name	TSC Act Status	EPBC Act Status	Liklelihood of Occurrence/Habitat in the proposal footprint
				proposal footprint. Does not breed on the Australian mainland. Few local records.
Varied Sittella	*Daphoenositta chrysoptera*	V		Possible. May occur on occasion, although previous clearing may have reduced structural complexity required for this species. Good quality habitat present in adjacent areas.
REPTILES				
Rosenberg's Goanna	*Varanus rosenbergi*	V		Unlikely. No evidence of the species during camera surveys for this proposal or previous trapping surveys in nearby areas (GHD 2011).
FROGS				
Giant Burrowing Frog	*Heleioporus australiacus*	V	V	Unlikely. Potential shelter habitat in woodland habitat and along riparian zone and potential breeding habitat in swamps and ephemerals pools along Mill Creek. Previous and ongoing disturbance may have reduced habitat quality for the species. A previous record exists in the study area (OEH 2014). Not recorded during targeted survey in appropriate conditions.
Red-crowned Toadlet	*Pseudophryne australis*	V		Few ephemeral streams present in the proposal footprint. This species requires unpolluted water between 5.5 and 6.5 pH. The pH levels recorded along Mill Creek make this waterway unsuitable for this species.

4.3.5 Migratory species

The desktop analysis highlighted a number of migratory species with potential to occur in the locality. The proposal footprint does not contain habitat for marine migratory species, and contains no areas that are unlikely to represent important habitat for wetland bird species. The Rainbow Bee-eater (*Merops ornatus*), Satin Flycatcher (*Myiagra cyanoleuca*) and Rufous Fantail (*Rhipidura rufifrons*) are nomadic woodland birds that disperse widely across south-eastern Australia in response to seasonal cues and food availability. Accordingly, individuals of these species could occur within the woodland habitats in the study area on a seasonal or opportunistic basis. However, their occurrence on the site is likely to be transient and the site would represent only marginal foraging habitat for these highly mobile species. Vegetation within the study area is highly modified, fragmented and would have only limited value for migratory species listed under the EPBC Act. Habitat in the study area is not likely to support an ecologically significant proportion of the population of any of these species, be of critical importance to the species at particular life-cycle stages, located at the limit of any of the the species' range, and/or be located within an area where the species is declining. As such, potential habitat in the study area is not 'important habitat' for any of these species, as defined in DotE (2013).

4.3.6 Other Matters of National Environmental Significance

The protected matters search (DotE 2014b) identified one National Heritage Place and Wetland of International Importance in the locality. The National Heritage Place is not relevant to this biodiversity assessment report. Towra Point Wetland is located in Botany Bay. Botany Bay is within the same catchment as the study area and is located 20km downstream of the site on the Kurnell Peninsula. Towra Point Wetland is unlikely to be impacted by the proposal due to its distance from the proposal and appropriate environmental management measures will be implemented to protect water quality in Mill Creek. These additional MNES are not considered further in this report.



LEGEND

Study area
Project footprint
Mill Creek
10m Contour

Threatened species

?Greater Broad-nosed Bat
Allocasuarina diminuta subsp. *mimica* (2015 Survey)
Allocasuarina diminuta subsp. *mimica* (2016 Survey)
Eucalyptus camfieldii x *E. capitellata* hybrid
Eucalyptus (?) sp. aff. *camfieldii*
Melaleuca biconvexa
Melaleuca deanei

Habitat feature

Hollow-bearing tree
Rock outcrop

Paper Size A4
0 50 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

SITA Australia
Lucas Heights Resource Recovery Park

Job Number 21-23482
Revision A
Date 05 May 2016

Vegetation, threatened biota and habitat resources

Figure 4-1

G:\21\23482\GIS\Maps\MXD\21-23482-Z042_Vegetation and Threatened BiotaECOLOGY_Rev.mxd

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Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by:mking3

5. Impact assessment

5.1 Approach

As noted in Section 1.3, the proposal will be staged, with the GO facility to be built as soon as possible following project approval, and the AART facility to be constructed upon securing waste supply. A review has been undertaken which concludes that SITA has approval under the current consent (1999 EIS and associated Consent R97/00029) to clear vegetation on the batters of the existing landfill as it is not yet at final profile. As such, impacts associated with the clearing of regenerated/planted vegetation on the batters of the existing landfill for reprofiling have not been considered in the impact assessment and biobanking credit calculations.

5.2 Construction and operation of the proposal

5.2.1 Direct impacts

Clearing of vegetation

The majority of the proposal is to be undertaken in areas which have previously been disturbed (see Figure 4-1). Landfill reprofiling would be mainly within the existing landfill footprint, which has all been completely cleared in the past. A very small area of young regenerating native vegetation is present at the western side of the landfill, east of Mill Creek. Construction of the ARRT and GO facilities, including the access road and realignment of Mill Creek, would mainly occur in areas that are currently vegetated, but have previously been disturbed. Historical aerial photographs show that the landfill, GO facility and ARRT facility areas appeared vegetated in the earliest available photograph (1947) before being largely cleared of vegetation at some stage between 1947 and 1961. The GO facility and ARRT facility areas remained predominantly cleared until the 1982 photograph where vegetation was observed. Mill Creek was previously located further to the east of the proposed GO facility and ARRT facility area, within the area currently occupied by the landfill. It was realigned to its present location in the late 1980s.

The proposal would directly affect up to 13.31 hectares of mainly regenerating Red Bloodwood - Scribbly Gum heathy woodland for the construction of the ARRT and GO facilities, access road and realignment of Mill Creek, as well as a small area located in the landfill. This comprises the removal of 4.84 ha for the construction of the GO Facility, 4.41 ha for the construction of the ARRT Facility, and 4.06 ha for the landfill (although this is not being considered here as it is subject to a prior approval). As such, a total of this 9.25 ha of native vegetation would be removed for the proposal, of which only 2.42 hectares is in good condition. Due to the construction of these facilities, a small section of Mill Creek would be realigned. Details regarding the Mill Creek realignment involved as part of this proposal are described in Chapter 6 of the EIS main document.

There would be no direct impacts on any threatened ecological communities (TECs). The sediment pond adjacent to the ARRT facility is located about 50 metres from the Needlebush - Banksia wet heath on sandstone plateaux of the Sydney Basin (ME015) (Coastal Upland Swamp).

The proposal would remove up to 67 ramets of *Allocasuarina diminuta* subsp. *mimica* (listed as an endangered population under the TSC Act) for construction of the ARRT facility (see Figure 4-1). Further assessment of impacts on this endangered population is provided in section 7.6.3.

The proposal would not directly impact any individuals of *Eucalyptus camfieldii, Melaleuca deanei* or *Melaleuca biconvexa* recorded outside the proposal footprint. No individuals were recorded in the proposal footprint despite targeted surveys. No other threatened flora species are likely to occur within the proposal footprint given the historical clearing and disturbance, and lack of evidence of any individuals.

Table 5-1 Proposed removal of vegetation within the proposal footprint

Vegetation Community	PCT / NSW Veg. Type ID (OEH 2014d)	Condition	Area within the LHRRP (ha)	GO facility	ARRT facility
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux	ME014	Moderate/ good	2.63	1.18	1.25
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux (regenerating and planted)	ME014	Moderate/ good (low)	10.68	3.66	3.16
Total native vegetation			**13.31**	**4.84**	**4.41**
Total native vegetation not including landfill regrowth			**9.25**		
Exotic grassland			26.77	1.16	0.21
Cleared land			71.77	0.09	0.25
Total area			**111.85**		

Note: Vegetation to be removed is inclusive of Asset Protection Zones (APZ).

This reduction in the extent of native vegetation in the locality would not threaten the persistence of local populations of native plants. The proposal would remove a small number of individuals of plant species. Flora populations would persist within adjoining areas of alternative habitat outside the site. This reduction in extent is also highly unlikely to affect the viability of remnant vegetation in the study area or locality or reduce the extent of habitat below a minimum size required for any fauna species. Further, much of the vegetation is disturbed, and has a much lower diversity than the adjacent intact native vegetation.

Construction within the remainder of the site would remove non-threatened native plants and noxious and environmental weeds within highly modified habitat that does not support a native vegetation community.

Removal of habitat resources

The proposal footprint provides habitat resources for native fauna species and contains mainly foraging and shelter resources for common native fauna. The 9.25 ha of native vegetation that would be removed provides foraging, breeding, roosting and nesting resources for a range of fauna species, including threatened species. Eucalypts and other native canopy species would provide nectar resources as well as foraging substrate for a diverse range of arboreal species, such as birds, reptiles (varanids), arboreal mammals and bats. The magnitude of impact is likely to be low given extensive areas of similar habitat in surrounding protected areas.

The proposal would remove five hollow-bearing trees containing very small hollows (~ 5cm diameter). These may be utilised by mammal species such as the Eastern Pygmy Possum and Sugar Glider and some microbat species, as well as tree frogs.The removal of these trees within the construction footprint is unlikely to comprise the removal of a significant proportion of the total resource, such that any local populations of fauna would experience significant negative impacts, given the expansive tracts of vegetation containing hollow-bearing trees that are present in the locality.

The proposal would remove fallen logs and rock outcrops, and termite mounds, which represent potential den habitat for the Spotted-tailed Quoll and potential nest sites for Rosenberg's Goanna, respectively. The removal of vegetation would also lead to the loss of potential foraging habitat for these and other ground-dwelling species.

The realignment of Mill Creek would result in the loss of riparian, stream and dam habitat for a range of frog, reptile and macroinvertebrate species. This potentially includes the loss of breeding habitat for the Giant Burrowing Frog, although this habitat is likely to be suboptimal, given the surrounding disturbance.

The proposal would also involve the removal of 1.37 ha of exotic grassland, which provides foraging habitat for common birds and mammals, as well as shelter and foraging habitat for reptiles and frogs. The removal of 25.4 ha of exotic grassland from the landfill is covered by the previous approval.

Fauna injury and mortality

As described above, the proposal footprint provides habitat resources for native fauna species and would contain mainly foraging and shelter resources for common native fauna. Ringtail Possums are present, and some common bird species may also nest in native vegetation. Groundcover vegetation, leaf litter and woody debris would provide shelter and foraging substrate for mammals (such as bandicoots), reptiles, frogs and invertebrates. Construction is likely to result in the injury or mortality of some individuals of these less mobile fauna species and other small terrestrial fauna that may be sheltering in vegetation within the proposal footprint during clearing activities. There are few hollow-bearing trees in the proposal footprint, and hollows are very small, which reduces the risk of injury or mortality of larger arboreal mammals or hollow-nesting birds. Alternative habitat resources and refuge from construction activities is available in native vegetation adjoining the site. The potential injury or mortality of individuals within a maximum of 39.71 hectares of habitat (including 26.77 ha of exotic grassland), is highly unlikely to affect an ecologically significant proportion of any local populations. More mobile native fauna such as native birds, bats, terrestrial and arboreal mammals that may be sheltering in vegetation in the proposal footprint are likely to evade injury during construction activities by moving into adjacent areas of habitat. However, displaced individuals may suffer stress, increased energy costs or increased risk of predation.

Recommendations have been made in Section 6.3 to minimise the risk of vegetation clearing activities resulting in the injury or mortality of resident fauna.

Fragmentation or isolation of habitat

The removal of native vegetation would occur to the west of the existing cleared landfill. There would be no isolation of habitat as a result of the proposal. A narrow band of vegetation (up to 10m wide) would remain along the road reserve of Heathcote Road. This would connect to the existing narrow band of vegetation to the south of the study area along Heathcote Road. Large expanses of vegetation occur on the western side of Heathcote Road. There would be negligible impact on the movement of mobile species such as the Grey-headed Flying-fox and Swift Parrot. Koalas may utilise the road the road reserve on occasion for dispersal. There would be no isolation of habitat for these species as a result of the proposal. The realignment of Mill Creek would allow continued connectivity along the creekline. Giant Burrowing Frog (if present) would be able to continue to move along Mill Creek, although the unnatural creek bed and bank downstream of the proposed ARRT facility may limit this movement. Fish passage is already interrupted by pipes and weirs in the study area. A narrow band of riparian vegetation along Mill Creek would continue to link vegetation to the north with vegetation to the south, although regeneration of riparian vegetation may take time.

Aquatic habitats

The proposal would remove a section of the previously realigned Mill Creek and a dam. Mill Creek is already highly modified through previous realignment and disturbance. These aquatic habitats are not potential habitat for threatened fish or dragonflies and are not classified as Key Fish Habitat (see section 4.2.7). Indirect impacts may include the disturbance of large woody debris, and changes to water quality downstream of realignment works. Note that Mill Creek immediately downstream of the proposed ARRT facility has an unnatural bed and bank and has limited aquatic habitats present. Once outside the LHRRP Mill Creek reverts to a natural creek.

5.2.2 Indirect and operational impacts

Weed invasion and edge effects

'Edge effects' refers to factors including increased noise and light, weed invasion, tree failure or erosion and sedimentation at the interface of intact vegetation and cleared areas. Edge effects may result in impacts such as changes to vegetation type and structure, increased growth of exotic plants, increased predation of native fauna or avoidance of habitat by native fauna. Edge effects would result from construction activities and then continue to affect vegetation and habitats adjoining the proposal footprint.

Altered environmental conditions along new edges can allow invasion by pest animals specialising in edge habitats and/or change the behaviour of resident animals. Edge zones can be subject to higher levels of predation by introduced mammalian predators and native avian predators. Edge effects have mainly been recorded adjacent to roads and at distances greater than 1,000 metres from the road surface (Forman et al. 2000). However, Bali (2005), in a comparison of edge effects in a variety of different habitat types, estimated that average edge effects generally occur up to 50 metres away from the road edge.

The impacts of edge effects are visible across much of the western portion of the proposal footprint due to the presence of existing clearings for access tracks, as well as the adjoining landfill and Heathcote Road. Existing edge effects include light, noise, and weeds. The proposal would create a new edge around the proposed ARRT and GO facilities. Construction activities may, in general, increase the degree of weed infestation through dispersal of weed propagules (seeds, stems and flowers) into areas of native vegetation via erosion (wind and water), via workers shoes and clothing or through construction vehicles. The majority of the existing edge is already impacted by edge effects from Heathcote Road and disturbed areas within the SICTA area. The proposal is not likely to substantially increase the existing edge effects at this location.

There is potential for edge effects on Coastal Upland Swamp, as this is located about 50 m from the proposal at its closest. This small swamp is already subject to existing edge effects due to adjacent cleared areas to the west and east. The swamp may be impacted by erosion and sedimentation during construction due to the proximity of the construction area.

Shale-Sandstone Transition Forest is located near the existing landfill. No additional edge effects would occur in this location. Similarly, known individuals of *Eucalyptus camfieldii, Melaleuca deanei* and *Melaleuca biconvexa* are unlikely to be impacted due to the distance from the proposal footprint or the presence of existing edge effects.

Allocasuarina diminuta subsp. *mimica* in the study area was recorded in disturbed edges, including along tracks and the edges of Heathcote Road. The proposal would increase edge effects on the retained population within SICTA land and the adjacent individuals retained in the Heathcote Road reserve. This species likely benefits from disturbances, and possibly from increased light levels afforded along an edge, therefore it is possible that some edge effects are beneficial to the survival of *Allocasuarina diminuta* subsp. *mimica.*

Impacts from edge effects on wide-ranging species such as the Grey-headed Flying-fox, Swift Parrot and Spotted-tailed Quoll are unlikely due to the small area of impact, the already disturbed nature of the much of the native vegetation, and the existing edge effects in adjacent areas. Edge effects may reduce the habitat quality in vegetation adjacent to newly cleared areas for smaller species such as the Eastern Pygmy-possum and Giant Burrowing Frog.

Given the level of existing disturbance, the proposal would have a minor impact on the degree of weed infestation in the study area. Recommendations have been made in Section 6.3 to minimise the spread of weeds.

Surface water

The major potential indirect impacts of the proposal relating to surface water include:

- The proposal includes a number of best practice erosion and sediment control measures to achieve compliance with the EPA's surface water discharge requirements. It is noted that discharge of sediment laden waters during large storms is unavoidable however the impact of such discharges is minimised through appropriate erosion and sediment control. Qualitative analysis of monitored downstream total suspended solids (TSS) concentrations suggests that the current operation of the LHRRP is not resulting in a significant impact to TSS levels in the downstream waterway. Mitigation measures are proposed in Section 4 in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom 2004) and *Managing Urban Stormwater, Soils and Construction. Volume 2b, Waste Landfills* (DECC 2008) which are expected to result in a further improvement in erosion and sediment control outcomes. Water actively managed for erosion and sediment control in the main sediment and water reuse basin will be treated and discharged off site in accordance with the quality limits applying to the facility (GHD 2015a). Impacts on downstream aquatic habitats are likely to be minimal.
- Increase in the peak rate of discharge from the site during flood events due to changing catchment conditions within the site. The resulting change in flood conditions could result in increasing flooding risks downstream. The results of the modelling show that the proposal will increase the peak flow rate discharged from the site by up to approximately 1%. This level of increase is not expected to have a significant effect on downstream flood conditions, particularly considering that additional runoff from adjacent catchments begins entering Mill Creek immediately downstream of the site, further reducing the expected increase proportion of the total flows. The removal of the western sediment control and water reuse basin as a component of the GO/ARRT facilities construction is not expected to have a significant impact on peak flow rates or velocities in the downstream waterway as this dam is currently regularly full and overflowing and in its current state it provides minimal flood protection through detention storage (GHD 2015a).
- Discharge of leachate. The total quantity of leachate stored within the landfill is kept to a minimum through extraction, storage in dedicated leachate ponds and treatment for discharge to sewer. In areas to be re-profiled, the existing cover and capping system will be stripped to promote leachate percolation from the new waste into the existing waste and to the existing leachate collection system. The GO / ARRT facilities and leachate ponds are not expected to be inundated during the 100-year ARI event. As such, the proposal is not expected to result in unacceptable flood risk from water inundating these facilities (GHD 2015a). Downstream aquatic and terrestrial habitats are unlikely to be negatively impacted by discharge of leachate.
- Reduction in surface water reaching adjacent vegetation through reduction in catchment area as a result of clearing of vegetation for construction of facilities. The construction of the ARRT and GO facilities will slightly reduce the catchment area of the tributary of Mill

Creek located in the SICTA area to the north of these facilities. The majority of the catchment of this swamp is located to the west, with only a small area to the south contributing to its water levels. There would be no change in surface runoff to the east of the landfill, as these areas are already impacted by the existing landfill.

The Coastal Upland Swamp located about 50 m downslope of the detention pond that will be located north of the ARRT facility may be indirectly impacted by changes to water regimes. The majority of the catchment of this swamp is located to the west, and would not be impacted by the proposal. There would be a small reduction in water flow from the south due to the construction of the ARRT facility and detention pond. The risk of overflow from the adjacent detention pond is very low. Water balance modelling carried out for various meteorological conditions found that overflow is not expected (GHD 2015c). The Coastal Upland Swamp located to the east of the landfill is unlikely to be impacted by the proposal, as the existing landfill would have already impacted surface flow in this location.

A narrow strip of the critically endangered Shale-Sandstone Transition Forest is located to the north-east of the existing landfill. The majority of the stand is located over 200 metres from the proposal footprint. This community is unlikely to be impacted by changes to water regimes. Stands of Red Bloodwood - Scribbly Gum heathy woodland are located between the proposal footprint and much of this TEC. The existing landfill would have already impacted surface flow to this CEEC. Additional impacts from construction are unlikely. The perimeter drain would prevent contamination from leachate reaching this community following reprofiling.

Indirect impacts on *Melaleuca deanei, Melaleuca biconvexa* or *Eucalyptus camfieldii* are unlikely due to the distance between these individuals and the proposal. *Melaleuca deanei* individuals are located about 200 m from the proposal footprint to the south and east, and on the opposite side of Heathcote Road. One *Melaleuca biconvexa* is located in the Heathcote Road reserve about 50 m from the proposal boundary. *Eucalyptus camfieldii* individuals are located about 100 m from the proposal footprint.

Aquatic disturbance

The aquatic ecosystem assessment (GHD 2015d) assessed the magnitude and extent of any impacts on Mill Creek resulting from the existing operations at the LHRRP. The assessment found that while the LHRRP may be having an influence on the aquatic and riparian habitat, the water quality and macroinvertebrate communities are only showing minimal signs of impairment. It also found that the recovery of habitat condition at the downstream site suggests that any impacts are spatially limited and decrease with distance (see section 4.2.7).

The introduction of pollutants and sediments from the proposal footprint into the surrounding environment, if uncontrolled, could potentially impact on water quality and aquatic habitats. The potential for water quality impacts on Mill Creek outside the proposal footprint are likely to continue to be low, as discussed above in the assessment of surface water impacts. Potential water quality impacts during construction would be managed through the implementation of mitigation measures, including the provision of sedimentation basins, silt fences and other structures to intercept runoff. The existing dirty water drain diverts dirty water away from Mill Creek to treatment ponds. This would be extended as required during reprofiling of the landfill. There would be complete containment of leachate from the landfill, GO and ARRT facilities, which would exclude this leachate from the surface water system water that is able to be discharged off-site. The proposed staging for reprofiling the landfill will progressively cap and revegetate areas which are currently not capped and revegetated. The cap will consist of a low permeability compacted clay layer (or an EPA approved alternative) which will reduce the generation of leachate through reduced rainfall infiltration and the ability to more effectively shed surface water off the site. These actions will also reduce the potential risk of leachate entering surface water and being discharged off-site (GHD 2015b).

Based on the details above, and the limited impacts the existing LHRRP is currently having on downstream environments, the proposal is likely to have a minor impact on aquatic habitats within the immediate area only. There would be no impact on Key Fish Habitat as a result of the proposal. No endangered aquatic communities, aquatic fauna or marine vegetation listed under the FM Act or EPBC Act occur in the study area and no significant impacts on riparian vegetation or habitats downstream of the proposal footprint are anticipated as a result of the proposal.

Groundwater impacts

As discussed in section 4.2.4, vegetation within the proposal footprint and adjacent areas is likely to be groundwater dependent to some degree. In particular, Coastal Upland Swamps located outside the proposal footprint are highly likely to be groundwater dependent. The impacts to sub-surface groundwater dependent ecosystems (vegetation communities) and the potential groundwater inflow dependent ecosystems (such as Mill Creek, Deadmans Creek and Woronora River) due to operation of the ARRT and GO facilities are expected to be localised and minor. The reasons for this conclusion are discussed below.

The construction of the new ARRT facility and detention pond and the relocation of the GO facility would involve excavation works but these works are not expected at depths that would intercept groundwater. 1992 data for BH07 located near to the proposed ARRT and GO site and surrounding wells suggests that the flow direction is generally eastward toward Mill Creek. Given that this site is located near to the top of a ridgeline and that there is no groundwater elevation data further to the west, groundwater flow could quite plausibly be to the west toward Deadmans Creek (GHD 2015b). As such, the Coastal Upland Swamp located north of the proposed ARRT facility is unlikely to be impacted by construction in this area.

A reduction in groundwater infiltration associated with the facility will reduce groundwater elevations locally within the vicinity of Mill Creek and potentially reduce baseflow to these creeks. This could subsequently impact GDEs and aquatic ecosystems in these creeks. Impacts are likely to be negligible as the size of the ARRT and GO facilities relative to the Mill Creek and Deadmans Creek Catchments is negligible. Flows in Mill Creek appear to be intermittent, which suggests that there is a low reliance on groundwater inflow for flow maintenance. While there are pools present that may be reliant on surrounding groundwater it is unlikely that the project will result in groundwater elevation reduction below the base of the creek systems, especially downslope of the site were instream ecosystems are less disturbed and the stream bed is lower than the minimum elevations of the landfill. Given the presence of downward hydraulic gradients created by very low permeability lithological units in this area, it is not expected that groundwater elevations will change substantially, however, localised/isolated flow reductions to seeps and stream baseflow may occur (GHD 2015b). These localised flow reductions are likely to have a negligible impact on any downstream GDEs.

Once in operation the ARRT facility will potentially have infrastructure that could have the following interactions with groundwater (GHD 2015b):

- Infiltration of dirty waste streams into the underlying groundwater systems. This could occur via leakage to groundwater through the waste collection and treatment scheme. This may primarily occur in areas of waste storage such as detention basins and leachate ponds. It is expected that all these systems will be lined with impermeable infrastructure.
- Reduction in groundwater recharge associated with the emplacement of impermeable surfaces such as buildings and impermeable surfaces for processing waste. This may result in a decrease in groundwater elevations beneath the site.

The migration of impacts to underlying groundwater during both construction and operation could result in impacts to GDEs and aquatic ecosystems present downstream of the project within Deadmans Creek or Mill Creek (GHD 2015b). Impacts are expected to be negligible as the ARRT waste stream will be impermeable and sealed and will prevent migration to groundwater.

The existing landfill footprint is unlikely to change. Excavation of the site historically would have already impacted groundwater in the vicinity. Water quality data suggests that there is a limited hydraulic connection between the landfill and underlying groundwater, which therefore suggests changes in leachate generation, will not result in significant changes to groundwater discharge to creeks and groundwater elevations near potentially dependent vegetation further downslope.

The geometry of the current approved final landform in places allows ponding of rainwater, increases the potential for increased infiltration into the waste and results in additional leachate generation. The proposed re-profiling of the landform would reduce the potential for rainfall infiltration and thereby reduce leachate generation. The intention is to further reduce the potential risk of leachate impacting on groundwater at the site. Leachate is unlikely to impact GDEs downstream of the proposal footprint.

Post closure, the potential for degradation of groundwater quality by site activities would be negligible as potentially contaminating site activities would no longer be taking place. Any reduction in infiltration rates to groundwater and associated impacts would be less than or similar to those that will be incurred during operation when rainfall and surface water management systems on the site are in place (GHD 2015b).

Pests and pathogens

Construction activities within the proposal footprint have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*) into adjacent native vegetation through vegetation disturbance and increased visitation. There is little available information about the distribution of these pathogens within the locality, and no evidence of these pathogens was observed during surveys. Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and damage to fauna habitats. Chytrid fungus affects both tadpoles and adult frogs and can cause 100% mortality in some populations once introduced into an area.

Mitigation measures would be included in the CEMP to prevent the introduction or spread of disease that could potentially impact threatened biota in the study area (see Section 6.3).

Dust generation

Dust as a result of wind and vehicle movement may currently affect native vegetation located adjacent to the existing landfill, however there was little evidence of dust in adjacent vegetation. Dust is likely to be generated during clearing and construction activities. High dust levels could reduce habitat quality for flora and fauna species by reducing plant and animal health in areas of retained vegetation. The proposal would include paved roads and buildings, thus generation of dust would be minimised. Some dust transfer could occur during reprofiling of the landfill.

Mitigation measures would be included in the CEMP to minimise impacts of dust (section 7). Dust is unlikely to substantially impact habitat for any threatened biota due to the mitigation measures proposed.

Noise

There would be noise impacts during the construction and operation phases as a result of vegetation clearing, the movement of vehicles and operation of plant. The proposal footprint currently experiences ongoing noise from vehicles travelling along Heathcote Road, and from the activities in the landfill. There is the potential for individuals that nest in trees that are close to the proposal edge abandoning their nests as a result of noise during construction and operation. Noise may also affect general fauna activity in these areas. Given the existing noise levels in the vicinity of the proposal, any localised and temporary increase in noise levels during the construction activities are unlikely to substantially impact on native biota.

Vibration

Vibration impacts may result from works associated with the proposal, such heavy vehicle movement and construction and operational activities. Vibration may deter native fauna from using the area surrounding the source of vibration. This may potentially interrupt dispersal within the locality if an individual is unwilling to travel through an area where vibration is detectable, or may cause some species to abandon an area in search of areas where vibration is not detectable.

Within the proposal footprint, some level of vibration is already present as a result of vehicles travelling along Heathcote Road and within the adjacent landfill. The proposal has the potential to increase vibration throughout the proposal footprint and adjacent areas during construction. Impacts would be localised and temporary during construction. No works would be conducted at night, and thus construction is unlikely to impact the behaviour of nocturnal fauna.

5.3 Cumulative impacts

The proposal would increase the extent of vegetation clearing in the locality, and increase the removal of habitats for flora and fauna species, including threatened species. Other developments in the locality would also lead to a reduction in vegetation and habitats available. One large development is currently proposed north of the LHRRP at Heathcote Ridge. This is described below.

The Gandangara Local Aboriginal Land Council (GALC) is proposing a development at Heathcote Ridge in the West Menai area. This proposal has not yet been assessed under NSW legislation, although a strategic assessment (Cumberland Ecology 2012) has been approved by the Commonwealth. As such, the status of this proposal is not known. The Heathcote Ridge site contains 849 ha of mostly undeveloped land, covering parts of Menai, Barden Ridge and Lucas Heights. The site is currently zoned ‘1(b) Rural (Future Urban)’ under the Sutherland Shire LEP 2000. The western boundary of the proposed development is Heathcote Road and the site extends east across Mill Creek to the edge of the existing Menai residential area close to New Illawarra Road. The southern boundary of this development is located about 1 km to north of the proposal footprint.

The GALC is seeking to list the Heathcote Ridge site as a State Significant Site and rezone the land to allow for:

- 566 ha of conservation land
- 182.7 ha of residential land, proposed to accommodate approximately 2,400 dwellings
- 51.4 ha of employment land, proposed to provide up to 4,700 jobs
- 17.2 ha of sports fields and other open space
- New roads, bridges and community facilities.

This proposal is currently being assessed by the Department of Planning and Environment and would have the following impacts on biodiversity values (Cumberland Ecology 2012):

- Translocation of 21 individuals of *Acacia bynoeana*. Approximately 51.24ha of suitable habitat, including seven known individuals, will be conserved within the project area.

- Removal of potential habitat for a range of flora and fauna species. Up to 566 ha of potential habitat will be conserved within the conservation land.

In addition, 78% of the vegetation type containing the endangered population of *Allocasuarina diminuta* subsp. *mimica* at this site would be lost (Graham, B. in NSW Scientific Committee 2014).

The Heathcote Ridge development would impact similar vegetation types to those present in the proposal footprint being assessed in this Biodiversity Assessment Report, further reducing habitats available for flora and fauna in the area. In particular, as highlighted above, it would also result in the loss of individuals of the threatened flora species *Acacia bynoeana* and *Allocasuarina diminuta* subsp. *Mimica,* and would further remove habitat for a range of threatened fauna species, if approved.

5.4 Key threatening processes

A key threatening process (KTP) is defined in the TSC Act (DEC 2005) as an action, activity or proposal that:

- Adversely affects two or more threatened species, populations or ecological communities
- Could cause species, populations or ecological communities that are not currently threatened to become threatened.

There are currently 38 KTPs listed under the TSC Act and eight listed under the FM Act. A number of KTPs are listed under more than one Act. Those potentially relevant to this proposal are listed in Table 5-2 below. Mitigation measures to limit the impacts of these KTPs are discussed in Chapter 6.

Table 5-2 Key Threatening Processes of relevance to the proposal

KTP	Status	Comment
Clearing of native vegetation	TSC Act EPBC Act	The proposal includes the clearing of 9.25 hectares of native vegetation, much of which is disturbed from previous clearing. Vast areas of intact native vegetation are present in the locality. This minor reduction in extent is highly unlikely to affect the viability of remnant vegetation in the study area or locality or reduce the extent of habitat below a minimum size required for any fauna species. The implementation of vegetation management procedures is recommended to limit impacts on vegetation (see Section 6.3.1).
Clearing of hollow-bearing trees	TSC Act	A low number of trees with suitable hollows for small birds or mammals are likely to be removed by the proposal. No large hollows suitable for species such as cockatoos and forest owls will be removed. The implementation of habitat management procedures is recommended to limit impacts on fauna and their habitats (see Section 6.3.1).
Removal of dead wood and dead trees	TSC Act	The proposal footprint contains areas of fallen timber. The proposal will result in the removal of this timber during construction of the proposal. The implementation of habitat management procedures is recommended to limit impacts on fauna and their habitats (see Section 6.3.1).
Invasion of plant communities by perennial exotic grasses	TSC Act	The proposal footprint features large areas of exotic grassland. There is the potential for perennial exotic grasses to invade adjacent native vegetation through disturbance during construction of the proposal and a shift of the disturbed edge into intact native vegetation. The proposal would include environmental management measures, including weed management and specific

KTP	Status	Comment
		consideration of potential impacts on soil, water and native vegetation (see Section 6.3.1).
Infection of native plants by *Phytophthora cinnamomi*	TSC Act; EPBC Act	Construction activities have the potential to introduce Phytopthora into the study area, through the transport and movement of plant, machinery and vehicles, as well as through any landscaping works following construction. The proposal would include environmental management measures, including specific consideration of measures to reduce potential impacts on soil, water and native vegetation (see Section 6.3.1).
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae	TSC Act	Construction activities have the potential to introduce Myrtle Rust to the study area. The proposal would include environmental management measures, including specific consideration of measures to reduce potential impacts on soil, water and native vegetation (see Section 6.3.1).
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis	TSC Act; EPBC Act	Construction activities have the potential to introduce amphibian chytrid to the study area, which could lead to death of local frogs. The proposal would include environmental management measures including specific consideration of measures to reduce potential impacts on soil, water and native vegetation (see Section 6.3.1).
The degradation of native riparian vegetation along NSW water courses	FM Act	The proposal will require the realignment of a section of Mill Creek, which was previously realigned for the existing landfill. Realignment and construction activities could have indirect impacts on riparian vegetation downstream of the study area. Mitigation measures are recommended to limit the potential for adverse impacts on riparian vegetation (see Section 6.3.1).
The removal of large woody debris from NSW riers and streams	FM Act	The realignment of a section of Mill Creek may result in the disturbance of large woody debris, although few large snags were observed in this section of the creek. Removal of large woody debris could reduce habitat for aquatic fauna. Any woody debris present in the section to be removed should be relocated to the newly aligned section to maintain habitat values for aquatic fauna (see Section 6.3.1).
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	TSC Act; FM Act	The hydrology of the study area is already substantially modified by the existing landfill and previous realignment of Mill Creek. The proposal would realign a section of this creek. The proposal would alter the natural landform through placement of fill, increase the proportion of hardstand surfaces in the study area and modify surface water flows. Mitigation measures are recommended to limit the potential for adverse impacts on aquatic habitats (see Section 6.3.1).
Human-caused climate change	TSC Act EPBC Act	Combustion of fuels associated with construction and operation of the proposal would contribute to anthropogenic emissions of greenhouse gases. Operational emission sources include fuel consumption by vehicles, fugitive emissions from the waste disposal area, the collection and combustion of biogas and electricity imported from the grid. The increase in greenhouse gases could impact average temperatures, rainfall patterns and bushfires, which can impact vegetation and habitats for flora and fauna.

5.5 Impacts on threatened biota listed under NSW legislation

5.5.1 Direct impacts

The proposal may result in direct and indirect impacts on threatened biota listed under the TSC Act, including the removal of one individual of *Acacia bynoeana,* up to 58 ramets of *Allocasuarina dinimuta* subsp*. minica*, and potential habitat for a range of fauna species (see section 5.1). There would be no direct impact on any threatened ecological communities.

Impacts on threatened biota listed under the TSC Act have been assessed through the FBA calculations included in Chapter 7.

No aquatic threatened biota listed under the FM Act or their habitats are likely to occur in the study area or to be affected by the proposal.

5.5.2 Indirect impacts on threatened biota located outside the proposal footprint

Threatened ecological communities

The proposal could indirectly impact the small Coastal Upland Swamp located about 50 m downslope of the detention pond that will be located north of the ARRT facility. The proposal has the potential to change water regimes of this swamp. The majority of the catchment of this swamp is located to the west, and would not be impacted by the proposal. There would be a small reduction in water flow from the south due to the construction of the ARRT facility. This is not likely to substantially change the species composition o extent of this community. The Coastal Upland Swamp located to the east of the landfill is unlikely to be impacted by the proposal. The existing landfill is likely to have already impacted surface and groundwater flow in this location. Given the distance between the boundary and this vegetation (about 50m), further impacts from reprofining are unlikely.

A narrow strip of the critically endangered Shale-Sandstone Transition Forest is located to the north-east of the existing landfill, outside the proposal footprint. The majority of the stand is located over 200 metres from the proposal footprint. This community is unlikely to be indirectly impacted by changes to water regimes. Stands of Red Bloodwood - Scribbly Gum heathy woodland are located between the proposal footprint and much of this TEC. The existing landfill would have already impacted surface and groundwater flow to this CEEC. Additional impacts from construction are unlikely. The final re-profiling of the landfill may again allow surface water flow to this area, as the land surface would be reprofiled to a more natural position.

Threatened flora species and populations

No individuals of *Acacia bynoeana* were recorded in the study area outside the proposal footprint. The loss of one individual is not likely to indirectly impact the population in the locality through changes to pollination or genetic diversity. Changes to edges and water flows are not likely to impact the population in the locality givent he distance between known individuals and the proposal boundary.

Indirect impacts on *Melaleuca deanei, Melaleuca biconvexa* or *Eucalyptus camfieldii* are unlikely due to the distance between these individuals and the proposal. *Melaleuca deanei* individuals are located about 200 m from the proposal footprint to the south and east, and on the opposite side of Heathcote Road. One *Melaleuca biconvexa* is located in the Heathcote Road reserve about 50 m from the proposal boundary. *Eucalyptus camfieldii* individuals are located about 100 m from the proposal footprint.

The proposal would remove up to 58 ramets of *Allocasuarina diminuta* subsp. *mimica* (listed as an endangered population under the TSC Act) (see Figure 4-1). About 24 ramets would be retained in SICTA land and about 120 ramets would be retained along Heathcote Road. A detailed assessment of direct and indirect impacts on this endangered population is provided in section 7.6.3.

Threatened fauna species

The Giant Burrowing Frog has previously been recorded along Mill Creek (OEH 2014a) south of where the GO facility is proposed to be located, and may forage and breed in the proposal footprint and adjacent areas. The Coastal Upland Swamp located to the north of the proposed ARRT facility, which is potential breeding habitat, may be indirectly impacted by changes to hydrology. There may be a small reduction of water catchment for the swamp, however the majority of this swamp's catchment would remain unaffected. This swamp has high levels of lead shot present from the adjacent clay target club, which may reduce habitat quality for this species. When lead shot is deposited on the soil, lead compounds are oxidised and released into the soil (Jorgensen and Willems 1987), where they become bioavailable for a range of flora and fauna within the ecosystem. Elevated lead levels in frogs is known to significantly affect the mortality of some species (Stansley et al 1997) and can inhibit the growth and development of frogs (Power et al 1989). Further research is required to assess the impacts of accumulated lead intake from shooting ranges on Australian frog species and specifically threatened species such as the Giant Burrowing Frog. Better quality habitat for the species is present outside the proposal footprint, in more intact vegetation and natural swamps and creeks. Direct impacts on potential habitat for this species in the proposal footprint have been assessed through the FBA calculations included in Chapter 7.

As discussed in section 5.2.2, the proposal may indirectly impact threatened fauna species through noise, vibration, and dust. Given the existing levels of these disturbances in the vicinity of the proposal, any increases during the construction activities are unlikely to substantially impact on threatened species.

5.6 Impacts on matters of national environmental significance

Potential impacts on matters of national environmental significance, including threatened and migratory biota, have been assessed via a referral for the proposal (GHD 2015b). The referral was assessed by the Department of the Environment. On 13 April 2015 a decision was recorded that the proposal is not a controlled action and that no further assessment and approval under the EPBC Act is required before it can proceed (EPBC Ref: 2015/7432).

The majority of the study area is located within the existing landfill, and thus has minimal value for threatened or migratory biota listed under the EPBC Act. A small area of native vegetation (comprising 2.4 ha of good quality vegetation and 10.5 ha of regenerating and planted native vegetation) would need to be removed for the construction of the ARRT and re-profiling of the landfill. About 300 metres of Mill Creek would be removed for the realignment of the creek, which will be realigned along a shorter, more direct length. The proposal footprint provides known habitat for *Acacia bynoeana*, and potential habitat for the Grey-headed Flying-fox, Koala, Swift Parrot, Spotted-tailed Quoll, Giant Burrowing Frog and a number of migratory bird species listed under the EPBC Act. The area of vegetation to be removed is very small compared to large expanses of native vegetation present in the locality and given its small extent and modified nature is not considered habitat critical to the survival of any local populations of these threatened species.

The proposal is not likely to impose a significant impact on any relevant matters of national environmental significance listed under the EPBC Act. Assessments of significance, according to the Significant Impact Guidelines 1.1 (DotE 2013) were prepared for the threatened and migratory biota listed above that are known or may occur in the proposal footprint and be impacted by the proposal and were included in the referral. The conclusion of these assessments was that the proposal would not significantly impact any of these biota.

6. Mitigation and management measures

6.1 Introduction

The general principle to minimise impacts to biodiversity, should in order of consideration, endeavour to:

- avoid impacts on habitat, through the planning process
- mitigate impacts on habitat, though the use of a range of mitigation measures
- offset any residual impact that can not be avoided or mitigated.

Impact avoidance and mitigation is discussed in sections 6.2 and 6.3. Offsets are discussed in section 8.

6.2 Avoidance of impacts

The proposal is largely contained within the existing landfill. The area proposed for the ARRT and GO facilities falls within land which has been previously modified by clearing. Impacts on native flora and fauna are substantially less than would be associated with an undisturbed 'green field' site. Development of the proposal layout was based on an initial constraints assessment of the site. The proponent has recognised the importance of retaining good quality native vegetation and known occurrences of threatened species where possible.

The key impact avoidance measures for the proposal include:

- Locating the footprint of the ARRT and GO facilities to the west of the existing landfill in vegetation that has been previously cleared and disturbed, and generally avoiding impacts on large stands of good quality vegetation.
- Locating access roads within already disturbed areas of the existing landfill.
- Redesiging the GO and ARRT facilities to minimise impacts on the *Allocasuarina diminuta* subsp. *mimica* endangered population.

Siting of construction compounds and other construction infrastructure in already cleared areas would also avoid impacts on native biodiversity values.

6.3 Mitigation of impacts

6.3.1 Construction

In order to address the potential impacts of the proposal on biodiversity as discussed in Chapter 5, the mitigation and management measures outlined in Table 6-1 would be implemented as part of the Construction Environment Management Plan (CEMP) for the site.

Table 6-1 Mitigation measures (construction)

Impact	Mitigation
General	• Ensure all workers are provided an environmental induction prior to starting work on site. This would include information on the ecological values of the site, protection measures to be implemented to protect biodiversity and penalties for breaches. • Prepare a flora and fauna management sub-plan as part of the CEMP, incorporating recommendations below, and expanding where necessary. • Measures to suppress dust would be put in place during clearing, construction and operation. • Removal of lead shot in the SICTA area should be carried out prior to contruction to ensure no additional lead shot enters adjacent vegetation,

Impact	Mitigation
	including the upland swamp.
Flora species	• Further counts of *Allocasuarina diminuta* subsp. *mimica* should be undertaken within the footprint for the ARRT facility prior to construction of this facility to revise credits required to offset this population. Specimens that may be hybrids should be sent to the National Herbarium of NSW for verification. • Collection of seeds and propagules of *Allocasuarina diminuta* subsp. *mimica* should be carried out by the Menai Wildlower Group who run the on-site nursery in March prior to vegetation clearing occurring. Seeds should be planted in the nursery and any individuals grown used for on site plantings. Species of this genus can be propagated from seed (Wrigley and Fagg 2007). Preliminary seed collection was carried out in March 2015 by the Menai Wildlower Group. • Ramets of *Allocasuarina diminuta* subsp. *mimica* and associated soil should be collected by the Menai Wildlower Group prior to vegetation clearing and transferred to the on-site nursery for propogation and replanting. Replanting should be undertaken in areas that are not likely to be impacted by future development, including the proposed offset site. The location of the proposed offset site will be discussed with OEH during the preparation of the offset strategy. Planting of ramets along the realigned Mill Creek where the ironstone soil is present is recommended. No *Allocasuarina littoralis* shoud be planted near these plants as this species can shade out *Allocasuarina diminuta* subsp. *mimica* and mycorrhyzial associations may be different. Any removal and replanting should be carried out with input from the Sutherland Shire Council bushcare staff. • A management plan for the collection of seed and translocationof plants would be prepared as part of the CEMP for the proposal (see section 6.3) and would include monitoring and assessment of the success of the program.
Vegetation clearing	• Limit disturbance of vegetation to the minimum necessary to construct the proposal. • Vehicles must be appropriately washed prior to work on site to prevent the potential spread of Cinnamon Fungus (*Phytophthora cinnamomi*) and Myrtle Rust (Pucciniales fungi) in accordance with the national best practice guidelines for Phytophthora (DEH 2006) and the Myrtle Rust factsheet (DPI 2011c) for hygiene control. • Where the proposal footprint adjoins native vegetation mark the limits of clearing and install fencing around the construction footprint area prior to the commencement of construction activities to avoid unnecessary vegetation and habitat removal. • Ensure any *Allocasuarina diminuta* subsp. *mimica* along the access track are protected from construction activities for the GO facility to avoid accidental removal and/or damage of ramets. • Stockpiles of fill or vegetation should be placed within existing cleared areas (and not within areas of adjoining native vegetation). • Sediment fences should be installed to prevent transfer of sediments into adjacent vegetation.
Weeds	• Develop weed management actions to manage weeds during the construction phase of the proposal. This would include the management and disposal of the weeds that were recorded within the proposal footprint, including the noxious weeds listed in Table 4-2 in accordance with the NW Act. • Vehicles and other equipment to be used on site should be cleaned to minimise seeds and plant material entering the site to prevent the introduction of further exotic plant species or disease. • Incorporate control measures in the design of the proposal to limit the spread of weed propagules downstream of study area. Sediment control devices, such as silt fences, would assist in reducing the potential for spreading weeds.
Fauna	• Protocols to prevent introduction or spread of chytrid fungus should be

<table>
<tr><th>Impact</th><th>Mitigation</th></tr>
<tr><td>habitat</td><td>implemented following Office of Environment and Heritage Hygiene protocol for the control of disease in frogs (DECCW, 2008).
• A trained ecologist should be present during the clearing of native vegetation or removal of potential fauna habitat to avoid impacts on resident fauna and to salvage habitat resources as far as is practicable. Clearing surveys should include:
– Staged vegetation clearing, commencing in the south of the GO facility and progressing northwards to increase the opportunity for fauna to vacate the site and move into areas of 'secure' habitat to evade injury.
– Any hollow-bearing trees to be felled should be marked prior to clearing of vegetation. The removal of hollow bearing trees is to be undertaken in accordance with a hollow-bearing tree management protocol and would include the presence of a qualified ecologist or wildlife expert experienced in the rescue of fauna.
– Habitat features (fallen logs and tree hollows) removed from site would be salvaged and relocated within adjacent areas of vegetation.
– Inspections of native vegetation for resident fauna and/or nests or other signs of fauna occupancy
– Deferral of vegetation removal and associated construction activity in areas occupied by more mobile threatened fauna until the fauna has vacated the proposal footprint
• An ecologist should be present during works along Mill Creek to rescue and relocate any frogs to other locations along Mill Creek. Any handling of frogs should be undertaken with respect to the Office of Environment and Heritage Hygiene protocol for the control of disease in frogs (DECCW, 2008).</td></tr>
<tr><td>Water Quality and aquatic habitats</td><td>• Erosion and sediment control plans should be prepared in accordance with Volume 2D of Managing Urban Stormwater: Soils and Construction (DECC 2008). The erosion and sediment control plans would be established prior to the commencement of construction and be updated and managed throughout as relevant to the activities during the construction phase.
• Erosion and sediment control measures should be established prior to construction.
• Erosion and sediment control measures would be regularly inspected, particularly following rainfall events, to ensure their ongoing functionality.
• Stabilised surfaces should be reinstated as quickly as practicable after construction.
• Water should be applied to exposed surfaces that are causing dust generation. Surfaces may include unpaved roads, stockpiles, hardstand areas and other exposed surfaces (for example recently graded areas).
• Vehicles must follow appropriate speeds to limit dust generation.
• All stockpiled material should be stored in bunded areas and kept away from waterways to avoid sediment entering the waterway.
• Spill kits would be made available to construction vehicles. A management protocol for accidental spills would be put in place.
• Plague Minnow (if present) must not be released into local waterways as a result of draining of dams or realignment of Mill Creek. Plague Minnow should be eradicated from dams prior to decommissioning using humane methods and under an appropriate licence from NSW Primary Industries (Animal Welfare branch and Fishing and Aquaculture branch).
• Any large woody debris removed from the realigned Mill Creek should be salvaged and placed in the new alignment to maintain habitat values.
• The new section of Mill Creek should be constructed to mimic a natural ecosystem and revegetated with locally endemic species. Consideration should be given to using propagated Allocasuarina diminuta subsp. mimica.</td></tr>
</table>

6.3.2 Operation

A comprehensive list of prevention, mitigation and rectification measures has been identified and they are detailed in the LHRRP Operational Environment Management Plan (SITA, 2014). The identified mitigation and rectification measures would be implemented as required and their exact details would be based on a case by case situation depending on the issue and technical solutions available at the time. The operations of the GO facility is not expected to increase the presence of weeds in the riparian zone as materials are tipped and processed inside the facility in accordance with strict guidelines for compost production. The operations of the LHRRP ARRT facility is not expected to increase the presence of weeds in the riparian zone as materials are tipped and processed inside the facility in accordance with strict guidelines for compost production. The ARRT facility is also fully enclosed and constructed on hardstand. Pest, vermin and weed management measures for the whole LHRRP are detailed in the LHRRP OEMP.

Examples of key measures that are included in the OEMPs are provided below:

- A joint noxious weed control program with SSC which provides a cooperative approach to weed control
- A feral animal control program (in place since 2008)
- Engage specialist contractor to control noxious weeds
- Engage registered pest exterminator to inspected the LHRRP annually and carry out any recommended actions

As described in Section 5.2.2, the proposal would have a minor increase in existing impacts on native biodiversity values during operation. Little mitigation of the proposal is therefore likely to be required for biodiversity during this phase. Mitigation measures are provided in Table 6-1.

Table 6-2 Mitigation measures (operation)

Impact	Mitigation
Vegetation and weeds	• Ongoing management of noxious weeds according to legislative requirements. • Ongoing suppression of dust within the landfill and ARRT and GO facilities. • Ongoing water quality management. • Monitoring of revegetation of realigned Mill Creek to ensure planted individuals are thriving.
Feral animals	• Ongoing control of feral animals. • Minimise sources of food and habitat for pest species.

6.3.3 Post closure

A post closure environmental management plan (EMP) has been prepared for the project (GHD 2014). As part of this EMP, the site would be landscaped and there would be management of surface water, leachate and gas. Mitigation measures proposed for biodiversity are provided in Table 6-3.

Table 6-3 Mitigation measures (post closure)

Impact	Mitigation
Vegetation and weeds	• Exposed soil should be sown with native seed immediately to prevent colonisation by weeds. • Revegetation should use locally sourced native species. • Use of propagated individuals of *Allocasuarina diminuta* subsp. *mimica* from the site should be incorporated into the landscaping plan. • Ongoing management of noxious weeds according to legislative requirements. • Revegetation areas, including planted *Allocasuarina diminuta* subsp. *mimica,* should be monitored and managed as per the EMP.

7. FBA Calculations

7.1 Introduction

The FBA credit calculations were performed by Kirsten Crosby (assessor accreditation number 160) using credit calculator Version 4.0. The credit calculations will be submitted to OEH and the biodiversity credit report is included in Appendix A.

As noted in Section 1.3 and 5.1, SITA are proposing a staged approach, and credits required to offset the landfill and GO facility have been calculated separately to those required for the construction of the ARRT facility, as this facility would be constructed many years later. Credit calculations have been performed for two stages as follows:

1. Impacts resulting from reprofiling of the landfill and construction of the GO facility
2. Impacts resulting from construction of the ARRT facility

The data and assumptions used to perform the FBA credit calculations are summarised below according to the structure and information requirements outlined in Appendix 7 of the FBA (OEH, 2014a).

As described earlier, impacts associated with the clearing of regenerated/planted vegetation on the batters of the existing landfill for reprofiling have not been considered in the biobanking credit calculations as SITA has approval under the current consent (1999 EIS and associated Consent R97/00029) to clear vegetation on the batters of the existing landfill.

7.2 Landscape features

The FBA requires the assessment of landscape features to help describe the biodiversity values of the study area and assess the impacts of the proposal. Landscape features relevant to the FBA calculations are shown on Figure 7-1 and summarised in Table 7-1.

Table 7-1 Landscape features – stage 1

Landscape feature	Stage 1	Stage 2
Interim Biogeographic regionalisation of Australia (IBRA) bioregion and IBRA subregions	The proposal footprint is located entirely within the 'Sydney Basin' IBRA bioregion and Sydney Cataract – Sydney Metro IBRA subregion.	
Mitchell landscapes	The proposal footprint is located on the Woronora Plateau Mitchell landscape (DECC 2008a).	
Rivers, streams and estuaries	The proposal footprint contains a first order stream, Mill Creek, which has historically been realigned to its current position within the proposal footprint.	
Wetlands	The proposal footprint does not contain any important or local wetlands as defined in the FBA (OEH, 2014a).	
% Native vegetation cover	The outer assessment circle is 1000 hectares in area and the inner assessment circle is 100 hectares.	
Current percent native vegetation cover in the outer assessment circle	71-75% (around 741 hectares out of the 1000 hectare circle).	71-75% (around 736 hectares out of the 1000 hectare circle, given the previous removal of 8.9 hectares of remnant, regrowth or planted native vegetation for the GO facility)
Future percent native vegetation	remains 71-75% (around 736 hectares out of the 1000 hectare	Remains 71-75% (around 736 hectares out of the 1000 hectare

Landscape feature	Stage 1	Stage 2
cover in the outer assessment circle	circle, given the removal of only 4.84 hectares of remnant, regrowth or planted native vegetation for the GO facility).	circle, given the removal of an additional 4.41 hectares of remnant, regrowth or planted native vegetation for the ARRT facility).
Current percent native vegetation cover in the inner assessment circle	66-70% (around 70 hectares out of the 100 hectare circle).	61-65% (around 65 hectares out of the 100 hectare circle, given the previous removal of 4.84 hectares of remnant, regrowth or planted native vegetation for the GO facility).
The future percent native vegetation cover in the inner assessment circle	60-65% (around 65 hectares out of the 100 hectare circle, given the removal of 4.84 hectares of remnant, regrowth or planted native vegetation for the GO facility).	56-60% (around 60 hectares out of the 1000 hectare circle, given the removal of an additional 4.41 hectares of remnant, regrowth or planted native vegetation for the ARRT facility).
Connectivity value - class	The proposal would affect only a local area biodiversity link, because it affects vegetation in a link that is <1000 ha in area.	
Connectivity value - width	The primary link for the proposal before development is located in the adjacent Holsworthy army base and is over 1 km wide (>500m linkage width class).	
	The primary link for the proposal remains in the adjacent Holsworthy army base and will remain over 1 km wide (>500m linkage).	
Connectivity value - condition	The projective foliage cover (PFC) of over storey and mid storey vegetation in the primary link before development is at benchmark values.	
	The average projective foliage cover (PFC) of over storey and mid storey vegetation in the primary link after development would be at benchmark values because the proposal would affect only a 200 metre wide strip out of the >1km link.	
Patch size	The patch size is 500 hectares, comprising the remnant vegetation in Holsworthy army base and other adjacent areas.	

7.3 Native vegetation

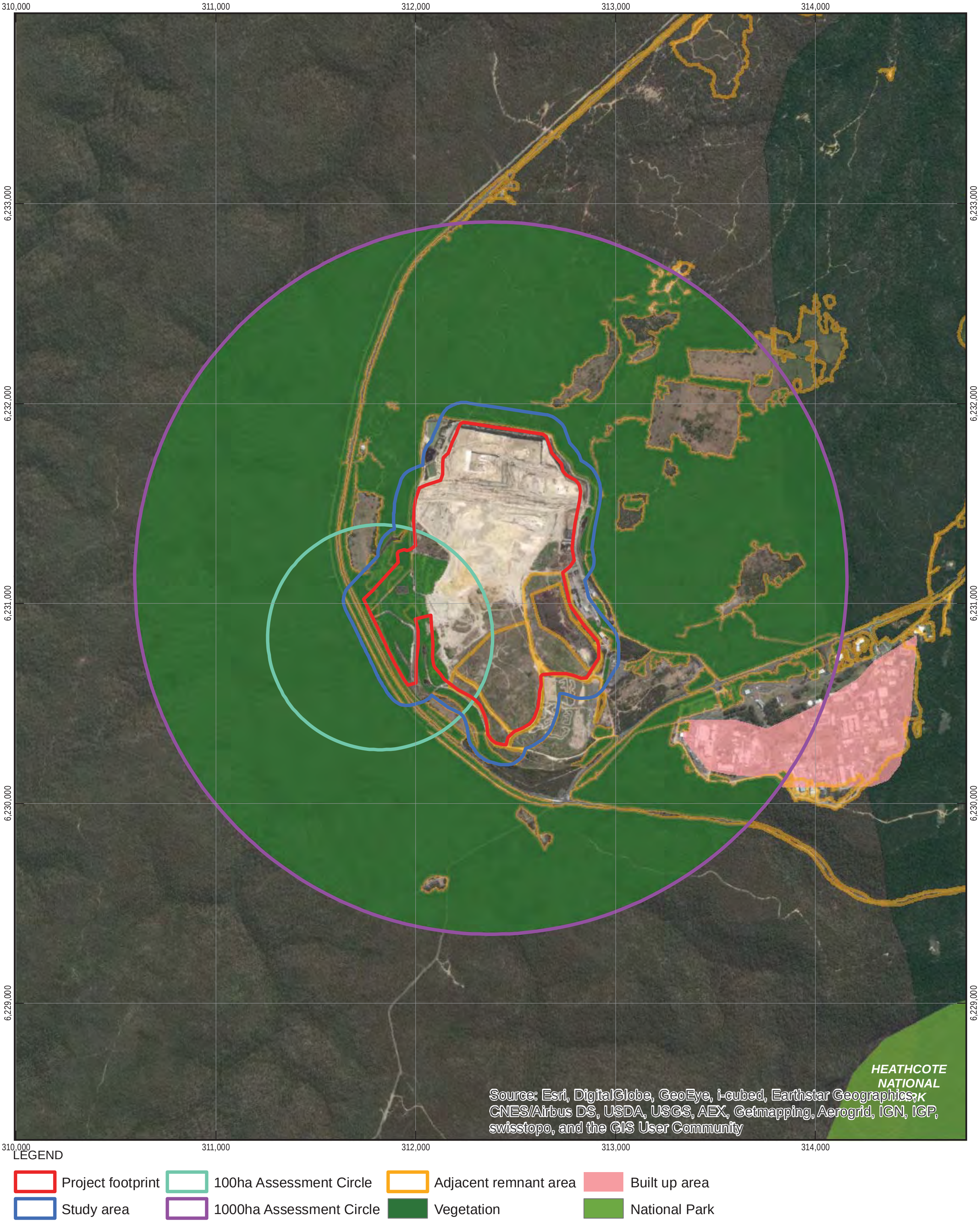
One vegetation zone and threatened species sub zone was created for each plant community type (PCT) and broad condition state in the proposal footprint. The area of each zone was calculated using GIS. Site score values (out of 100) reflect the disturbed nature of much of the native vegetation within the proposal footprint. Vegetation zones within the footprint of the GO facility are summarised in Table 7-2, and for the ARRT facility in Table 7-3. Note that as plot/transects were surveyed prior to the decision to split the project into two stages, some plots have been used in both sets of calculations.

Table 7-2 Vegetation zones for the GO facility

Vegetation Zone ID	PCT	Condition	Area (ha)	Site score	Patch size (ha)	Extent cleared in the CMA sub region	Plot / transects required	Plot / transects completed
1	Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014)	Moderate to good (moderate)	1.18	60.94	501	25	1	Plot/ transect 5
2	Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (regenerating and planted) (ME014)	Moderate to good (poor)	3.66	53.12	501	25	2	Plot/ transect 4 Plot/ transect 6

Table 7-3 Vegetation zones for the ARRT facility

Vegetation Zone ID	PCT	Condition	Area (ha)	Site score	Patch size (ha)	Extent cleared in the CMA sub region	Plot / transects required	Plot / transects completed
1	Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014)	Moderate to good (moderate)	1.25	47.05	501	25	1	Plot/ transect 2
2	Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (regenerating and planted) (ME014)	Moderate to good (poor)	3.16	46.18	501	25	2	Plot/ transect 3 Plot/ transect 4



Legend

Paper Size A4
0 100 200 400 600 800 1,000
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	04 May 2016

Landscape features

Figure 7-1

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Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by:apmiller

7.4 Threatened species

7.4.1 Predicted threatened species

The credit calculator reports the suite of threatened fauna species that are predicted to be associated with ecosystem credits generated for the proposal. That is, the threatened fauna species that are predicted to use habitat within the vegetation types in the proposal footprint. Each of these species has a 'threatened species multiplier' that feeds into the ecosystem credit calculations. If that fauna species or specific habitat resources for that species are not present at the development site, then the threatened species multiplier score may be adjusted.

The suite of threatened species associated with ecosystem credits for the development is shown in Table 7-4 along with an assessment of whether habitat components for these threatened species are present in the vegetation zones within the proposal footprint. The highest threatened species multiplier for the assessment was associated with the life cycle multiplier for the Masked Owl (*Tyto novaehollandiae*) and Powerful Owl (*Ninox strenua*) (3.0) which is based on the assumption that the proposal would remove suitable nest hollows for these threatened forest owls. The proposal site does not contain any large hollow-bearing trees that would comprise suitable nesting habitat for the Masked Owl and Powerful Owl. Therefore the threatened species multiplier for these species was adjusted to their 'effective management / rare populations' score (1.3) which meant that the highest threatened species multiplier for the assessment was associated with the Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) (2.6). The Spotted-tailed Quoll is likely to occur in the proposal footprint and to be affected by the proposal and so the credit calculations for threatened species were not adjusted further

Table 7-4 Predicted threatened species (ecosystem credit species)

Common name	Scientific name	Threatened species multiplier	Habitat components present in vegetation zones ?	Justification
Eastern Freetail-bat	*Mormopterus norfolkensis*	2.2	Yes	
Gang-gang Cockatoo	*Callocephalon fimbriatum*	2.0	Yes	
Greater Broad-nosed Bat	*Scoteanax rueppellii*	2.2	Yes	
Little Eagle	*Hieraaetus morphnoides*	1.4	Yes	
Masked Owl	*Tyto novaehollandiae*	1.3*	Yes	No large hollow-bearing trees are present in the proposal footprint.
New Holland Mouse	*Pseudomys novaehollandiae*	2.6	No	No suitable coastal heath habitat is present in the proposal footprint.
Powerful Owl	*Ninox strenua*	1.3*	Yes	No large hollow-bearing trees are present in the proposal footprint.
Scarlet Robin	*Petroica boodang*	1.3	Yes	
Spotted-tailed Quoll	*Dasyurus maculatus*	2.6	Yes	
Varied Sittella	*Daphoenositta chrysoptera*	1.3	Yes	

*Tg value altered as no breeding habitat is present (original value of 3).

7.4.2 Species credits

The credit calculator references geographic, vegetation and habitat data for the proposal footprint to generate a list of the species credit-type threatened species predicted to occur and requiring targeted survey.

Two flora species identified as requiring survey are unlikely to occur in the proposal footprint and targeted surveys were not conducted in the flowering season. These comprise:

- *Pterostylis* sp. Botany Bay (Botany Bay Bearded Orchid). This species is currently only known to occur within coastal heath on the Kurnell Penisula. It historically occurred at Maroubra. There are no local records of this species. No suitable habitat is present in the study area. No targeted surveys have been conducted for this species.
- *Calladenia tessellata* (Thick-lip Spider Orchid). This species usually occurs in grassy dry sclerophyll woodland, and occasionally in heathland on sandy loal soils. Limited potential habitat is present in the proposal footprint. No grassy woodland is present. Previous clearing is likely to have removed any individuals if present. There have been no records of this species in the greater Sydney region in the last 20 years. No targeted surveys have been conducted for this species.

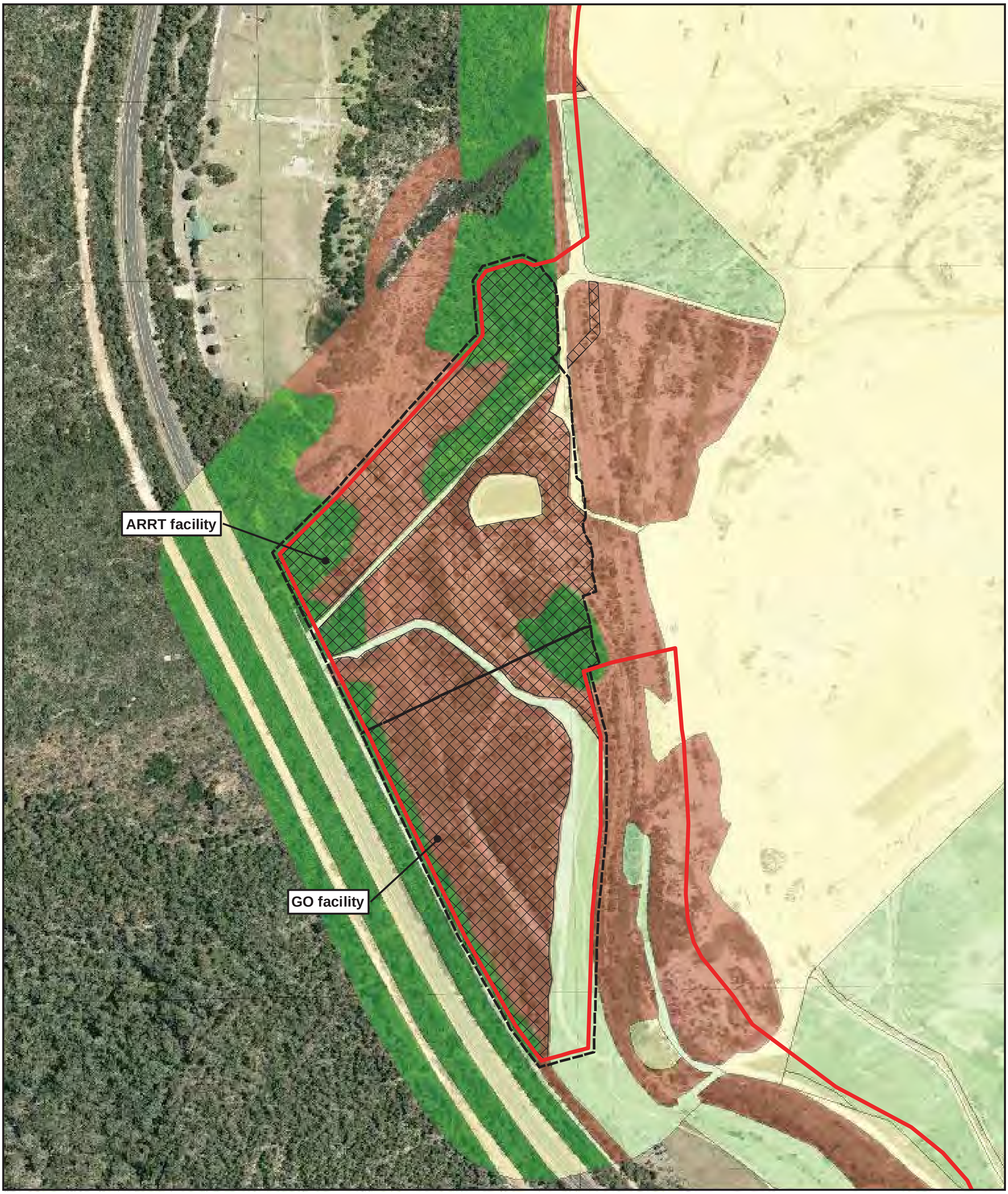
Surveys for the Eastern Pygmy-possum included habitat assessment and spotlighting surveys. No trapping was undertaken in the project site. The species was not trapped during targeted trapping surveys conducted to the east of the project site in November 2010 (GHD 2011). This species is considered likely to occur based on the presence of suitable habitat and local records. A species polygon is provided for this species in Figure 7-2, and includes all native vegetation in the footprints for the GO and ARRT facilities (Red Bloodwood - Scribbly Gum Heathy woodland, including regenerating and planted areas) (9.25 ha).

Surveys were conducted in the appropriate season for the Giant Burrowing Frog, Rosenberg's Goanna and Koala. As described in section 4.2.6, habitat for these species is very poor, and no evidence of their presence was recorded. These species have not been included in the credit calculations.

Surveys were conducted in the appropriate season for remaining species credit-type flora species (see Table 4-1). *Allocasuarina diminuta* subsp. *mimica* was recorded in the ARRT facility footprint. A species polygon is provided for this species (Figure 7-3). The endangered population of *Allocasuarina diminuta* subsp. *mimica* is a new listing under the TSC Act and is not yet included in the credit calculator. A detailed discussion of impacts on this endangered population is provided in section 7.6.3. The proposal would remove about 67 ramets.

Given the lack of evidence of other threatened flora species and existing disturbance in the proposal footprint, no other threatened flora species are likely to occur. As noted in section 4.3.2, the one individual of *Acacia bynoeana* previously recorded in the footprint for the GO facility has died. This species is therefore no longer included in the credit calculations.

A table of 'Threatened species survey / time matrix and survey effort' in accordance with the FBA is included in Appendix C.



Legend

Project footprint

Eastern Pygmy-possum

Vegetation type

Cleared/Dam

Grassland

Red Bloodwood - scribbly gum heathy woodland

Red Bloodwood - scribbly gum heathy woodland (regenerating and planted)

Hairpin Banksia - Slender Tea-tree heath (Coastal Upland Swamp EEC)

Paper Size A4

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	04 May 2016

Species polygon
Eastern Pygmy-possum

Figure 7-2

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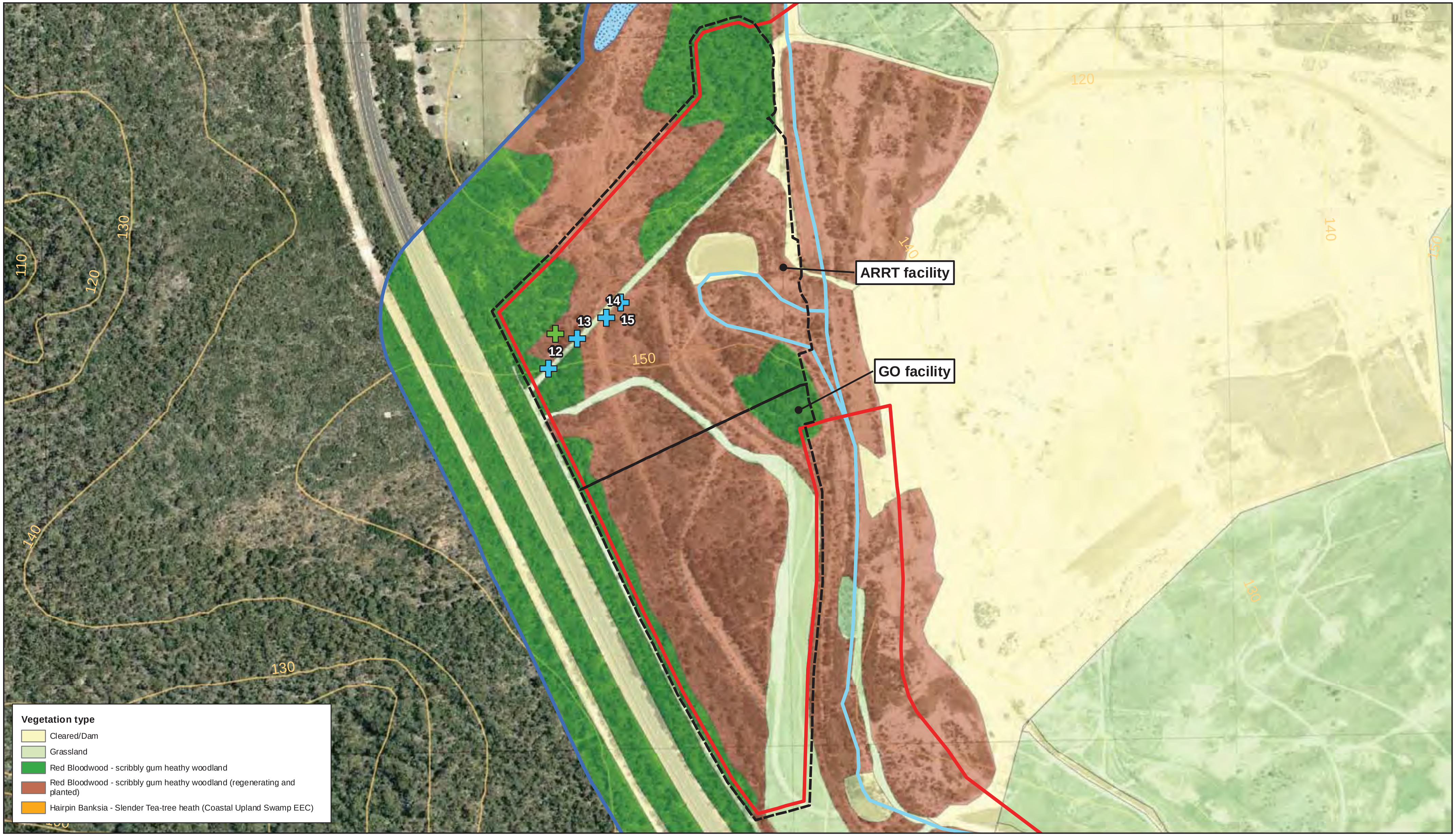
Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: Google Earth: Imagery- May 2014, NSW Department of Lands: contours - Jan 2012. Created by:apmiller



Paper Size A4

0 15 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Legend

Project footprint

Study area

Allocasuarina diminuta subsp. *mimica* (2015 Survey)

Allocasuarina diminuta subsp. *mimica* (2016 Survey)

SITA Australia
Lucas Heights Resource Recovery Park

Job Number | 21-23482
Revision | A
Date | 05 May 2016

Species polygon
Allocasuarina diminuta subsp. *mimica*

Figure 7-3

N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z065_Species_Polygons_Flora.mxd

Level 15, 133 Castlereagh Street Sydney NSW 2000 **T** 61 2 9239 7100 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Data source: ESRI, 2014. Works: GHD/SITA, 204. Topo: NSW LPMA 2012 Created by:mking3

7.5 Avoid and minimise impacts

7.5.1 Impact avoidance

The majority of the proposal is to be undertaken in areas which have previously been disturbed. The construction of the ARRT and GO facilities, including construction of the access road and realignment of Mill Creek, would mainly occur in areas that have previously been disturbed but are currently vegetated. The construction of the ARRT and GO facilities would remove 9.25 ha of native vegetation in total, of which 6.82 ha is regenerating and planted.

Adjustments have been made to the GO facility design since the submission of the EIS to DP&E to minimise impacts on the endangered population of *Allocasuarina diminuta* subsp. *mimica.* A survey was conducted in the company of a qualified surveyor in March 2016 to accurately map the location of the ramets with respect to the layout of the GO and ARRT facilities, and to refine the layout of these facilities in order to minimise impacts on the endangered population. Due to redesign of the GO facility, no *Allocasuarina diminuta* subsp. *mimica* ramets are present with the GO facility footprint. A total of about 67 ramets are within the ARRT facility footprint (66 along the track margin between SITA and SICTA land), and one in regenerating woodland in SICTA land.

The redesign of the GO facility has also allowed a reduction in the size of the pond that was located to the north of the ARRT facility. This is now set back further from the nearby Coastal Upland Swamp EEC, further minimising the potential for indirect impacts on this community.

7.5.2 Final proposal footprint

The final proposal footprint is shown on Figure 1-1 along with details of the proposal design and construction areas. The proposal footprint along with vegetation, threatened biota and habitat resources is shown on Figure 4-1**.** As noted previously, impacts associated with the landfill have not been considered in the biobanking credit calculations as these impacts relate to a previous approval.

7.5.3 Direct impacts

The proposal would result in direct impacts within the final proposal footprint shown on Figure 7-1 comprising:

- Disturbance of an overall construction footprint of 111.86 ha of which 71.77 ha is cleared land associated with the landfill and associated infrastructure. Much of this clearing relates to removal of vegetation on the existing landfill batters and has not been considered in the biobanking credit calculations as a review has been undertaken which concludes that SITA has approval under the current consent (1999 EIS and associated Consent R97/00029) to clear vegetation on the batters of the existing landfill as it is not yet at final profile..
- Removal or modification of 9.25 ha of native vegetation and associated habitat resources for threatened species and other native biota.
- Removal or modification of 1.37 ha of exotic grassland that does not comprise native vegetation or habitat for threatened species according to the FBA and has minimal value for native biota.
- Generation of noise, light, traffic and altered environmental conditions associated with the final proposal layout and operation of the landfill, ARRT and GO facilities which would comprise a minor impact on biodiversity values in the context of the landfill operations and the surrounding road network.

A more detailed description of direct impacts and the likely effect on the biodiversity values of the study area is provided in Chapter 5.

7.5.4 Indirect impacts

The impact mitigation and environmental management measures specified in Chapter 6 are likely to ensure that the majority of construction impacts are restricted to the proposal footprint. There are unlikely to be any substantial indirect impacts associated with construction activities (see section 5.2.2). As described in Section 5.2.2 the proposal would not result in any substantial operational impacts. Given the proposed mitigation measures, adjoining land uses, existing activities in the proposal footprint, the proposal would not result in any tangible indirect impacts.

Therefore no additional, indirect impacts have been included in the credit calculations.

7.6 Impact summary

7.6.1 Areas not requiring assessment

An assessor is not required to assess areas in a proposal footprint without native vegetation unless the SEARs for the proposal specifically require it.

The majority of the proposal footprint contains cleared land or exotic grassland that does not comprise native vegetation within the meaning of the FBA. These areas comprise ‘cleared land’ according to the FBA and the BioBanking methodology (DECC, 2009) because they contain no native over storey or mid storey vegetation and greater than 50% exotic ground cover cover or >90% bare earth. Further, the majority of exotic grassland present is located on fill material associated with unnatural landforms.

There are also small areas of planted trees in the proposal footprint (eg near the existing site buildings) that do not comprise native vegetation within the meaning of the FBA. These also comprise ‘cleared land’ according to the FBA and the BioBanking methodology (DECC, 2009).

These areas of cleared land within the proposal footprint were not sampled with plot/transects. A more detailed description of this vegetation and justification for the decision for no further assessment under the FBA is provided in Section 4.2.2.

The proposal footprint also includes gravel tracks, hardstand areas and other infrastructure with occasional plants associated with cracks or shallow soil deposits that clearly do not comprise native vegetation within the meaning of the FBA and therefore do not require assessment.

7.6.2 Areas not requiring offset

The majority of the proposal footprint is cleared land according the FBA. These areas have not been identified as native vegetation by Tozer (2010).

One exotic grassland area was sampled using a plot/transect and compared with benchmark values for the PCTs that were likely to have formerly occurred in such areas (see Appendix C). The plot/transect data confirms that this area is in substantially poorer condition than intact native vegetation.

None of this vegetation comprises a local occurrence of a TEC or contains species credit type threatened species or their habitats. Therefore impacts on cleared land as defined in the FBA in the proposal footprint do not require the calculation of offsets according to the FBA.

A more detailed description of this vegetation and justification for the decision for no further assessment under the FBA is provided in Section 4.2.2.

Note that impacts associated with the landfill have not been considered in the biobanking credit calculations as these impacts relate to a previous approval.

7.6.3 Impacts requiring further consideration

Certain impacts on biodiversity values of a major proposal require further consideration by the consent or approval authority. These are impacts that are particularly complicated or severe. A decision will be made by the consent or approval authority on whether it is appropriate for these impacts to occur or whether modifications to the major proposal are required to avoid or minimise the impact.

Impacts that require further consideration include:

- Significant impacts on landscape features.
- Impacts on CEECs or impacts on EECs that are likely to significantly affect the persistence or viability of an EEC.
- Impacts on critical habitat or on threatened species that are likely to significantly affect the persistence or viability of a population of a threatened species.

If a Major Project proposal includes an impact on biodiversity that requires further consideration it is recommended that a proponent discuss the impact with the NSW Department of Planning and Environment (DP&E) prior to lodging the EIS to avoid uncertainty and potential delays to project approval (OEH, 2014a).

The proposal has been purposefully designed to avoid impacts on biodiversity values as far as is practicable (see Section 1.1).

OEH specifically identified these matters as impacts requiring further consideration:

- Shale Sandstone Transition Forest CEEC
- *Allocasuarina diminuta* subsp. *mimica* L.A.S.Johnson endangered population in the Sutherland and Liverpool local government areas
- *Prostanthera saxicola* endangered population in the Sutherland and Liverpool local government areas.

These are discussed below.

Shale Sandstone Transition Forest

A narrow strip of this CEEC is located to the north-east of the existing landfill, outside the proposal footprint (see Figure 4-1). The majority of the stand is located over 200 metres from the proposal footprint. A second, smaller stand is located further to the north. These stands have been mapped by Sutherland Shire Council and have a combined area of 19.10 ha. The stand near the proposal footprint is in good condition, based on surveys carried out by GHD (2011). Shale Sandstone Transition Forest has also been mapped within Holsworthy army base by French et al (2000). About 1706 ha of plateau forest, including both Shale Sandstone Transition Forest and Shale Plateau Forest, were mapped in this area (French et al 2000). These communities could not be separated by this study, and thus the total area of Shale Sandstone Transition Forest cannot be provided. Much of this vegetation type in Holsworthy army base is likely to be in good condition, due to relatively little disturbance. A total of 7.2 ha of Shale Sandstone Transition Forest is mapped by Tozer et al (2010) within the 1000ha circle in which the proposal is located and a total of 11.95 ha of this community is mapped by Tozer et al (2010) within the 10,000ha circle in which the proposal is located. This mapping is broad-scale, based on a combination of remote sensing and on-ground surveys, and does not necessarily identify all vegetation communities present in a particular location. Based on other vegetation mapping described above, this is likely to be an underestimate of the total area of this CEEC in the assessment circles.

Shale Sandstone Transition Forest is located outside of the proposal footprint, to the north-east of the existing landfill, and would not be directly affected by the proposal. The existing approved landfill boundary had been located to avoid impacts on this community, and there would be no change to this boundary. No additional areas of vegetation would be cleared from near this community. Large tracts of vegetation are present to the northeast, south and east of the site, and connectivity with these areas would not be affected.

The edge of the stand of Shale Sandstone Transition Forest is located adjacent to the existing landfill void. Currently this is approximately 40 m deep. The landfill will eventually be reprofiled, with the surface matching nearby areas in about 2025. There will be no additional impacts on groundwater and surface water related to the proposal that could impact this CEEC.

The proposal footprint contains four species declared as noxious weeds in the Sutherland Local Government Area: Ludwigia (*Ludwigia peruviana*), Pampas Grass (*Cortaderia selloana*), Lantana (*Lantana camara*) and Fireweed (*Senecio madagascariensis*). These noxious species occurred in disturbed areas of the proposal footprint. Given that the existing landfill void is located about 40 m below the surface, and the majority of construction work will occur well to the south-west, there is minimal risk of weeds becoming established in the Shale Sandstone Transition Forest as a result of the proposal. There is some risk of weed spread occurring once the landfill has been reprofiled, if surfaces are not stabilised promptly with native species. Mitigation measures to prevent the spread of weeds are included in the proposal (see section 6.3).

European Foxes, Feral Cats, Rabbits and introduced mice and rats are present in the proposal footprint and surrounds. The proposal is unlikely to increase the incidence of these species in this community. No additional invasive fauna species are likely to become established as a result of the proposal.

The proposal is unlikely to interfere with the recovery of the community given that:

- there would be no direct impacts on this community
- there would be no additional clearing of nearby vegetation that would result in edge effects on this community
- there would be no fragmentation or isolation of this community
- any impacts on groundwater and surface water have already occurred and there would be no additional groundwater and surface water impacts relating to the proposal
- the proposal is unlikely to increase the incidence of weeds and feral animals.

There would be no change in extent or condition of the community within the IBRA subregion as a result of the proposal. Given the lack of impacts resulting from the proposal, no specific measures are proposed to contribute to the recovery of the CEEC in the INBRA subregion.

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A population of *Allocasuarina diminuta* subsp. *mimica*, listed as an endangered population under the TSC Act, was identified in the proposal footprint during the January 2015 surveys. This population is restricted to the Sutherland and Liverpool LGAs, with most of the population records occurring in land alongside Heathcote Road (OEH 2015b). Targeted surveys were conducted on 2 February 2015 to map the extent of the population within the proposal footprint and adjacent areas. An additional survey was conducted in March 2016 to more accurately survey the location and number of ramets in the proposal site.

The GO facility and ARRT facility have been redesigned since the March 2016 survey to avoid impacts on this population where possible. The boundary of both facilities has been moved away from the boundary fence to leave the access track in situ, which would avoid impacts on all ramets growing along the western boundary fence. A total of 66 ramets were recorded in the proposal footprint in the March 2016 survey, all within the footprint of the ARRT facility. One additional ramet is located in SICTA land to the north. There are now no ramets present within the GO facility footprint as a result of the redesign (see Figure 7-3). The stems are described as ramets, because it is possible that most stems have developed vegetatively after previous disturbances. Cones and female flowers were recorded on many ramets, however, so it is likely that there is also sexual reproduction within this sub-population. In addition, 62 ramets within the ARRT facility footprint appeared to be hybrids with the common *Allocasuarina littoralis.* Specimens have been forwarded to the National Herbarium of NSW for further comment.

The number of ramets recorded within the boundary fence in March 2016 has increased between the two targeted surveys, likely as a result of further disturbance (eg access track maintenance). It is recommended that further surveys are conducted to accurately quantify the number of ramets present in the ARRT facility prior to construction.

A much larger subpopulation (over 200 ramets) of *Allocasuarina diminuta* subsp. *mimica* occurs outside the proposal footprint. A total of 89 ramets were counted within SITA land in March 2016 along the western access track (outside the proposal footprint). A total of 137 ramets were counted outside the proposal footprint, both along Heathcote Road (between the intersection with New Illawarra Road and the Mills Creek crossing) and within SICTA land in the February 2015 survey. At least 12 ramets were recorded on the eastern side of Heathcote Road, and 101 in the drainage line and slopes along the western road reserve. About 24 ramets were recorded in disturbed vegetation immediately to the north of the proposal footprint in SICTA land. The species is also known to occur in heath vegetation to the east of the landfill (GHD 2011). This species was recorded during surveys by GHD at this location prior to the population being listed as endangered, and thus no counts of individuals were made.

There is a conserved population of *Allocasuarina diminuta* subsp. *mimica* in a Council Reserve, just to the north of the LHRRP, which has many hundreds of ramets present (B. Graham, SSC, pers. comm.). A population is also known at the proposed Heathcote Ridge development and adjacent areas.

The proposal would remove up to 67 ramets of *Allocasuarina diminuta* subsp. *mimica* for construction of the ARRT facility. Impacts on 89 ramets have been avoided by changing the layout of the GO and ARRT facilities to avoid construction along the access track adjacent to the western boundary fence. The 24 ramets growing north of the ARRT facility in SICTA land would not be removed, but may be indirectly impacted by the proposal by edge effects and changes to surface water flow. Ramets present along the edges of Heathcote Road (~112 ramets) are unlikely to be affected by the proposal. Further discussions of direct and indirect impacts are provided below.

Details of stands of *Allocasuarina diminuta* subsp. *mimica* recorded during the targeted survey in March 2016 are provided in Table 7-5. Locations of the ramets are mapped on Figure 7-3.

Table 7-5 *Allocasuarina diminuta* subsp. *mimica* recorded during the 2016 survey

WP	No. of ramets	Comments
1	0	One occurs in road reserve, near fence
2	4	>3 ramets adjacent, over fence
3	14	Along edge of track in 10 m x 1m patch
4	14	Along edge of track in 22 m x 1m patch; other ramets are adjacent, over fence
5	10	Ramets adjacent, over fence
6	11	Along edge of track in 7 m x 1m patch; Ramets adjacent, over fence
7	5	Growing in the middle of track
8	6	Ramets adjacent, over fence
9	1	Growing in patch of *Allocasuarina littoralis* Ramets adjacent, over fence
10	21	Growing in patch of *Allocasuarina littoralis*
11	3	Growing in patch of *Allocasuarina littoralis*
12*	3	along edge of track in 5 m x 1m patch; Numbers of Ramets adjacent, over fence
13*	1	Growing in patch of *Allocasuarina littoralis*
14*	40	Possibly inter-specific hybrids – awaiting comment from Herbarium
15*	22	Possibly inter-specific hybrids – awaiting comment from Herbarium

* located within the footprint of the ARRT facility. All other ramets recorded during this survey were outside the project footprint. Note that one additional ramet is located in the ARRT footprint in the SICTA land.

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The endangered population occurs along sandstone ridges and upper hillsides in the region northwest from Heathcote, towards Menai and Holsworthy, in heathy and low open woodland communities (OEH 2015c). In the study area it was observed to occur on trail margins (SITA land), in previously cleared areas (SICTA land) and along edges of woodland in the road reserve of Heathcote Road. All locations were on slopes, with the species not being recorded on the ridgetops. In all locations it was recorded in open areas, without a dense overstory. Parts of the proposal footprint have a dense overstory of *Allocasuarina littoralis* present. Further to the north, in the proposed Heathcote Ridge development area, it is known to occur heath and open woodland dominated by *Angophora hispida* and *Eucalyptus haemastoma* (Graham, B. in NSW Scientific Committee 2014), similar to the vegetation present in the study area.

The proposal would remove about 67 ramets and up to 9.25 ha of potential habitat for the species. Not all this habitat is suitable due to the presence of a closed overstorey in parts of the proposal footprint. No additional ramets were observed elsewhere in the proposal footprint. Approximately 89 ramets would be retained along the western boundary fence, and 24 ramets would be retained on the SICTA land to the north of the proposal footprint, in similar open, disturbed land (see Figure 4-1). Greater than 100 ramets were also observed in the road reserve on the eastern and western sides of Heathcote Road (see Figure 4-1), and the population is also known to occur to the east of the landfill (GHD 2011).

The total size of the endangered population is not known. A proportion of the known population may be removed for the proposed Heathcote Ridge development further to the north. In July 2015, the NSW Planning Minister approved rezoning of only 23 ha of the Heathcote Ridge site, much less than the 306 ha that the Land Council originally wished to rezone for urban purposes (DP&E 2015). There is a possibility that further land would be rezoned in the future. No targeted surveys for the subspecies were conducted at the Heathcote Ridge site as the subspecies had not been listed as an endangered population at the time surveys were conducted by Cumberland Ecology (2012). The proposed Heathcote Ridge development (if approved by the NSW government) was expected to affect about 188 ha of known and potential habitat for *Allocasuarina diminuta* subsp. *mimica*, which equates to about 78% of the known and potential habitat present in this area (Graham, B. in NSW Scientific Committee 2014). Based on the current approval, impacts on the population are likely to be substantially less than that quoted above, although further land may be rezoned in the future. A large population of many hundred of ramets is also present in the Council reserve north of the LHRRP (Graham, B, SCC, pers. comm.). Based on these numbers the subpopulation present in the proposal footprint is estimated to represent a minor proportion of the total endangered population (including the Heathcote Ridge population). In the local context, the known habitats along both sides of Heathcote Road, the heath to the east of the LHRRP and in the Council Reserve to the north of the LHRRP will not be affected by the proposed development.

The location of the core population of *Allocasuarina diminuta* subsp. *mimica* covers an area of approximately 32 km² on Heathcote Ridge. There are 15 database records for this subspecies, including sub-populations along Heathcote Road (NSW Scientific Committee 2014). The size of the sub-populations in the LHRRP are small and mostly consist of resprouted stems after initial damage during track maintenance and operation. The sub-population in the proposal footprint has a direct connection with sub-populations on the eastern road reserve of Heathcote Road. Large sub-populations were recorded on the western side of Heathcote Road. The sub-population on the eastern side of Heathcote Road will be reduced as a result of the proposal.

Preliminary seed collection was carried out by the on-site nursery staff in early March 2015, following the targeted survey, in order to propagate plants for future planting as part of the recommended mitigation for the proposal (see section 6.3). Further seed collection will be carried out prior to clearing. . Species of this genus can be propagated from seed (Wrigley and Fagg 2007). Efforts would also be made to translocate the ramets in the SITA site to the nursery for care and for future planting into areas of appropriate habitat which will not be disturbed or affected by the proposed development.

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Little is known about the ecology of the species. Cone production in the species in central NSW appears to be linked to rainfall, with fewer cones produced in dry years. Drought conditions resulted in the failure of plants to produce seed and caused the death of significant numbers of plants (Cameron 2005). The subspecies in the locality may be similarly reliant on rainfall for cone production. *Allocasuarina* species are wind pollinated and their seeds are wind dispersed (Benson and McDougall 1995). Because of wind pollination, plants are generally outcrossing, and very little hybridisation occurs within the genus. *Allocasuarina diminuta* subsp. *mimica* is probably killed by fire, regenerating from seed with 90% seed is released within 1 week of fire (Benson and McDougall 1995). Regeneration from seed after fire has been observed (NSW Scientific Committee 2014). Other members of the species are however known to resprout after fire and it is possible that *A. diminuta* subsp. *mimica* has the same capacity. *Allocasuarina diminuta* subsp. *diminuta* may resprout after fire (Benson and McDougall 1995) and *A. diminuta* subsp. *annectans*, is known to resprout after fire (DECCW 2010). *Allocasuarina diminuta* subsp. *mimica* has a symbiotic relationship with the actinomycete *Frankia*, a nitrogen-fixing bacteria (Benson and McDougall 1995).

Recent counts have identified 67 ramets that would be removed for the construction of the ARRT facility, therefore the number of female flowering stems in the endangered population will be reduced. No male flowering ramets were recorded on the in the proposal footprint or adjacent areas. Seedbanks, mycorrhizal associations and opportunity for recruitment in the proposal footprint would be removed. About 89 ramets would be retained along the western boundary fence and 24 ramets would be retained in the SICTA land north of the proposal footprint. Seedbanks, mycorrhizal associations and recruitment opportunities along Heathcote Road and the SICTA land to the north of the proposal footprint are unlikely to be impacted by the proposal. The stand of *Allocasuarina diminuta* subsp. *mimica* immediately to the north of the proposed ARRT facility may be impacted by changes to water flow at this location. This stand is located on skeletal soils in a previously cleared area, and a number of dead ramets were observed. Reduction in water could cause further death of ramets at this location. The pollination cycle, seedbank and recruitment opportunities of the larger subpopulation (>100 ramets) along the western side of Heathcote Road are unlikely to be impacted by the proposal. Mycorrhizal associations in these areas are unlikely to be disturbed. Smaller subpopulations on the eastern side of Heathcote Road, in SICTA land, and in heath to the east of the LHRRP will be able to continue to interact genetically with this larger population and other populations in the area.

Ideally, all cones will be harvested from ramets prior to clearing and all rootstocks and ramets will be collected during clearing and translocated initially to the nursery for replanting in appropriate habitat in areas which will not be disturbed. This would be carried out with input from the Sutherland Shire Council bushcare staff.

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The subpopulations in the proposal footprint are connected to or are located near subpopulations present along Heathcote Road. A narrow band of vegetation would remain along Heathcote Road, adjacent to the proposal site, providing connectivity between the main population to the north and records to the south. A subpopulation of about 12 ramets was recorded in this vegetation adjacent to the proposal footprint, and a subpopulation of over 100 ramets was recorded on the opposite side of Heathcote Road. The access track along the western boundary fence would be retained, meaning that the 89 ramets counted would also be retained. Large areas of potential habitat exist in surrounding areas, such as Holsworthy Army Base, the ANSTO buffer zone and Heathcote National Park. Red Bloodwood - Scribbly Gum heathy woodland, the vegetation type in which this species occurs in the study area, is the dominant vegetation type in the surrounding study area and nearby areas in the locality. The vegetation to be removed is located adjacent to the already cleared landfill and Heathcote Road. No area of vegetation would be isolated as a result of the proposal. Vast expanses of vegetation are present on the western side of Heathcote Road, which may also provide habitat for this endangered population. The larger subpopulation along Heathcote Road is already fragmented from thepopulations along the eastern side of Heathcote Road and in the proposal footprint. The proposal is unlikely to fragment an important population of this species into two or more populations.

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The sub-population in the LHRRP is small and mainly occurs in disturbed locations. It is located near the southern end of the endangered population’s range. Adjacent populations include those located alongside Heathcote Road. The loss of the subpopulation from within the proposal footprint will reduce genetic diversity to a small degree. The removal of 67 ramets for the ARRT facility represents a loss of about 23% of the immediate subpopulation, however given the size of the populations known to occur in the Council reserve and Heathcote Ridge, this is likely to represent less than 3% of the total population currently present in the locality. Pollination between the Heatcote Road populations and the population retained within SICTA land to the north of the proposal footprint could continue to occur following construction as these stands occur in contiguous vegetation. There are also conserved populations to the north-east of the LHRRP, in a Council Reserve and in the Holsworthy army base. The loss of the ramets in the proposal footprint is not likely to reduce the genetic viability or diversity of the endangered population as a whole. In addition, propogatino of individuals from seed and relocated stock will assist with the preservation of the genetic present in the proposal footprint. In the long-term there is potential to increase the size of this subpopulation through propogation.

the e tent to hi h the ro osed de elo ent ill lead to an in rease in threats and indire t i a ts in l din i a ts ro in asi e lora and a na that a in t rn lead to a de rease in the ia ilit o the lo al o lation

This endangered population is threatened by destruction of habitat, fragmentation, changes to fire regimes, fragmentation and weeds (OEH 2015c). The likely impacts from the loss of habitat and fragmentation are discussed above. The proposal is unlikely to alter fire regimes in the surrounding area. There is unlikely to be an increase in fire frequency that could lead to insufficient seed production and loss of mature individuals in the surrounding area as a result of the proposal. Weeds such as African Lovegrass (*Eragrostis curvula*) which can affect the intensity of fire as well as be an impediment to recruitment (OEH 2015c) are present in the proposal footprint and in SICTA land to the north. The proposal is unlikely to result in increases in the incident of weed species. Mitigation measures are proposed to manage weeds during construction and operation (see section 6.3).

Possible changes to hydrology resulting from clearing of vegetation from the site may impact small areas of vegetation immediately adjacent to and downslope of the proposal. Construction of the ARRT facility would result in changes to surface water flow in the immediate vicinity. The construction of the new ARRT facility and the relocation of the GO facility would involve excavation works but these works are not expected at depths that would intercept groundwater. The stand of *Allocasuarina diminuta* subsp. *mimica* immediately to the north of the proposed ARRT facility may be impacted by changes to water flow at this location. This stand is located on skeletal soils in a previously cleared area, and a number of dead ramets were observed. Reduction in water could cause further death of ramets at this location. The proposal may also lead to a reduction in water reaching stands of the subspecies located between the proposal footprint and Heathcote Road (including those along the boundary fence). These would also receive runoff from Heathcote Road and are not likely to rely on water seeping from the proposal footprint. The large stands located on the western side of Heathcote Road would not be impacted by the proposal.

Edge effects could impact potential habitat for this species. Edge effects (changes in environmental conditions) occur in zones of vegetation on the edges of fragments. The edge affected zone is generally taken to be 50 m from the disturbed edge (Bali 2005). The proposal footprint is already highly disturbed. The impacts of edge effects are also visible across much of the area where the species occurs due to the presence of existing clearings for access tracks, as well as the landfill and Heathcote Road. The proposal would create a new edge around the proposed ARRT and GO facilities, however the majority of this edge is already impacted by edge effects from Heathcote Road and disturbed areas within the SICTA area. Specimens recorded outside the footprint were located alongside Heathcote Road and adjacent to cleared areas within SICTA land, all of which are already edge-effected. This species prefers disturbed edges and is unlikely to be impacted by changes to edges resulting from the proposal.

A noted above, the number of ramets along the access track increased between the February 2015 and March 2016 surveys. This is likely in part due to maintenance activities along the access track (eg grading of the track), or disturbance from occasional vehicular movements. Further disturbance from ongoing occasional vehicle movements could further encourage growth of ramets, potentially increasing the population size at this location.

the eas re s ro osed to ontri te to the re o er o the s e ies in the s re ion

Despite the removal of stands of *Allocasuarina diminuta* subsp. *mimica*, the proposal should also contribute to the recovery of the species. SITA has long association with the Menai Wildflower Group who operates a native seedling nursery at the LHRRP. The Menai Wildflower Group has been in operations for 28 years and have been providing approximately 10,000 to 15,000 seedlings per year to schools, national parks and other community groups to propagate plants. The native seedling nursery was originally established to produce native plants for the rehabilitation of the New Illawarra Road landfill and is fully equipped with a glass house that has heated propagation beds plus an igloo and shade house with automated watering systems. The Menai Wildflower Group will assist with the cultivation of individuals of the species, through collection of seed prior to clearing, and propogation of plants from seed and collection of ramets from the proposal footprint. Preliminary seed collection took place in early March 2015, following the targeted survey. Ideally, all cones will be harvested from ramets prior to clearing and all rootstocks and ramets will be collected during clearing and translocated initially to the nursery for replanting in appropriate habitat in areas which will not be disturbed. This would be carried out with input from the Sutherland Shire Council bushcare staff. Plants would be propagated for eventual planting elsewhere on the LHRRP where appropriate soil and vegetation type is present, and where the plants are unlikely to be impacted by future development. Soil should also be translocated to preserve associated mycorrhyzia. Seedlings would also be provided to Sutherland Council for planting in other suitable areas.

A management plan for the collection of seed and translocation would be prepared as part of the CEMP for the proposal (see section 6.3) and would include monitoring and assessment of the success of the program. Any planting carried out in the proposed offset site would be included in the Management Action Plan for the offset site (see section 8).

rostanthera sa i ola population

This population occurs mainly between Holsworthy station and Sutherland station, north from Lucas Heights and south of the Georges River (OEH 2015b). Five records of the species are mapped in the Atlas of NSW Wildlife. Four records are located north of the study area in land adjacent to Heathcote Road, and one is located to the east at Woronora Heights (OEH 2015a). The closest record is located over 1 km to the north of the study area boundary.

This species grows primarily in eucalypt forest, heath and low shrubland, often in damp or moist sites (OEH 2015a). Woodland in the proposal footprint has been heavily disturbed, with much of it being regrowth on skeletal soils. Intact vegetation is dry, with few, if any, damp or moist sites. This species was not recorded during surveys in the proposal footprint and adjacent areas. Given the lack of preferred habitat and lack of any evidence of its occurrence, this population is unlikely to be present in the proposal area.

The proposal would remove 9.25 of woodland habitat from the locality. Large areas of woodland habitat are located within the locality, including within Holsworthy army reserve (where individuals of this species have been recorded), Heathcote National Park, Georges River National Park and the Royal National Park. The loss of vegetation from the proposal footprint is not likely to affect the available habitat for the species, as no individuals were recorded in the proposal footprint and preferred habitat is not present. Vegetation to be removed as a result of the proposal is located alongside the existing landfill and Heathcote Road. The proposal will not isolate any habitat for the species. The proposal would cause an incremental increase in fragmentation in the locality. Given the distance of the proposal from the known population and comparatively small area of vegetation that would be removed, the proposal is unlikely to interfere with the pollination cycle, local seedbanks, recruitment, and interactions with pollinators.

The proposal is unlikely to increase threats or result in indirect impacts on this species, given the closest record is located over 1 km from the study area. An expert report has been provided in Appendix E that further discusses this endangered popualtion.

7.6.4 Biodiversity credits

The data from the fieldwork and mapping was entered into Version 4.0 of the BioBanking credit calculator as a ‘Major Project’ assessment to determine the number and type of biodiversity credits that would be required to offset impacts at the proposal footprint. As noted in Section 1.3 and 5.1, SITA are proposing a staged approach, and credits required to offset the contruction of the GO facility have been calculated separately to those required for the construction of the ARRT facility.

The Biodiversity credit reports are included in Appendix A and are summarised below.

A total of **185** ecosystem credits would be required to offset the impacts of constructing the GO facility. A further **143** ecosystem credits would be required to offset the impacts of constructing the ARRT facility at the time of construction of this facility (see Table 7-6).

Species credits for the Eastern Pygmy-possum were calculated using the Major Project credit calculator. A total of **97** species credits would be required for constructing the GO facility. A further **88** species credits would be required for the construction of the ARRT facility at a later date.

For *Allocasuarina diminuta* subsp. *mimica*, which is not yet in the credit calculator, species credits were calculated using Equation 6 of the FBA, and the T_g value of 0.125 as directed by OEH (67 individuals x 1/0.13 x 10). Note that the T_g value has been rounded to 0.13 as is the case in the credit calculator for *Acacia bynoeana*, which has the same T_g value. As discussed earlier, there are no *Allocasuarina diminuta* subsp. *mimica* in the landfill or GO facility footprints. All ramets are located in the footprint for the ARRT facility. Based on the removal of 67 ramets, a total of **5154** species credits would be required. The identity of many of these would need to be further assessed, as many appeared to be hybrids. Note that these credits would not be required until the construction of the ARRT facility.

Species credits required to offset the impacts of the proposal are shown in Table 7-7.

Table 7-6 Ecosystem credits required to offset impacts of the proposal

Plant community type	Area (ha)	Loss in landscape value	Loss in site value score	TEC offset multiplier	Threatened species with highest credit requirement	Threatened species offset multiplier	Ecosystem credits required	Total ecosystem credits required for each stage
Stage 1: GO facility								**185**
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014)	1.18	9.40	60.94	1.0	Spotted-tailed Quoll	2.6	50	
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (regenerating and planted (ME014)	3.66	9.40	53.12	1.0	Spotted-tailed Quoll	2.6	135	
Stage 2: ARRT facility								**143**
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014)	1.25	9.4	47.05	1	Spotted-tailed Quoll	2.6	41	
Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (regenerating and planted (ME014)	3.16	9.4	46.18	1	Spotted-tailed Quoll	2.6	102	

Table 7-7 Species credits required to offset impacts of the proposal

Scientific name	Common name	TS offset multiplier	Species credits required – GO Facility	Species credits required – ARRT Facility
Cercartetus nanus	Eastern Pygmy-possum	2.0	178	88
Allocasuarina diminuta subsp. *mimica*	*Allocasuarina diminuta* subsp. *mimica*	0.125	0	5154

8. Biodiversity offset strategy

8.1 Introduction

This section presents the Biodiversity Offset Strategy (BOS), which outlines how the proponent intends to offset the impacts of the proposal.

The credit calculator has been used in this Biodiversity Assessment Report to determine the number and type of biodiversity credits required to offset impacts of the proposal. The Biodiversity credit reports are included in Appendix A.

The BOS for the proposal would include the purchase and retirement of the biodiversity credits as calculated in accordance with the FBA. The proposal involves two stages of works, these being:

- Stage 1 – which includes construction of the GO facility and associated infratsructue (e.g. water quality dam). SITA will purchase and retire credits required as soon as possible following approval and prior to construction of the facility.
- Stage 2 – which includes the construction of the ARRT facility and associated infrastructure. The construction of this facility is not immediate and, as such, SITA is seeking approval for the project on the provision that the credits for that facility will be purchased and retired separately to those required for the GO facility, and before any construction of the ARRT facility commences.

Accordingly, biodiversity offsets are also proposed to be delivered in two stages. The first stage will see the purchase and retirement of the biodiversity credits required for the GO facility and the second stage will require the securing of the biodiversity credits for the ARRT.

As discussed earlier, the project has been redesigned so that no *Allocasuarina diminuta* subsp. *mimica* would be impacted by the first stage of works (construction of the GO facility). Therefore, the biodiversity credit requirements for the proposal are as follows:

- Stage 1 –**185** ecosystem credits of Red Bloodwood – Scribbly Gum heathy woodland (ME014) and **97** species credits for the Eastern Pygmy-possum would be required to offset the impacts of constructing the GO facility. .
- Stage 2 –**143** ecosystems credits of Red Bloodwood – Scribbly Gum heathy woodland (ME014) would be required to offset the impacts of constructing the ARRT facility at later date. An additional **88** species credits for the Eastern Pygmy possum and **5,154** species credits for the *Allocasuarina diminuta* subsp. *mimica* endangered population would also be required prior to contruction of the ARRT facility.

8.2 Requirement to offset

This BOS documents the process SITA has completed to identify suitable offset options for the Project. It describes the staged approach required by the project to secure biodiversity credits for both the GO and ARRT Facilities. Importantly the BOS describes the preferred sites for purchasing biodiversity credits for the GO Facility and commits to the process of securing and retiring these credits. In addition, the BOS outlines the requirements and commitments for SITA to complete its offset requirements should the ARRT Facility be constructed in the future.

8.3 Offset investigations

Under the FBA, ecosystem and species credit requirements identified for the proposal can be offset in a number of ways, including:

- Retiring credits via a BioBanking agreement
- Contributing money to supplementary measures
- Contributing money to a BioBanking fund.

The BioBanking Fund has not been established and is therefore not an option for this proposal at the time of writing.

Where possible, the BOS will aim to match ecosystem and species credits on a 'like for like' basis through the retirement of biodiversity credits, in accordance with the credit profiles provided in the Project's credit report (refer Appendix A). Where this is not possible, the credit trading rules associated with Major Projects can be used to source suitable credits and/or supplementary measures will be investigated in consultation with the consent authority.

GHD has investigated the availability of credits currently available and biobank sites that have commenced their BioBanking agreement assessments to offset the construction of the GO Facility. The results of this investigation indicate the proposal will be able to achieve the 'like for like' principle for the ecosystem credit types requiring offsetting for the GO Facility. Further investigation of species credits required is currently taking place. Credits required to offset the ARRT facility will be purchased and retired at the time that this facility is proposed to be constructed.

8.4 Proposed credit trades – Stage 1 GO facility

The proponent proposes to purchase and retire credits from biobank sites managed by The Hills Shire Council (THSC) to offset the construction of the GO Facility. As described in Section 7.6.4, **185** ecosystem credits are required to offset the construction of the GO Facility. SITA will enter into negotiations with THSC to secure these credits. A breakdown of credits available for purchase and retirement from THSC is provided in Table 8-1.

Table 8-1 Proposed credit trades for the GO facility

Credit type	Number available	Biobank No.	Biobank owner	Trading rules used
HN566	76	Agreement 37	THSC	Direct match
HN566	29	Agreement 38	THSC	Direct match
HN586	14	Agreement 37	THSC	Direct trade
HN586	93 (need 66)	Agreement 38	THSC	Direct trade
Total:	185			

Note: Suitable credits are also available from Biobank Agreement No. 117. Should discussions with THSC secure not all the credits required above for any reason the credits would be sourced from this site.

The are currently no Eastern Pygmy-possum credits available on the open market. SITA is investigating several opportunities to secure these credits. These include working with existing biobank site owners to undertake the necessary assessment to generate these credits at their sites and/or working with Sutherland Shire Council to identify a suitable site which may be placed under a BioBanking Agreement to generate and secure these credits. Either way, these credits will be required before construction can commence.

8.5 Potential future credit trades – Stage 2 ARRT facility

Stage 2 of the BOS will be to secure and retire the necessary biodiversity credits for the ARRT Facility. The construction of this facility is not immediate and, as such, SITA is seeking approval for the project on the provision that the credits for that facility will be purchased and retired separately to those required for the GO facility, and before any construction of the ARRT facility commences. This will require SITA to submit a credit retirement form for the following credits before construction can commence:

- 143 ecosystems credits of Red Bloodwood – Scribbly Gum heathy woodland (ME014)
- 88 species credits for the Eastern Pygmy-possum
- 5,154 species credits for the *Allocasuarina diminuta* subsp. *mimica* endangered population. This is based on the the removal of 67 ramets. The identity of many of these would need to be further assessed, as many appeared to be hybrids. A targeted survey is recommended closer to the time that this facility is proposed for construction to assess the total number of ramets that would be impacted. Further consultation with the National Herbarium of NSW is also recommended.

SITA understands these credits will be required to be secured and retired before construction can commence on the ARRT facility. SITA will consult with Sutherland Shire Council to identify a suitable biobank site and/or engage with the BioBanking open market and provide evidence that the appropriate type and number of credits have been retired, through the provision of a retirement certificate/s, at an appropriate time should the facility be constructed.

The impacts on MNES have been assessed in a referral to the Commonwealth Government. The Minister for the Environment has determined that the proposal is not a controlled action under the EPBC Act. As such, there is no requirement for biodiversity offsets under the EPBC Act and associated offsets policy (DSEWPaC, 2012).

9. Conclusions

9.1 Summary of key findings

This Biodiversity Assessment Report has been prepared in accordance with the FBA to describe the biodiversity values present wihtin the proposal footprint, assess impacts of the proposal and determine the number of biodiversity credits required to offset impacts of the proposal.

The majority of the proposal footprint is located within the existing landfill, which has been cleared and substantially modified. The proposed ARRT and GO facility have been positioned within vegetated land of which much had been previously cleared but is now regenerating. The proposal's impacts are therefore substantially less than would be associated with an undisturbed 'green field' site. The proposal has been purposefully designed to avoid or further reduce impacts on biodiversity values as far as is practicable.

Specific mitigation measures are recommended to minimise impacts on the natural environment and threatened biota, including:

- Erosion and sediment control measures to avoid secondary impacts on surrounding native vegetation and aquatic habitats
- Restriction of access into adjacent remnant vegetation during construction and machinery hygiene protocols, washing of vehicles and erection of appropriate barriers to reduce the risk of transmission of weeds, contaminants or pathogens
- Management of noxious and environmental weeds.
- Pre-clearing surveys for fauna such as frogs and hollow-depedent species.
- Fauna management during clearing activities.

Despite measures taken to avoid and mitigate impacts, the proposal would result in some unavoidable residual adverse impacts imposed upon some elements of the natural environment, including removal of native vegetation, a threatened plant and ramets of a threatened population, fauna habitat resources and imposition of edge effects on adjoining areas of native vegetation. These residual impacts are small in extent and magnitude and would comprise a minor reduction in biodiversity values in the study area.

No threatened ecological communities would be directly impacted. The proposal may have a minor indirect impact on a nearby Coastal Upland Swamp, however this is unlikely to change the species composition of the community or reduce its extent. The stand of Shale Sandstone Transition Forest located to the north of the existing landfill is unlikely to be impacted by the proposal given its distance from the proposal footprint and lack of any clearing in this area.

A total of 67 ramets of *Allocasuarina diminuta* subsp. *mimica* that form part of the the endangered population in the proposal footprint would be removed as a result of the construction of the ARRT facility. No ramets of this endangered population would be removed for the construction of the GO facility and the reprofiling of the landfill.

The proposal would remove a very small proportion of available habitat resources for local populations of native fauna. Impacts would include the removal of:

- Up to 9.25 ha of potential foraging habitat for mobile threatened fauna species, including the Grey-headed Flying-fox, birds and microbats
- Up to 9.25 ha of potential foraging, shelter and nest or den sites for the Eastern Pygmy-possum and the Spotted-tailed Quoll

- Up to five hollow-bearing trees and two rock outcrops
- One artificial dam and a section of Mill Creek. Mill Creek would be realigned to allow continued flow.

The proposal would not impact any threatened biota listed under the FM Act.

A FBA assessment and credit calculations have been performed in accordance with the methodology (OEH 2014a) and using credit calculator Version 4.1. The FBA includes thresholds for assessing and offsetting impacts of development (see table 4 of OEH, 2014a). As noted above, the proposal would be constructed in two stages. As such, credit calculations have been undertaken for the initial work (construction of the GO facility) and for the later construction of the ARRT facility. This means that credits to offset the impacts on the endangered population of *Allocasuarina diminuta* subsp. *mimica* can be sourced at a later date as no ramets would be affected by the construction of the GO facility. Impacts associated with the landfill have not been considered in the biobanking credit calculations as these impacts relate to a previous approval.

With reference to these thresholds the proposal includes:

- 4.84 hectares of impacts resulting from the construction of the GO facility for which the assessor is required to determine an offset, comprising:
  - 185 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014).
  - 97 species credits for the Eastern Pygmy-possum.
- 4.41 hectares of impacts resulting from the construction of the ARRT facility for which the assessor is required to determine an offset, comprising:
  - 143 ecosystem credits for impacts on Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME014).
  - 5,154 species credits for *Allocasuarina diminuta* subsp. *mimica*
  - 88 species credits for the Eastern Pygmy-possum.
- 1.71 hectares of impacts for which the assessor is not required to determine an offset, comprising the removal of exotic grassland and cleared land.
- 100.9 hectares of land for which SITA has prior approval to clear and has not been included in this assessment.

The Biodiversity Offset Strategy for the proposal would include the purchase and retirement of biodiversity credits as calculated in accordance with the FBA.

9.2 Meets identified objectives

This report addresses the Secretary’s Environmental Assessment Requirements (Section 1.6) and concludes that the proposal would meet the following objectives as identified in Section 1.2:

- No significant impacts on the natural environment and threatened biota
- Avoid or further reduce impacts on biodiversity values as far as is practicable
- Minimise the occurance of pests, vermin and noxious weeds.

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11. Limitations

This report: has been prepared by GHD for SITA Australia Pty Ltd and may only be used and relied on by SITA Australia Pty Ltd for the purpose agreed between GHD and the SITA Australia Pty Ltd as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than SITA Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer Section 3.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect. Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Appendices

Appendix A Final credit reports

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 2/05/2016 Time: 10:30:02PM Calculator version: v4.0

Major Project details

Proposal ID:	0160/2016/3584MP
Proposal name:	Lucas Heights RRP - GO Facility
Proposal address:	Little Forest Road Lucas Heights NSW 2234
Proponent name:	SITA Australia
Proponent address:	3 Rider Boulevarde Rhodes NSW 2138
Proponent phone:	02 9708 7853
Assessor name:	Kirsten Crosby
Assessor address:	Level 15 133 Castlereagh Street Sydney NSW 2000
Assessor phone:	02 9239 7225
Assessor accreditation:	0160

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	4.84	185.00
Total	4.84	185

Credit profiles

1. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (ME014)

Number of ecosystem credits created	185
IBRA sub-region	Sydney Cataract - Sydney Metro

Offset options - Plant Community types	Offset options - IBRA sub-regions
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (ME014) Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion, (ME012) Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (ME029) Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion, (ME039)	Sydney Cataract - Sydney Metro and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Eastern Pygmy-possum	Cercartetus nanus	4.84	97

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 2/05/2016 Time: 10:48:20PM Calculator version: v4.0

Major Project details

Proposal ID:	0160/2016/3585MP
Proposal name:	Lucas Heights RRP - ARRT Facility
Proposal address:	Little Forest Road Lucas Heights NSW 2234
Proponent name:	Sita Australia
Proponent address:	Level 3 3 Rider Ave Rhodes NSW 2138
Proponent phone:	02 9708 7853
Assessor name:	Kirsten Crosby
Assessor address:	Level 15 133 Castlereagh Street Sydney NSW 2000
Assessor phone:	02 9239 7225
Assessor accreditation:	0160

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	4.41	143.00
Total	4.41	143

Credit profiles

1. Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (ME014)

Number of ecosystem credits created	143
IBRA sub-region	Sydney Cataract - Sydney Metro

Offset options - Plant Community types	Offset options - IBRA sub-regions
Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion, (ME014) Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion, (ME012) Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, (ME029) Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin Bioregion, (ME039)	Sydney Cataract - Sydney Metro and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Eastern Pygmy-possum	Cercartetus nanus	4.41	88

Appendix B Desktop assessment of threatened biota

Threatened e olo i al o nities that o r in the st d area

Name	TSC Act Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Coastal Upland Swamp in the Sydney Basin Bioregion	EEC	EEC	Community known to occur within locality (OEH 2015a) Community recorded east of the site by GHD (2011)	Includes open graminiod heath, sedgeland and tall scrub associated with periodically waterlogged soils on the Hawkesbury sandstone plateaus. Generally associated with soils that are acidic and vary from yellow or grey mineral sandy loams with a shallow organic horizon to highly organic spongy black peat soils with pallid subsoils. May include tall open scrubs, tall closed scrubs, closed heaths, open graminoid heaths, sedgelands and fernlands.	Present. Occurs about 50 m north of the proposed pond to the north of the ARRT facility.	Nil. Community not identified in the proposal footprint.	No direct impacts. Potential for indirect impacts as the community is located downslope of the proposal.
Shale/Sandstone Transition Forest	CEEC	CEEC	Community known to occur within locality (OEH 2015a); community likely occur within locality (DotE 2015a) Community recorded to the north of the proposal footprint by Sutherland Shire Council.	Occurs on the edges of the Cumberland Plain where clay soils on shale intergrade with sandstone soils, or where shale caps overlay sandstone. Species composition variable depending on soil influences. Dominant tree species include *Eucalyptus tereticornis, E. punctata, E. globoidea, E. eugenioides, E. fibrosa* and *E. crebra*. Areas with a low sandstone influence have an understorey closer to Cumberland Plain Woodland.	Present. Occurs to the north-east of the proposal footprint (and the existing void).	Nil. Community not identified in the proposal footprint.	No direct impacts. Unlikely to be indirectly impacted by the proposal due to the distance from the proposal and lack of clearing activities nearby .

Threatened lora s e ies and o lations no n or redi ted to o r in the lo alit

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Acacia bynoeana	Bynoe's Wattle	E	V	1 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Endemic to central eastern NSW, currently known from only 34 locations, many of only 1-5 plants. Grows mainly in heath/ dry sclerophyll forest on sandy soils, prefers open, sometimes slightly disturbed sites such as trail margins, road edges, and in recently burnt open patches. Flowers September to March, and fruit matures in November.	**Likely**. Records exist within the locality and suitable habitat occurs throughout native vegetation in the study area.	**Present**. One individual recorded in woodland vegetation within the area proposed for the ARRT facility. No additional specimens recorded during surveys.	One individual would be removed. No other individuals have been recorded in the proposal footprint.
Acacia pubescens	Downy Wattle	V	V	118 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs mainly in Bankstown-Fairfield-Rookwood and Pitt Town areas, with outliers at Barden Ridge, Oakdale and Mountain Lagoon. Grows on alluviums, shales and shale/sandstone intergrades. Soils characteristically gravely, often with ironstone. Occurs in open woodland and forest, in communities including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland. Flowers August to October.	**Likely**. Records exist within the locality and suitable habitat occurs in good quality woodland in the study area.	**Unlikely**. Could theoretically occur in woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Allocasuarina diminuta subsp. *mimica*	*Allocasuarina diminuta* subsp. *mimica* L.A.S.Johnson population in the Sutherland and Liverpool local government areas	EP		22 records within 10km (OEH 2015a)	Occurs along sandstone ridges and upper hillsides in the region northwest from Heathcote, towards Menai and Holsworthy, in heathy and low open woodland communities. It is restricted to the Local Government Areas listed in this instance (Sutherland and Liverpool).	Present. About 136 ramets recorded along Heathcote Road and in SICTA land to the north of the proposal footprint.	Present. 58 ramets recorded within the proposal footprint.	Proposal would remove 58 ramets.
Allocasuarina glareicola		E	E	1 record within 10km (OEH 2015a); Species or species habitat	Primarily restricted to small populations in and around Castlereagh NR (NW Cumberland Plain), but with an outlier population at Voyager Point, Liverpool. Also	**Unlikely**. Potential habitat may be present, however no Castlereagh	**Unlikely**. Could theoretically occur in woodland vegetation within the	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
				may occur within locality (DotE 2015a)	reported from Holsworthy Military Area. Grows on tertiary alluvial gravels, with yellow clayey subsoil and lateritic soil. Occurs in Castlereagh open woodland.	woodland known from the study area.	area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	
Asterolasia elegans		E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby LGAs, may also occur in the western part of Gosford LGA. 7 known populations. Occurs on Hawkesbury sandstone, commonly amongst rocky outcrops and boulders in sheltered forests on mid- to lower slopes and valleys.	**Nil.** Outside known distsribution.	**Nil.** Outside known distsribution.	Nil
Astrotricha crassifolia	Thick-leaf Star-hair	V	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs near Patonga (Gosford LGA), and in Royal NP and on the Woronora Plateau (Sutherland and Campbelltown LGAs). There is also a record from near Glen Davis (Lithgow LGA). Grows on dry ridgetops to 300 m altitude, associated with very rich heath, or dry sclerophyll woodland on sandstone.	**Possible**. Suitable habitat exists in good quality woodland in the study area.	**Unlikely**. Could theoretically occur in woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Caesia parviflora var. minor	Small Pale Grass-lily	E		1 record within 10km (OEH 2015a)	In NSW occurs in Barcoongere State Forest between Grafton and Coffs Harbour. May be more widely distributed as not often identified to subspecies level. Grows in	**Nil.** Outside known distribution.	**Nil.** Outside known distribution.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					damp open places in open forest on sandstone.			
Caladenia tessellata	Thick Lip Spider Orchid	E	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs from Central Coast NSW to southern VIC. Mostly coastal but extends inland to Braidwood in southern NSW. In NSW grows in grassy dry sclerophyll woodland on clay loam or sandy soils, and less commonly in heathland on sandy loam soils (Duncan 2010).	**Possible**. Potential habitat present in grassy woodland located to the north and east of the proposal footprint.	**Unlikely**. No grassy woodland present in the proposal footprint. Historical clearing in the study area likely to have substantially reduced habitat quality.	Impacts unlikely
Callistemon linearifolius	Netted Bottle Brush	V		7 record within 10km (OEH 2015a)	Recorded from the Georges to Hawkesbury Rivers in Sydney, and north to Nelson Bay. There is also a recent record from the northern Illawarra. In Sydney, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. Grows in dry sclerophyll forest on the coast and adjacent ranges.	**Possible**. Suitable habitat occurs in low woodland in the study area, although outside the main distribution of the species.	**Unlikely**. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015 searches.	Impacts unlikely
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in coastal areas from East Gippsland to southern Queensland. Habitat preferences not well defined. Grows mostly in coastal heathlands, margins of coastal swamps and sedgelands, coastal forest, dry woodland, and lowland forest. Prefers open areas in the understorey and is often found in association with *Cryptostylis subulata* and the *Cryptostylis erecta*. Soils include moist sands, moist to dry clay loam and occasionally in accumulated eucalypt leaves. Flowers November-February.	**Possible**. Potential habitat occurs in low woodland in the study area.	**Unlikely**. Historical clearing in the study area likely to have substantially reduced habitat quality. No related orchids recorded in the proposal area. No moist soils present. Not recorded during November 2012/January 2015 searches.	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Deyeuxia appressa		E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Known only from two pre-1942 records in Sydney, at Saltpan Creek and Killara. May be extinct in the wild. Thought to occur in moist conditions.	**Nil**. Outside predicted area of distribution.	**Nil**. Outside predicted area of distribution.	Nil
Epacris purpurascens var. purpurascens		V		1 record within 10km (OEH 2015a)	Occurs from Gosford in the north, Narrabeen in the east, Silverdale in the west and Avon Dam vicinity in the South. Grows in a range of sclerophyll forest, scrubs and swamps, most of which have a strong shale soil influence.	**Possible**. May occur in woodland in shale transition areas.	**Unlikely**. No shale soils present. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Eucalyptus camfieldii	Camfield's Stringybark	V	V	17 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a) **Species recorded immediately east of the site by GHD (2011)**	Occurs from Raymond Terrace to Waterfall, with populations known from Norah Head (Tuggerah Lakes), Peats Ridge, Mt Colah, Elvina Bay Trail (West Head), Terrey Hills, Killara, North Head, Menai and the Royal NP. Occurs in exposed situations on sandstone plateaus, ridges and slopes near the coast, often on the boundary of tall coastal heaths or low open woodland. It grows in shallow sandy soils overlying Hawkesbury sandstone.	**Present**. Recorded in heath vegetation in the eastern portion of the study area. Potential habitat is restricted to heath and the edges of heath in the study area.	**Unlikely**. Could theoretically occur in woodland vegetation within the area proposed for the ARRT facility, however none recorded during surveys.	Low potential for indirect impacts
Genoplesium baueri	Bauer's Midge Orchid	E	E	Species or species habitat known to occur within locality (DotE 2015a)	Occurs from Ulladulla to Port Stephens, with only 13 known extant populations. Grows in sparse sclerophyll forest and moss gardens over sandstone. Flowers from February to March.	**Possible**. Potential habitat occurs in sandstone woodland in the study area. No local records.	**Unlikely**. Historical clearing in the study area likely to have substantially reduced habitat quality. Few orchids recorded in the proposal area. No moss gardens present. Not recorded during March 2015 searches. No orchids recorded during this survey	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
							despite good growing conditions.	
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	V	V	5 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs between Moss Vale/Bargo and lower Hunter Valley, with most occurrences in Appin, Wedderburn, Picton and Bargo. Broad habitat range including heath, shrubby woodland and open forest on light clay or sandy soils, and often in disturbed areas such as on the fringes of tracks.	**Likely**. Records exist within 10km and suitable habitat occurs in native vegetation in the study area.	**Unlikely**. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Hibbertia stricta subsp. furcatula		E		17 records within 10km (OEH 2015a)	2 known populations: one either side of the Woronora River gorge including the Menai-Bangor, Alfords Point and Illawong areas in the north and Maandowie Reserve, Loftus on the southern side; and west and southwest of Nowra. Occurs in dry sclerophyll forest and woodland. Northern metapopulation occurs on upper slopes and above the Woronora escarpment, at or near the interface of Hawkesbury sandstone and the Lucas Heights soil landscape. Southern population appears to occur in sandy soils on sandstone with one record from gravelly clay soil.	**Likely**. Records exist within 10km and suitable habitat occurs in native vegetation in the study area.	**Unlikely**. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Leucopogon exolasius	Woronora Beard-heath	V	V	7 records within 10km (OEH 2015a); Species or species habitat	Occurs along the upper Georges River and in Heathcote NP, Royal NP and is also known from the Blue Mountains along the Grose River. Grows in woodland on	**Likely**. Records exist within 10km and suitable habitat occurs in woodland in the	**Unlikely**. Could theoretically occur in good quality	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
				likely to occur within locality (DotE 2015a)	sandstone and prefers rocky hillsides along creek banks up to 100 m altitude. Associated species include *Eucalyptus piperita, E. sieberi, Pultenaea flexilis, Leptospermum trinervium* and *Dillwynia retorta*.	study area.	woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	
Leucopogon fletcheri subsp. fletcheri		E		1 record within 10km (OEH 2015a), last recorded 1989	Restricted to NW Sydney between St Albans and Annangrove, within the Hawkesbury, The Hills and Blue Mountains LGAs. Occurs in dry eucalypt woodland or shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs. Flowers August to September.	**Nil.** Outside known distribution.	**Nil.** Outside known distribution.	Nil
Melaleuca biconvexa	Biconvex Paperbark	V	V	Species or species habitat may occur within locality (DotE 2015a)	Scattered, disjunct populations in coastal areas from Jervis Bay to Port Macquarie, with most populations in the Gosford-Wyong areas. Grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	**Present**. One individual recorded along Heathcote Road.	**Unlikely**. No suitable habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Melaleuca deanei	Deane's Paperbark	V	V	31 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a) **Species recorded immediately east of the site by GHD (2011)**	Occurs from Nowra- St Albans and west to the Blue Mountains, with most records in Ku-ring-gai / Berowra and Holsworthy/Wedderburn areas. Mostly grows on broad flat ridgetops, dry ridges and slopes and strongly associated with low nutrient sandy loam soils, sometimes with ironstone. Grows in heath- open forest, often in sandstone ridgetop woodland communities.	**Present**. One individual recorded along Heathcote Road.	**Unlikely**. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially	Low potential for indirect impacts

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
							reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	
Pelargonium sp. striatellum (G.W. Carr 10345)	Omeo Storksbill	E	E	Species or species habitat may occur within locality (DotE 2015a)	Omeo Storksbill is a tufted perennial forb known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities.	**Nil.** Outside known distribution.	**Nil.** Outside known distribution.	Nil
Persoonia hirsuta	Hairy Geebung	E	E	4 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs within the Blue Mountains, Southern Highlands and Sydney coastal regions from Hilltop to Glen Davis and Royal NP to Gosford. Population within the Hills Shire particularly important due to high density of plants. Grows on sandy soils in dry sclerophyll open forest, woodland and heath on sandstone up to 600m above sea level.	**Possible**. Records exist within 10km and suitable habitat occurs in native vegetation on site.	**Unlikely**. Could theoretically occur in good quality woodland vegetation within the area proposed for the ARRT facility, however none recorded during targeted surveys. Historical clearing in the study area likely to have substantially reduced habitat quality. Not recorded during November 2012/January 2015/March 2015 searches.	Impact unlikely
Persoonia nutans	Nodding Geebung	E	E	39 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs from Richmond to Macquarie Fields on the Cumberland Plain. Grows only on aeolian and alluvial sediments in sclerophyll forest and woodland vegetation communities. Largest populations occur in Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland.	**Unlikely**. No suitable alluvial habitat present.	**Unlikely**. No suitable alluvial habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Impacts unlikely
Pimelea curviflora var.		V	V	Species or species habitat likely to	Confined to area between North Sydney in the south and Maroota in the north-west.	**Nil.**	**Nil.**	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
curviflora				occur within locality (DotE 2015a)	Former range extended to Parramatta River including Five Dock, Bellevue Hill and Manly. Grows on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. Often grows amongst dense grasses and sedges. Flowers October to May.	Outside known distribution.	Outside known distribution.	
Pimelea spicata	Spiked Rice-flower	E	E	2 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Disjunct populations within the Cumberland Plain (from Mount Annan and Narellan Vale to Freemans Reach and Penrith to Georges Hall) and Illawarra (from Mt Warrigal to Gerroa) (DEC 2005). In the Cumberland Plain region, restricted to areas which support or historically supported Cumberland Plain Woodland. Grows on well-structured clay soils derived from Wianamatta Shale. In the Illawarra, grows on variable soils in close proximity to the coast on hills or coastal headlands. Inhabits coastal woodland or grassland with emergent shrubs (DEC 2005).	**Unlikely**. Limited shale habitat present. Study area not within the Cumberland Plain.	**Nil**. No suitable shale habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Nil.
Pomaderris brunnea	Brown Pomaderris	V	V	Species or species habitat likely to occur within locality (DotE 2015a)	Mainly occurs in SW Sydney (Wollondilly and Camden LGAs), with other populations in the Hawkesbury-Wollemi region, near Walcha in the New England tablelands and Gippsland in VIC. In NSW, grows in moist woodland or open forest on clay and alluvial soils on flood plains and creek lines. Near Sydney occurs in open woodland dominated by *E. amplifolia* with *Allocasuarina* sp. and *Bursaria* sp. understorey, or on alluvial flats with eucalypts including *E. elata, E. piperita* and *E. punctata* (Sutter 2011).	**Unlikely**. Limited suitable moist woodland habitat present. Outside area of known distribution.	**Unlikely**. No suitable habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Nil.
Prostanthera saxicola	*Prostanthera saxicola* population in Sutherland and Liverpool local government areas	EP		3 records within 10km (OEH 2015a)	This population is restricted to the named local government areas (Liverpool and Sutherland) in the southern to south-western parts of Sydney. Grows in eucalypt forest and heath in association with *Hakea dactyloides*, *Brachyloma daphnoides*, *Banksia spinulosa*, *Baeckea brevifolia*, *Epacris pulchella*, *Acacia myrtifolia* and *Acacia ulicifolia*. Also occurs in heathy woodland of *Angophora hispida*, *Eucalyptus*	**Possible**. Suitable habitat occurs on sandstone outcrops in the study area. Not recorded during targeted November 2012/January 2015/ March 2015 searches.	**Unlikely**. No suitable sandstone rock habitat present. Not recorded during November 2012/January 2015/March 2015 searches.	Nil. No suitable habitat present.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					squamosa and *Corymbia gummifera.*			
Pterostylis gibbosa	Illawarra Greenhood	E	E	Species or species habitat known to occur within locality (DotE 2015a)	Known from a small number of populations in the Illawarra, Nowra and Hunter regions. First collected in western Sydney. Only visible above the ground between late summer and spring, and only when soil moisture levels can sustain its growth. Grows in open forest or woodland, on flat or gently sloping land with poor drainage. In the Illawarra region, the species grows in woodland dominated by *Eucalyptus tereticornis*, *E. longifolia* and *Melaleuca decora*. Near Nowra, the species grows in an open forest of *Corymbia maculata*, *E.tereticornis* and *E. paniculata*. In the Hunter region, the species grows in open woodland dominated by *E. crebra, E.tereticornis* and *Callitris endlicheri*.	**Unlikely**. Outside area of known distribution.	**Unlikely**. Outside area of known distribution. Woodland not dominated by *Eucalyptus tereticornis* or *Corymbia maculata.* No orchid species recorded during March 2015 surveys despite good growing conditions.	Impacts unlikely.
Pterostylis saxicola	Sydney Plains Greenhood	E	E	16 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs in western Sydney between Picton and Freemans Reach. Grows in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. Associated vegetation above these rock shelves is sclerophyll forest or woodland on shale or shale/sandstone transition soils. Flowers from October to December.	**Possible**. May occur in intact vegetation in the study area where sandstone rock shelves are present.	**Unlikely**. Historical clearing in the study area likely to have substantially reduced habitat quality. No sandstone rock shelves above cliff lines present. Not recorded during November 2012searches.	Impacts unlikely.
Pultenaea aristata	Prickly Bush-pea	V	V	1 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Restricted to the Woronora Plateau, a small area between Helensburgh, south of Sydney, and Mt Kiera above Wollongong (OEH 2012). Occurs in either dry sclerophyll woodland or wet heath on sandstone.	**Unlikely**. Outside area of known distribution.	**Unlikely**. Outside area of known distribution.	Impacts unlikely.
Pultenaea pedunculata	Matted Bush-pea	E		1 record within 10km (OEH 2015a)	3 disjunct populations in NSW: in the Cumberland Plains in Sydney, the coast between Tathra and Bermagui and the Windellama area south of Goulburn (where it is locally abundant). NSW populations typically among woodland vegetation but	**Unlikely**. Outside area of known distribution.	**Unlikely**. Outside area of known distribution.	Impacts unlikely.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					also found on road batters and coastal cliffs. In Windellama it is largely confined to loamy soils in dry gullies.			
Streblus pendulinus	Siah's Backbone		E	Species or species habitat likely to occur within locality (DotE 2015a)	Siah's Backbone occurs from Cape York Peninsula to Milton, south-east New South Wales (NSW), as well as Norfolk Island (ATRP 2010; Jessup 2003; The Royal Botanic Gardens and Domain Trust 2011). Siah's Backbone is found in warmer rainforests, chiefly along watercourses. The species grows in well developed rainforest, gallery forest and drier, more seasonal rainforest (ATRP 2010).	Unlikely. No suitable habitat present.	Unlikely. No suitable habitat present.	Impacts unlikely.
Syzygium paniculatum	Magenta Lilly Pilly	E	V	1 record within 10km; Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in narrow coastal strip from Bulahdelah to Conjola State Forest. Grows in rainforest on sandy soils or stabilised Quaternary sand dunes at low altitudes in coastal areas, often in remnant littoral or gallery rainforests.	Unlikely. No suitable habitat present.	Unlikely. No suitable habitat present.	Impacts unlikely.
Thelymitra sp. Kangaloon	Kangaloon Sun Orchid	CE	CE	Species or species habitat likely to occur within locality (DotE 2015a)	Only known from three locations near Robertson in the Southern Highlands. Grows in seasonally swampy sedgeland on grey silty clay loam at 600–700 m above sea level. Flowers in late October and early November.	**Unlikely**. Outside area of known distribution.	**Unlikely**. Outside area of known distribution.	Impacts unlikely.
Thesium australe	Austral Toadflax	V	V	Species or species habitat may occur within locality (DotE 2015a)	Found in small, scattered populations along the east coast, northern and southern tablelands. Occurs in grassland or grassy woodland, and is often found in association with Kangaroo Grass (*Themeda australis*).	Possible. Potential habitat present in the north-east of the study area.	Unlikely. No grassy woodland present.	Impacts unlikely.

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Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
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Rostratula australis	Australian Painted Snipe	E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Normally found in permanent or ephemeral shallow inland wetlands, either freshwater or brackish. Nests on the ground amongst tall reed-like vegetation near water. Feeds on mudflats and the water's edge taking insects, worm and seeds. Prefers fringes of swamps, dams and nearby marshy areas with cover of grasses, lignum, low scrub or open timber.	Unlikely. No suitable wetland habitat present.	Unlikely. No suitable wetland habitat present.	Impacts unlikely
Botaurus poiciloptilus	Australasian Bittern	E	E	1 record within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Widespread but uncommon over most NSW except the northwest. Favours permanent freshwater wetlands with tall dense reedbeds particularly Typha spp. and Eleocharis spp., with adjacent shallow, open water for foraging. Roosts during the day amongst dense reeds or rushes and feeds mainly at night on frogs, fish, yabbies, spiders, insects and snails.	Unlikely. No suitable wetland habitat with emergent vegetation present.	Unlikely. No suitable wetland habitat with emergent vegetation present.	Impacts unlikely
Ixobrychus flavicollis	Black Bittern	V		1 record within 10km (OEH 2015a)	Occurs from southern NSW to Cape York and the Kimberley, and southwest WA. Inhabits terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. May occur in flooded grassland, forest, woodland, rainforest and mangroves as long as there is permanent water. Roosts by day in trees or within reeds on the ground. Nests in branches overhanging water and breeds from December to March.	Unlikely. No suitable wetland vegetation with emergent vegetation present in the proposal footprint.	Unlikely. No suitable wetland vegetation with emergent vegetation present in the proposal footprint.	Impacts unlikely
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V		4 records within 10km (OEH 2015a) **Species recorded immediately east of the site by GHD (2011)**	Widespread in NSW, but rarely recorded east of Great Dividing Range except in Richmond and Clarence River areas and scattered sites in the Hunter, Central Coast and Illawarra regions. Mostly in upper levels of drier open forests /woodlands dominated by box and ironbark eucalypts, or less commonly smooth-barked gums, stringybarks and tea-treas. Forage over home range of >5 ha. Tend to occur within largest woodland	Likely. May forage and breed in native vegetation in the study area.	Likely. May forage on occasion in the proposal footprint. Unlikely to breed in the proposal footprint due to disturbed nature of the vegetation.	Proposal would remove 9.25 ha of low quality foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					patches in the landscape. They forage for insects, nectar and honeydew. The nest is hidden by foliage high in the crown of a tree.			
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V		1 record within 10km (OEH 2015a)	Most common on the inland slopes and plains. Inhabits eucalypt woodlands and dry open forest, usually dominated by stringybarks or rough-barked species with open grassy understorey. Fallen timber is important foraging habitat. Nests in hollows in standing trees or stumps.	Possible. Could forage and breed in the study area.	Possible. Could forage in the study area on occasion. Minimal potential breeding habitat present in the proposal footprint.	Proposal would remove 9.25 ha of low quality foraging habitat. A low number of hollow-beairng trees with small hollows would be removed.
Dasyornis brachypterus	Eastern Bristlebird	E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in three disjunct areas of south-eastern Australia: southern Queensland/northern NSW, the Illawarra Region and in the vicinity of the NSW/Victorian border. Illawarra population comprises an estimated 1600 birds, mainly from Barren Grounds Nature Reserve, Budderoo National Park and the Jervis Bay area. Habitat characterised by dense, low vegetation including heath and open woodland with a heathy understorey. The fire history of habitat is important, and the Illawarra and southern populations reach maximum densities in habitat that have not been burnt for over 15 years.	Unlikely. Lmiited areas of dense heath present. No records from the Sydney Metro CMA.	Unlikely. Dense heath habitat not present in the proposal footprint.	Nil.
Pandion cristatus	Eastern Osprey	V		17 records within 10km (OEH 2015a)	Favours coastal areas, especially the mouths of large rivers, lagoons and lakes. They feed on fish over clear, open water. Breeding takes place from July to September in NSW, with nests being built high up in dead trees or in dead crowns of live trees, usually within one kilometre of the sea, though there are a handful of records from inland areas.	Nil. No suitable habitat present	Nil. No suitable habitat present	Nil
Petroica phoenicea	Flame Robin	V		2 record within 10km (OEH 2015a)	Breeds in upland moist eucalypt forests and woodlands, often on ridges and slopes, in areas of open understorey. Migrates in winter to more open lowland habitats such as grassland with scattered trees and open woodland on the inland slopes and plains. Forages from low perches, feeding on invertebrates taken	Possible. May forage in the study area on occasion. Preferred breeding habitat not present.	Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.	Proposal would remove 9.25 ha of potential foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					from the ground, tree trunks, logs and other coarse woody debris. Fallen logs and coarse woody debris are important habitat components. Open cup nest of plant fibres and cobweb is often built near the ground in a sheltered niche, ledge or shallow cavity in a tree, stump or bank.			
Callocephalon fimbriatum	Gang-gang Cockatoo	V		7 records within 10km (OEH 2015a)	Restricted to the south-eastern coast and highlands, from the lower Hunter and northern Blue Mountains to the Southwestern Slopes, south to and contiguous with the Victorian population. Inhabits eucalypt open forests and woodlands with an acacia understorey. In summer it lives in moist highland forest types, and in winter it moves to more open types at lower elevations. The Gang-Gang Cockatoo nests in hollows in the trunks, limbs or dead spouts of tall living trees, especially eucalypts, often near water. The Gang-gang Cockatoo feeds on seeds obtained in trees and shrubs, mostly from eucalypts and wattles.	Possible. Could forage and breed in the study area.	Possible. Could forage in the study area on occasion. No breeding habitat present in the proposal footprint.	Proposal would remove 9.25 ha of low quality foraging habitat.
Calyptorhynchus lathami	Glossy Black-Cockatoo	V		1 record within 10km (OEH 2015a), last recorded 1990	Widespread but uncommon from coast to southern tablelands and central western plains. Feeds almost exclusively on the seeds of *Allocasuarina* species. Prefers woodland and open forests, rarely away from Allocasuarina. Roost in leafy canopy trees, preferably eucalypts, usually <1km from feeding site. Nests in large (approx. 20cm) hollows in trees, stumps or limbs, usually in Eucalypts (Higgins 1999).	Likely. Could forage and breed in the study area.	Likely. Native vegetation dominated by *Allocasuarina* species. No breeding habitat present in the proposal footprint. No evidence of chewed cones found during surveys.	Proposal would remove 9.25 ha of good quality foraging habitat.
Glossopsitta pusilla	Little Lorikeet	V		13 records within 10km (OEH 2015a)	Occurs from coast to western slopes of the Great Dividing Range. Inhabits dry, open eucalypt forests and woodlands. Occurrence is positively associated with patch size, and with components of habitat complexity including canopy cover, shrub cover, ground cover, logs, fallen branches and litter. Feed primarily on profusely-flowering eucalypts and a variety of other	Likely. Could forage and breed in the study area.	Possible. May occur on occasion, although previous clearing may have impacted structural complexity required for this species. Limited potential breeding habitat	Proposal would remove 9.25 ha of low quality foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					species including melaleucas and mistletoes. Mostly nests in small (opening approx. 3cm) hollows in living, smooth-barked eucalypts. Most breeding records are from the western slopes.		present in the proposal footprint.	
Hieraaetus morphnoides	Little Eagle	V		9 records within 10km (OEH 2015a)	Occurs throughout NSW except most densely forested parts of the Dividing Range escarpment. Occupies habitats rich in prey within open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used. For nest sites it requires a tall living tree within a remnant patch, where pairs build a large stick nest in winter and lay in early spring.	Possible. May forage and breed in the study area.	Possible. May forage on occasion in the proposal footprint. No preferred breeding habitat (tall trees) present.	Proposal would remove 9.25 ha of potential foraging habitat.
Tyto novaehollandiae	Masked Owl	V		3 records within 10km (OEH 2015a)	Occurs across NSW except NW corner. Most common on the coast. Inhabits dry eucalypt woodlands from sea level to 1100 m. Roosts and breeds in large (>40cm) hollows and sometime caves in moist eucalypt forested gullies. Hunts along the edges of forests and roadsides. Home range between 500 ha and 1000 ha. Prey mostly terrestrial mammals but arboreal species may also be taken.	Possible. May forage and breed in the study area.	Possible. May forage on occasion in the proposal footprint. No breeding habitat (large old hollow trees) present.	Proposal would remove 9.25 ha of potential foraging habitat.
Neophema chrysogaster	Orange-bellied Parrot	CE	CE	Species or species habitat may occur within locality (DotE 2015a)	Breeds in Tasmania and migrates in winter to SE South Australia and southern Victoria. There are occasional reports from NSW, including Shellharbour, Maroubra and the Shoalhaven. In winter, usually found within 3 km of the coast in saltmarsh and strandline/ foredune vegetation. May also occur on golf-courses and other grassy areas, including improved pasture.	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil.
Petroica rodinogaster	Pink Robin	V		1 record within 10km (OEH 2015a), last recorded 1987	In NSW occurs mainly in the South Coast and Southern Tablelands regions. It is vagrant in the Sydney and Illawarra areas, with generally only individual birds recorded in these areas. It prefers a dense shrub layer in damp or wet forests or rainforests. It generally breeds in wet gullies. It forages for insects on the ground or in low undergrowth. It may be partly migratory or dispersive in autumn and	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					winter. It is generally seen in pairs, occasionally small flocks.			
Ninox strenua	Powerful Owl	V		962 records within 10km (OEH 2015a)	Occurs from the coast to the western slopes. Solitary and sedentary species. Inhabits a range of habitats from woodland and open sclerophyll forest to tall open wet forest and rainforest. Prefers large tracts of vegetation. Nests in large tree hollows (> 0.5 m deep), in large eucalypts (dbh 80-240 cm) that are at least 150 years old. Pairs have high fidelity to a small number of hollow-bearing nest trees and defend a large home range of 400 - 1,450 ha. Forages within open and closed woodlands as well as open areas.	Likely. May forage and breed in the study area.	Likely. May forage on occasion in the proposal footprint. No breeding habitat (large old hollow trees) present.	Proposal would remove 9.25 ha of potential foraging habitat.
Anthochaera phrygia	Regent Honeyeater	CE	E	1 record within 10km (OEH 2015a), last recorded 1983; Species or species habitat known to occur within locality (DotE 2015a)	In NSW confined to two known breeding areas: the Capertee Valley and Bundarra-Barraba region. Non-breeding flocks occasionally seen in coastal areas foraging in flowering Spotted Gum and Swamp Mahogany forests, presumably in response to drought.	**Unlikely**. No preferred feed trees present. Does not breed in this area.	**Unlikely**. No preferred feed trees present.	Impacts unlikely
Ptilinopus regina	Rose-crowned Fruit Dove	V		1 record within 10km (OEH 2015a)	Occurs from Newcastle north to Cape York, with vagrants occasionally as far south as Victoria. Occur mainly in sub-tropical and dry rainforest and occasionally in moist eucalypt forest and swamp forest, where fruit is plentiful. Thought to be locally nomadic in response to fruit availability.	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil
Petroica boodang	Scarlet Robin	V		7 records within 10km (OEH 2015a) **Species possibly recorded (call only) immediately east of the site by GHD (2011)**	In NSW occurs from coast to inland slopes. Breeds in drier eucalypt forests and temperate woodlands, often on ridges and slopes, within open understorey of shrubs and grasses and sometimes in open areas. In autumn and winter it migrates to more open habitats such as grassy open woodland or paddocks with scattered trees. Abundant logs and coarse woody debris are important habitat components.	Possible. May forage in the study area on occasion. Preferred breeding habitat not present.	Possible. May forage in the proposal footprint on occasion. Preferred breeding habitat not present.	Proposal would remove 9.25 ha of potential foraging habitat.
Tyto tenebricosa	Sooty Owl	V		22 records within 10km (OEH 2015a)	Occurs in the coastal, escarpment and tablelands regions of NSW. More common	Unlikely. Limited suitable habitat likely to	Nil. No suitable habitat present.	Nil.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					in the north and absent from the western tablelands and further west. Inhabits tall, moist eucalypt forests and rainforests, and are strongly associated with sheltered gullies, particularly those with tall rainforest understorey. Roosts in tree hollows, amongst dense foliage in gullies or in caves, recesses or ledges of cliffs or banks. Nest in large (>40cm wide, 100cm deep) tree hollows in unlogged/unburnt gullies within 100m of streams or in caves.	be present.		
Lophoictinia isura	Square-tailed Kite	V		8 records within 10km (OEH 2015a)	Occurs across NSW, resident in North, northeast and along west-flowing rivers. Summer breeding migrant to southeast of state. Inhabits a variety of habitats including woodlands and open forests, with preference for timbered watercourses. Favours productive forests on the coastal plain, box-ironbark-gum woodlands on the inland slopes, and Coolibah/River Red Gum on the inland plains. In Sydney area nests in mature living trees within 100m of ephemeral/permanent watercourse. Large home range > 100 km2.	Possible. May forage and breed in the study area.	Possible. May forage on occasion in the proposal footprint. No preferred breeding habitat (tall trees) present.	Proposal would remove 9.25 ha of potential foraging habitat.
Ptilinopus superbus	Superb Fruit-Dove	V		1 record within 10km (OEH 2015a)	Occurs mainly north from NE NSW, much less common further south and largely confined to pockets of habitat south to Moruya. Vagrants occur south to VIC and TAS. Inhabits rainforest and closed forests, may also forage in eucalypt or acacia woodland with fruit-bearing trees. Nests 5-30 m above ground in rainforest/rainforest edge tree and shrub species. Part of the population migratory/nomadic.	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil
Lathamus discolor	Swift Parrot	E	E	7 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Migratory, travelling to the mainland from March to October. Breeds in Tasmania from September to January. On the mainland, it mostly occurs in the southeast foraging on winter flowering eucalypts and lerps, with records of the species between Adelaide and Brisbane. Principal over-winter habitat is box-ironbark communities on the inland slopes and plains.	**Possible**. May forage on occasion in the study area. Does not breed on the Australian mainland.	**Possible**. *Corymbia gummifera*, a preferred forage tree in coastal areas, is the dominant eucalypt in the proposal footprint.	Proposal would remove 9.25 ha of low quality potential foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					Eucalyptus robusta, Corymbia maculata and C. gummifera dominated coastal forests are also important habitat.			
Daphoenositta chrysoptera	Varied Sittella	V		26 records within 10km (OEH 2015a)	Sedentary, occurs across NSW from the coast to the far west. Inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. Sensitive to habitat isolation and loss of structural complexity, and adversely affected by dominance of Noisy Miners. Cleared agricultural land is potentially a barrier to movement. Builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy, and often re-uses the same fork or tree in successive years.	Likely. May forage and breed in the study area.	Possible. May occur on occasion, although previous clearing may have impacted structural complexity required for this species.	Proposal would remove 9.25 ha of potential foraging habitat.
Epthianura albifrons	White-fronted Chat White-fronted Chat endangered population in the Sydney Metro CMA	V EP		4 records within 10km (OEH 2015a)	This species occurs from southern Queensland to Western Australia and down to Tasmania. There are two isolated sub-populations of White-fronted Chats currently known from the Sydney Metropolitan CMA: at Newington Nature Reserve and at Towra Point Nature Reserve.It is found in damp open habitats, particularly wetlands containing saltmarsh areas that are bordered by open grasslands. Along the coast they are found in estuarine and marshy habitats with vegetation <1m tall, and in open grasslands and areas bordering wetlands.	Nil. No suitable habitat present.	Nil. No suitable habitat present.	Nil
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Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	1 record within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs from the Shoalhaven north to the Queensland border. Now mostly extinct west of the Great Dividing Range, except in the Warrumbungles and Mt Kaputar. Occurs on rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. Diet consists of vegetation in adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Nil. No escarpment habitat present.	Nil. No escarpment habitat present.	Nil.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Cercartetus nanus	Eastern Pygmy-possum	V		25 records within 10km (OEH 2015a)	Occurs along the east coast of NSW, and inland to the Pillaga, Dubbo, Parkes and Wagga Wagga. Inhabits range of habitats from coastal heath and woodland though open and closed forests, subalpine heath and rainforest (Tulloch and Dickman 1995). Inhabits rainforest, sclerophyll forests and heath. Banksia spp. and myrtaceous shrubs and trees are favoured food sources and nesting subject sites in drier habitats. Diet mostly pollen and nectar from Banksia spp., Eucalyptus spp., Callistemon spp. and insects (Ward and Turner 2008). Nests in hollows in trees, under the bark of Eucalypts, forks of tea-trees, abandoned bird nests and Xanthorrhoea bases (Ward and Turner 2008, Tulloch and Dickman 2006).	Likely. Suitable foraging and nesting habitat present in native vegetation in the study area.	Likely. Suitable foraging and nesting habitat present in native vegetation in the proposal footprint. Many records present in the locality.	Proposal would remove 9.25 ha of potential foraging and breeding habitat.
Phascolarctos cinereus	Koala	V	V	371 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs from coast to inland slopes and plains. Restricted to areas of preferred feed trees in eucalypt woodlands and forests. Home range varies depending on habitat quality, from < 2 to several hundred hectares.	**Likely**. Has been recorded previously near the study area (OEH 2014a).	Unlikely. Poor quality foraging habitat present only. No primary feed trees present. Occasional secondary feed trees are present. Proposal footprint is not considered an important habitat area for the Koala. No habitat critical for the survival of the species is present in the proposal footprint.	Impacts unlikely
Potorous tridactylus	Long-nosed Potoroo,	V	V	Species or species habitat may occur within locality (DotE 2015a)	Restricted to east of the Great Dividing Range, with annual rainfall >760 mm. Inhabits coastal heath and dry and wet sclerophyll forests. Requires relatively thick ground cover and appears restricted to areas of light and sandy soil (Johnston 2008). Feeds on fungi, roots, tubers, insects and their larvae, and other soft-bodied animals in the soil.	**Unlikely**. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the study area. No populations known from the locality.	**Unlikely**. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the proposal footprint. Historical clearing in the study	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
							area likely to have substantially reduced habitat quality. No populations known from the locality.	
Pseudomys novaehollandiae	New Holland Mouse		V	4 record within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs in disjunct, coastal populations from Tasmania to Queensland. In NSW inhabits a variety of coastal habitats including heathland, woodland, dry sclerophyll forest with a dense shrub layer and vegetated sand dunes (Wilson and Bradtke 1999). Populations may recolonise/ increase in size in regenerating native vegetation after wildfire, clearing and sandmining. Presence strongly correlated with understorey vegetation density, and high floristic diversity in regenerating heath (Lock and Wilson 1999).	**Unlikely**. May occur in heath habitat, although not recorded during targeted trapping survey to the east of the proposal footprint (GHD 2011).	**Unlikely.** No suitable diverse heath habitat present in the proposal footprint.	Impacts unlikely
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E	E	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs mainly in 2 areas: Ku-ring-gai Chase and Garigal National Parks N of Sydney, and far SE NSW including Ben Boyd National Park, East Boyd State Forest, Nadgee Nature Reserve, Nadgee State Forest, South East Forest and Yambulla State Forest but also occurs between these areas. Inhabits scrubby vegetation, including heath, shrubland, and heathy forest and woodland. Often associated with well-drained soils and dry heathland communities, and prefers periodically burnt areas as this increases insect abundance.	**Unlikely**. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the study area. No populations known from the locality.	**Unlikely**. Potentially suitable foraging and breeding habitat occurs in better quality vegetation in the proposal footprint. Historical clearing in the study area likely to have substantially reduced habitat quality. No populations known from the locality.	Impacts unlikely
Dasyurus maculatus	Spotted-tailed Quoll	V	E	4 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Inhabits a range of environments including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Den sites are in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, usually traversed	**Possible**. May forage and breed in the study area.	**Possible**. May utilise the proposal footprint for dispersal and foraging. Two small rock outcrops (which appear to be utilised by foxes) and fallen timber	Proposal would remove 9.25 ha of potential foraging and breeding habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					along densely vegetated creek lines.		are present, representing potential foraging habitat. Tree hollows present are very small (~5cm diameter) and are not suitable denning habitat.	
Petaurus norfolcensis	Squirrel Glider	V		1 record within 10km (OEH 2015a)	Occurs along the drier inland slopes as well as coastal habitats. Inhabits woodland and open forest with a Eucalyptus, Corymbia or Angophora overstorey and a shrubby understorey of Acacia or Banksia. Key habitat components include reliable winter and early-spring flowering Eucalypts, Banksia or other nectar sources, and hollow-bearing trees for roost and nest sites (van der Ree and Suckling 2008, Quin et al 2004), with social groups moving between multiple hollows. Social groups include one or two adult males and females with offspring, and have home ranges of 5-10ha within NSW (van der Ree and Suckling 2008, Kavanagh 2004).	Possible. Could forage and breed in the study area.	**Unlikely**. Potentially suitable foraging habitat occurs in better quality vegetation outside the proposal footprint. Historical clearing in the study area likely to have substantially reduced habitat quality. Few hollow-bearing trees present. No mature forest present. Only one record in the locality.	Impacts unlikely
Petaurus australis	Yellow-bellied Glider	V		1 record within 10km (OEH 2015a)	Occurs along the east coast to the western slopes of the Great Dividing Range. Inhabits a variety of forest types but prefers tall mature eucalypt forest with high rainfall and rich soils. Relies on large hollow-bearing trees for shelter and nesting, with family groups of 2-6 typically denning together. In southern NSW its preferred habitat at low altitudes is moist gullies and creek flats in mature coastal forests. Mostly feeds on sap, nectar and honeydew.	Unlikely. No tall mature forest on rich soils present.	Unlikely. No tall mature forest on rich soils present.	Impacts unlikely.
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	88 records within 10km (OEH 2015a); Foraging, feeding or related behaviour known to occur within	Roosts in camps within 20 km of a regular food source, typically in gullies, close to water and in vegetation with a dense canopy. Forages in subtropical and temperate rainforests, tall sclerophyll	**Present**. Recorded in adjacent vegetation (GHD 2011). Would forage regularly in the area.	**Likely**. May forage in woodland habitat within the proposal footprint on	Potential for direct impacts on foraging habitat

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
				locality (DotE 2015a) **Species recorded immediately east of the site by GHD (2011)**	forests and woodlands, heaths, swamps and street trees, particularly in eucalypts, melaleucas and banksias. Highly mobile with movements largely determined by food availability (Eby and Law 2008). Will also forage in urban gardens and cultivated fruit crops.	No breeding habitat (camp site) present.	occasion. No breeding habitat present.	
Miniopterus schreibersii oceanensis	Eastern Bentwing-Bat	V		24 records within 10km (OEH 2015a) **Species recorded immediately east of the site by GHD (2011)**	Generally occurs east of the Great Dividing Range along NSW coast (Churchill 2008). Inhabits various habitats from open grasslands to woodlands, wet and dry sclerophyll forests and rainforest. Essentially a cave bat but may also roost in road culverts, stormwater tunnels and other man-made structures. Only 4 known maternity caves in NSW, near Wee Jasper, Bungonia, Kempsey and Texas. Females may travel hundreds of kilometres to the nearest maternal colony (Churchill 2008).	Present. Could forage in native vegetation and cleared areas within the study area. No breeding habitat present.	Likely. Could forage in native vegetation and cleared areas within the proposal footprint. No breeding habitat present.	Proposal would alter 9.25 ha of potential foraging habitat. Species could continue to forage above ARRT and GO facility after construction.
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V		7 records within 10km (OEH 2015a)	Occurs on southeast coast and ranges. Prefers tall (>20m) and wet forest with dense understorey. Absent from small remnants, preferring continuous forest but can move through cleared landscapes and may forage in open areas. Roosts in hollow trunks of Eucalypts, underneath bark or in buildings. Forages in gaps and spaces within forest, with large foraging range (12km foraging movements recorded) (Churchill 2008, Law et al 2008).	Likely. May forage and breed in the study area.	Possible. May forage on occasion in the study area. Previous clearing may have impacted structural complexity preferred by this species. No suitable roosting habitat present.	Proposal would remove 9.25 ha of potential foraging habitat.
Mormopterus norfolkensis	Eastern Freetail-Bat	V		4 records within 10km (OEH 2015a)	Occurs in dry sclerophyll forest and woodland east of the Great Dividing Range. Forages in natural and artificial openings in vegetation, typically within a few kilometres of its roost. Roosts primarily in tree hollows but also recorded from man-made structures or under bark (Churchill 2008).	Likely. May forage and breed in the study area.	Likely. May forage in the proposal footprint. Small number of potential roost trees present. No evidence of guano.	Proposal would remove 9.25 ha of potential foraging habitat. Limited potential breeding habitat would be removed.
Scoteanax rueppellii	Greater Broad-nosed Bat	V		7 records within 10km (OEH 2015a)	Occurs on the east coast and Great Dividing Range. Inhabits a variety of habitats from woodland to wet and dry sclerophyll forests and rainforest, also remnant paddock trees and timber-lined	Likely. May forage and breed in the study area.	Possibly recorded. Could forage in native vegetation and cleared areas within the proposal	Proposal would remove 9.25 ha of potential foraging habitat. Limited potential breeding

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					creeks, typically below 500m asl. Forages in relatively uncluttered areas, using natural or man-made openings in denser habitats. Usually roosts in tree hollows or fissures but also under exfoliating bark or in the roofs of old buildings. Females congregate in maternal roosts in suitable hollow trees (Hoye and Richards 2008, Churchill 2008).		footprint. Small number of potential roost trees present. No evidence of guano.	habitat would be removed.
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	3 record within 10km (OEH 2015a); Species or species habitat may occur within locality (DotE 2015a)	Occurs from the coast to the western slopes of the divide. Largest numbers of records from sandstone escarpment country in the Sydney Basin and Hunter Valley (Hoye and Schulz 2008). Roosts in caves and mines and most commonly recorded from dry sclerophyll forests and woodlands. An insectivorous species that flies over the canopy or along creek beds (Churchill 2008). In southern Sydney appears to be largely restricted to the interface between sandstone escarpments and fertile valleys.	**Possible**. May forage on occasion in the study area. No breeding habitat present.	**Possible**. Limited suitable forested foraging habitat present. No breeding habitat present. No record of the species during any surveys in the study area.	Proposal would remove 9.25 ha of potential foraging habitat.
Myotis macropus	Large-footed Myotis	V		13 records within 10km (OEH 2015a)	Mainly coastal but may occur inland along large river systems. Usually associated with permanent waterways at low elevations in flat/undulating country, usually in vegetated areas. Forages over streams and watercourses feeding on fish and insects from the water surface. Roosts in a variety of habitats including caves, mine shafts, hollow-bearing trees, stormwater channels, buildings, under bridges and in dense foliage, typically in close proximity to water (Campbell 2011). Breeds November or December (Churchill 2008)	Likely. May forage and breed in the study area.	Likely. May forage above dams and Mill Creek on occasion. Small number of potential roost trees present. No evidence of guano. Unlikely to breed in the proposal footprint.	Proposal would remove 9.25 ha of potential foraging habitat.
Miniopterus australis	Little Bentwing-Bat	V		4 records within 10km (OEH 2015a)	Occurs from Cape York to Sydney. Inhabits rainforests, wet and dry sclerophyll forests, paperbark swamps and vine thickets. Only one maternity cave known in NSW, shared with Eastern Bentwing-bats at Willi Willi, near Kempsey. Outside breeding season roosts in caves, tunnels and mines and has been recorded	Likely. May forage in the study area. No breeding habitat present.	Possible. May forage on occasion in the study area. Previous clearing may have impacted structural complexity preferred by this	Proposal would remove 9.25 ha of low quality potential foraging habitat.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					in a tree hollow on one occasion. Forages for insects beneath the canopy of well-timbered habitats (Churchill 2008, Hoye and Hall 2008).		species. No breeding habitat present.	
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		4 records within 10km (OEH 2015a)	Migrates from tropics to SE Aus in summer. Forages across a range of habitats including those with and without trees, from wet and dry sclerophyll forest, open woodland, Acacia shrubland, mallee, grasslands and desert. Roosts communally in large tree hollows and buildings (Churchill 2008).	Likely. Could forage in native vegetation and cleared areas within the proposal footprint. May roost/breed in hollow-bearing trees in the study area.	Likely. May forage in the proposal footprint. Small number of potential roost trees present. No evidence of guano.	Proposal would remove 9.25 ha of potential foraging habitat. Limited potential breeding habitat would be removed.
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Hoplocephalus bungaroides	Broad-headed Snake	E	V	15 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Nocturnal, sheltering in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter, and spring, moving to shelters in hollows of large trees within 200m of escarpments in summer. Feeds mostly on geckos and small skinks, and occasionally on frogs and small mammals.	Nil. No suitable escarpment habitat present.	Nil. No suitable escarpment habitat present in the proposal footprint.	Nil.
Varanus rosenbergi	Rosenberg's Goanna	V		19 records within 10km (OEH 2015a)	In NSW mainly occurs on the mid coast region from Wollemi NP to Nowra; the ACT and Goulburn regions and the South-west Slopes. Inhabits coastal heathlands, wet and dry sclerophyll forests, woodlands and mallee communities. Termite mounds are an important habitat feature: eggs are laid in the mounds in summer and incubate till spring, when the young dig themselves out. Young may return to the mound as a refuge for some months, while adults shelter in burrows dug under rocks or logs, or in rock crevices, hollow logs or even rabbit burrows (Sass 2008).	Likely. Potential foraging and breeding habitat present.	Unlikely. Potential foraging and breeding habitat present in the proposal footprint, however no evidence of species from camera surveys or previous trapping (GHD 2011).	Impacts unlikely
Fro s								
Heleioporus australiacus	Giant Burrowing Frog	V	V	26 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs along the coast and eastern slopes of the Great Dividing Range south from Wollemi National Park. Appears to exist as 2 populations with a 100km gap in records between Jervis Bay and Eden. Northern population occurs on sandy soils	**Likely**. A previous record exists in the study area (OEH 2014). Likely to occur along drainage lines and in adjacent	**Unlikely**. Potential habitat present however not recorded during targeted survey in appropriate	Impacts unlikely

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					supporting heath, woodland or open forest. Breeds in ephemeral to intermittent streams with persistent pools. Only infrequently moves to breeding sites, most commonly found on ridges away from creeks, several hundred metres from water.	vegetation.	conditions.	
Litoria aurea	Green and Golden Bell Frog	E	V	12 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Formerly occurred from Brunswick Heads to Victoria, but >80% populations now extinct. Inhabits marshes, natural and artificial freshwater to brackish wetlands, dams and in stream wetlands. Prefers sites containing cumbungi (*Typha* spp.) or spike rushes (*Eleocharis* spp.), which are unshaded and have a grassy area and/or rubble as shelter/refuge habitat nearby. Eastern Gambusia is a key threat as they feed on Green and Golden Bell Frog eggs and tadpoles.	Unlikely. No suitable habitat present in the study area..	Unlikely. No suitable habitat present in the proposal footprint. Some areas of *Typha* are present along Mill Creek in the study area. Was not recorded during targeted surveys in appropriate conditions.	Impacts unlikely
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Species or species habitat may occur within locality (DotE 2015a)	Occurs on plateaus and eastern slopes of the Great Dividing Range south from Watagan State Forest. Occurs along permanent rocky streams with thick fringing vegetation associated with eucalypt woodlands and heaths among sandstone outcrops, hunting either in shrubs or on the ground.	Unlikely. Potential habitat unlikely to be present in the study area.	Nil. No suitable rocky stream habitat present.	Nil.
Litoria raniformis	Southern Bell Frog	E	V	Species or species habitat may occur within locality (DotE 2015a)	Currently, the species is known to exist only in isolated populations in the Coleambally Irrigation Area, the Lowbidgee floodplain and around Lake Victoria. Usually found in or around permanent or ephemeral Black Box/Lignum/Nitre Goosefoot swamps, Lignum/Typha swamps and River Red Gum swamps or billabongs along floodplains and river valleys. They are also found in irrigated rice crops, particularly where there is no available natural habitat (OEH 2013).	Nil. No records of the species in the Sydney Basin. No suitable habitat present.	Nil. No records of the species in the Sydney Basin. No suitable habitat present.	Nil
Mixophyes balbus	Stuttering Frog	E	V	Species or species habitat likely to occur within locality (DotE 2015a)	Occurs along the east coast of Australia. Has undergone a massive range reduction particularly in the south of its range: within the Sydney Basin. Inhabits rainforest and	Nil. No suitable wet habitat present.	Nil. No suitable wet habitat present.	Nil

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					wet, tall, open forest. Shelter in deep leaf litter and thick understorey vegetation on the forest floor. Feeds on insects and smaller frogs, breeding in streams during summer after heavy rain. The species does not occur in areas where the riparian vegetation has been disturbed or where there have been significant upstream human impacts (Mahony et al 1997).			
Pseudophryne australis	Red-crowned Toadlet	V		77 records within 10km (OEH 2015a)	Restricted to Sydney Basin, from Nowra to Pokolbin and west to Mt Victoria. Inhabits heathland and open woodland on Hawkesbury and Narrabeen Sandstones, within 100m of ridgelines. Breeds in ephemeral feeder creeks or flooded depressions, requiring unpolluted water between 5.5 and 6.5 pH. Shelters under rocks, amongst masses of dense vegetation or leaf litter. Populations restricted to immediate vicinity of breeding areas.	Likely. May occur along ephemeral creeks and drainage lines within intact vegetation.	Unlikely. Few ephemeral creeks or drainage lines present. pH of Mill Creek recorded to be above 6.7 at all locations tested during surveys (average of pH 8 over five sites tested).	Low.
n erte rates								
Meridolum corneovirens	Cumberland Plain Land Snail	E		41 records within 10km (OEH 2015a)	Occurs within a small area of the Cumberland Plain, from Richmond and Windsor to Picton. Found primarily under litter of bark, leaves and logs, or in loose soil around grass clumps within Cumberland Plain Woodland. Has also been found under rubbish. Feeds on fungus. During periods of drought can burrow into the soil to escape the dry conditions.	Nil. No suitable habitat present in the study area.	Nil. No suitable habitat present in the proposal footprint.	Nil.
Archaeophya adamsi	Adam's Emerald Dragonfly	E (FM Act)		Known to occur in the Sydney Metro CMA (DPI 2014)	The species is only known from a few sites in the greater Sydney region (including northern Sydney, Blue Mountains and the Gosford area. Larvae have been found in small creeks with gravel or sandy bottoms, in narrow, shaded riffle zones with moss and rich riparian vegetation. Adult dragonflies generally fly away from the water to mature before returning to breed. Males congregate at breeding sites and often guard a territory. Females probably	Possible. May occur along creek lines in intact native vegetation.	Unlikely. Previous disturbance and realignment of the creek are likely to have made the habitat unsuitable for this species, if present in the locality.	Unlikely.

Scientific Name	Common Name	TSC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					lay their eggs into the water.			
Austrocordulia leonardi	Sydney Hawk Dragonfly	E (FM Act)		Known to occur in the Sydney Metro CMA (DPI 2014)	The Sydney Hawk Dragonfly has a very restricted distribution. The known distribution of the species includes three locations in a small area south of Sydney, from Audley to Picton. The species is known from the Hawkesbury-Nepean, Georges River, Port Hacking and Karuah drainages. The Sydney Hawk Dragonfly has specific habitat requirements, and has only ever been collected from deep and shady riverine pools with cooler water. Larvae are found under rocks where they co-exist with Austrocordulia refracta.	Nil. No suitable habitat present in the study area.	Nil. No suitable habitat present in the proposal footprint.	Nil.

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Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
Rostratula australis	Australian Painted Snipe	E	E, M	Species or species habitat likely to occur within locality (DotE 2015a)	Normally found in permanent or ephemeral shallow inland wetlands, either freshwater or brackish. Nests on the ground amongst tall reed-like vegetation near water. Feeds on mudflats and the water's edge taking insects, worm and seeds. Prefers fringes of swamps, dams and nearby marshy areas with cover of grasses, lignum, low scrub or open timber.	Unlikely. No suitable wetland habitat present.	Unlikely. No suitable wetland habitat present.	Impacts unlikely
Monarcha melanopsis	Black-faced Monarch		M	16 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Found along the coast of eastern Australia, becoming less common further south. Found in rainforests, eucalypt woodlands, coastal scrub and damp gullies. It may be found in more open woodland when migrating. Resident in the north of its range, but is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March. It may also migrate to Papua New Guinea in autumn and winter.	Possible. May occur on occasion during migration.	Possible. May occur on occasion during migration.	Proposal would remove 9.25 ha of potential foraging habitat.
Ardea ibis	Cattle Egret		C,J	4 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Occurs across NSW. Principal breeding sites are the central east coast from Newcastle to Bundaberg. Also breeds in major inland wetlands in north NSW (notably the Macquarie Marshes). Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. Uses predominately shallow, open and fresh wetlands with low emergent vegetation and abundant aquatic flora. Sometimes observed in swamps with tall emergent vegetation and commonly use areas of tall pasture in moist, low-lying areas. Occurs across NSW.	Possible. May forage on occasion in dams and waterways.	Possible. May forage on occasion in dams and waterways.	Proposal would have limited impact on the foraging habitat of this species.
Ardea modesta	Eastern Great Egret		C,J,K	20 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Occurs across NSW. Within NSW there are breeding colonies within the Darling Riverine Plains and Riverina regions, and minor colonies across its range including the north and north-east of the state. Reported from a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and	Possible. May forage on occasion in dams and waterways.	Possible. May forage on occasion in dams and waterways.	Proposal would have limited impact on the foraging habitat of this species.

Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					vegetated, large and small, natural and artificial).			
Pandion cristatus	Eastern Osprey	V	M	17 records within 10km (OEH 2015a)	Occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. Adult Eastern Ospreys are mostly resident or sedentary around breeding territories.	Nil. No suitable habitat present	Nil. No suitable habitat present	Nil
Apus pacificus	Fork-tailed Swift		C,J,K	2 records within 10km (OEH 2015a); Species or species habitat likely to occur within locality (DotE 2015a)	Recorded in all regions of NSW. Non-breeding, and almost exclusively aerial while in Australia. Occurs over urban and rural areas as well as areas of native vegetation. Recorded in all regions of NSW. Non-breeding, and almost exclusively aerial while in Australia. Occurs over urban and rural areas as well as areas of native vegetation.	Possible. May occur on occasion above the study area.	Possible. May occur on occasion above the proposal footprint.	Impacts unlikely.
Gallinago hardwickii	Latham's Snipe		C,J,K	79 records within 10km (OEH 2015a); Species or species habitat may occur within locality (DotE 2015a)	Occurs along the coast and west of the great dividing range. Non breeding visitor to Australia. Inhabit permanent and ephemeral wetlands up to 2000 m asl. Typically in open, freshwater wetlands with low, dense vegetation (incl. swamps, flooded grasslands and heathlands). Can also occur in saline/brackish habitats and in modified or artificial habitats close to human activity. Occurs along the coast and west of the great dividing range. Non breeding visitor to Australia. Inhabit permanent and ephemeral wetlands up to 2000 m asl. Typically in open, freshwater wetlands with low, dense vegetation (incl. swamps, flooded grasslands and heathlands). Can also occur in saline/brackish habitats and in modified or artificial habitats close to human activity.	Unlikely. No suitable wetland habitat present.	Unlikely. No suitable wetland habitat present.	Impacts unlikely
Merops ornatus	Rainbow Bee-eater		J	Species or species habitat may occur within locality (DotE 2015a)	Distributed across much of mainland Australia, and several near-shore islands. Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water. It also occurs in inland and coastal sand dune systems, and in mangroves	Possible. May forage and breed in the study area.	Possible. May forage and breed in the proposal footprint.	Proposal would remove 9.25 ha of potential foraging and breeding habitat.

Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
					in northern Australia, and has been recorded in various other habitat types including heathland, sedgeland, vine forest and vine thicket, and on beaches.			
Rhipidura rufifrons	Rufous Fantail		M	74 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Found along NSW coast and ranges. Inhabits rainforest, dense wet forests, swamp woodlands and mangroves. During migration, it may be found in more open habitats or urban areas (Birds Australia 2008).	Possible. May occur on occasion during migration.	Possible. May occur on occasion during migration.	Proposal would remove 9.25 ha of potential foraging habitat.
Myiagra cyanoleuca	Satin Flycatcher		M	1 record within 10km (OEH 2015a); Breeding known to occur within locality (DotE 2015a)	In NSW widespread on and east of the Great Divide, sparsely scattered on the western slopes, very occasional records on the western plains. Inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, often near wetlands and watercourses. On migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests. Generally not in rainforests.	Possible. May occur on occasion during migration.	Possible. May occur on occasion during migration.	Proposal would remove 9.25 ha of potential foraging habitat.
Symposiachrus trivirgatus	Spectacled Monarch		M	Species or species habitat may occur within locality (DotE 2015a)	The Spectacled Monarch is found in coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, New South Wales. It is much less common in the south. Prefers thick understorey in rainfprest, wet gullies and waterside vegetation as well as mangroves.	Unlikely. Outside usual distribution.	Unlikely. Outside usual distribution.	Impacts unlikely.
Haliaeetus leucogaster	White-bellied Sea-Eagle		C	32 records within 10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	Primarily coastal but may extend inland over major river systems. Breeds close to water, mainly in tall open forest/woodland but also in dense forest, rainforest, closed scrub or remnant trees. Usually forages over large expanses of open water, but also over open terrestrial habitats (e.g. grasslands).; Primarily coastal but may extend inland over major river systems. Breeds close to water, mainly in tall open forest/woodland but also in dense forest, rainforest, closed scrub or remnant trees. Usually forages over large expanses of open water, but also over open terrestrial habitats (e.g. grasslands).	Nil. No suitable habitat present	Nil. No suitable habitat present	Nil
Hirundapus	White-throated		C,J,K	11 records within	Recorded along NSW coast to the western	Possible. May	Possible. May	Impacts

Scientific Name	Common Name	NSW Status	EPBC Status	Source	Habitat Description	Likelihood of occurrence in the study area	Likelihood of occurrence in the proposal footprint	Potential impact
caudacutus	Needletail			10km (OEH 2015a); Species or species habitat known to occur within locality (DotE 2015a)	slopes and occasionally from the inland plains. Breeds in northern hemisphere. Almost exclusively aerial while in Australia. Occur above most habitat types, but are more frequently recorded above more densely vegetated habitats (rainforest, open forest and heathland) than over woodland or treeless areas.; Recorded along NSW coast to the western slopes and occasionally from the inland plains. Breeds in northern hemisphere. Almost exclusively aerial while in Australia. Occur above most habitat types, but are more frequently recorded above more densely vegetated habitats (rainforest, open forest and heathland) than over woodland or treeless areas.	occur on occasion above the study area.	occur on occasion above the proposal footprint.	unlikely.

Appendix C Framework for Biodiversity Assessment Data

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Impact?	Common name	Scientific name	Feature
☑	Rosenberg's Goanna	Varanus rosenbergi	Land within 250 m of termite mounds or rock outcrops
☑	Red-crowned Toadlet	Pseudophryne australis	Heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 m of, ephemeral or intermittent drainage lines
☐	Large-eared Pied Bat	Chalinolobus dwyeri	Land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels
☑	Giant Burrowing Frog	Heleioporus australiacus	Land within 40 m of heath, woodland or forest with sandy or friable soils
☐	Broad-headed Snake	Hoplocephalus bungaroides	Land within 50 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges
☐	Hygrocybe anomala subsp. ianthinomarginata	Hygrocybe anomala subsp. ianthinomarginata	Land within Blue Mountains National Park in Wollemi CMA subregion
☐	Eastern Bristlebird	Dasyornis brachypterus	Dense (>80% projected cover) heath, unburnt for 3 or more years
☑	Green and Golden Bell Frog	Litoria aurea	Land within 100 m of emergent aquatic or riparian vegetation
☐	Littlejohn's Tree Frog	Litoria littlejohni	Land within 100 m of permanent rocky streams with thick fringing vegetation
☐	Black Cypress Pine, Woronora Plateau population	Callitris endlicheri, Woronora Plateau population	Confined to the Woronora Plateau in Wollongong LGA

S r e ti e atri

Scientific name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
FLORA												
Acacia baueri subsp. *aspera*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Acacia bynoeana	Y	Y	Y						Y	Y	Y	Y
Acacia prominens - endangered population	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Acacia pubescens	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Astrotricha crassifolia	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Caesia parviflora subsp. *minor*	Y	Y							Y	Y	Y	Y
*Caladenia tessellata***									Y	Y		
Callistemon linearifolius	Y	Y	Y						Y	Y	Y	Y
Epacris purpurascens subsp. *purpurascens*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Eucalyptus camfieldii	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Genoplesium baueri		Y	Y									
Grevillea parviflora subsp. *parviflora*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hibbertia puberula	Y	Y							Y	Y	Y	Y
Hibbertia stricta subsp. *furcatula*	Y	Y	Y						Y	Y	Y	Y
Leucopogon exolasius	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Melaleuca deanei	Y	Y										Y
Persoonia bargoensis	Y	Y	Y	Y	Y							Y
Persoonia hirsuta	Y	Y	Y	Y	Y							Y
Prostanthera densa	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Pterostylis sp. Botany Bay**								Y	Y			
Pultenaea aristata	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FAUNA												
*Cercartetus nanus****	Y	Y	Y	Y					Y	Y	Y	Y
Heleioporus australiacus	Y	Y	Y	Y	Y				Y	Y	Y	Y

Scientific name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Isoodon obesulus subsp. *obesulus*	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Litoria aurea	Y	Y	Y					Y	Y	Y	Y	Y
Phascolarctos cinereus	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Pseudophryne australis	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Varanus rosenbergi	Y	Y									Y	Y

* bold type indicates that GHD field surveys were conducted in these months.

** no suitable habitat and/or no local records are present for these species. No surveys were considered necessary (see section 7.4.2).

*** note that OEH has not identified a suitable survey time for this species in the credit calculator, however recommended survey months are provided in the Threatened Species Profile Database.

Appendix D Survey results

lot transe t data

PCT ID	Condition	Plot ID	Native plant species richness	Native over-storey cover	Native mid-storey cover	Native ground cover (grasses)	Native ground cover (shrubs)	Native ground cover (other)	Exotic plant cover	Number of trees with hollows	Over storey regeneration	Total length of fallen logs
ME014		Benchmark	>39	17-27	75-85	1-10	7-11	13-17		>1	1	>30
	Mod-good (medium)	2	31	9	52	20	10	44	0	0	1	2
	Mod-good (medium)	5	49	52	13	4	8	46	0	3	1	0
ME014		Benchmark	>39	17-27	75-85	1-10	7-11	13-17		>1	1	>30
	Mod-good (poor)	3	33	1	28	6	8	36	0	0	1	0
	Mod-good (poor)	4	32	17	30	2	6	16	0	0	1	0
	Mod-good (poor)	6	21	27	21	2	12	14	0	0	1	1
ME015		Benchmark	29	19-24	20-30	23-31	0-5	12-20		1		5
	Mod-good	1	58	0	4	0	8	90	0	0	1	2
Exotic grassland		7	4	0	0	8	0	0	92	0	0	0

Flora s e ies re orded in the ro osal oot rint

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Apiaceae		*Actinotus minor*	Lesser Flannel Flower			3	2	2		2	2		X
	*	*Foeniculum vulgare*	Fennel										X
		Platysace linearifolia											X
		Xanthosia tridentata	Rock Xanthosia										X
Apocynaceae	*	*Araujia sericifera*	Moth Vine										X
Asparagaceae	*	*Asparagus aethiopicus*	Asparagus Fern										X
Asteraceae	*	*Ageratina adenophora*	Crofton Weed										X
	*	*Ageratina riparia*	Mistflower										X
	*	*Bidens pilosa*	Cobbler's Pegs									2	X
	*	*Cirsium vulgare*	Spear Thistle									2	X
	*	*Conyza bonariensis*	Flaxleaf Fleabane									3	X
	*	*Conyza sumatrensis*	Tall fleabane									2	X
	*	*Lactuca serriola*	Prickly Lettuce										X
	*	*Hypochaeris radicata*	Catsear									2	X
		Ozothamnus diosmifolius	White Dogwood										X
		Pseudognaphalium luteoalbum	Jersey Cudweed									3	
	*	*Senecio madagascariensis*	Fireweed									2	
	*	*Sonchus oleraceus*	Common Sowthistle									2	X
	*	*Taraxacum officinale*	Dandelion									2	X
Basellaceae	*	*Anredera cordifolia*	Madeira Vine										X
Blechnaceae		*Blechnum indicum*	Swamp Water Fern			2							
Brassicaceae	*	*Capsella bursa-pastoris*	Shepherd's Purse										X
Brassicaceae	*	*Hirschfeldia incana*	Buchan Weed										X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed										X
Casuarinaceae		*Allocasuarina diminuta* subsp. *mimica*		EP					2				X
		Allocasuarina distyla					4	3	2		3		X
		Allocasuarina littoralis	Black She-Oak			3	5	4	3	4	4	4	X
		Allocasuarina torulosa	Forest Oak										X
		Casuarina cunninghamiana subsp. *cunninghamiana*	River Oak										X
Centrolepidaceae		*Centrolepis fascicularis*				2							
Commelinaceae	*	*Tradescantia fluminensis*	Wandering Jew										X
Convolvulaceae		*Dichondra repens*	Kidney Weed										X
Cyperaceae		*Baumea acuta*				2							
		Baumea rubiginosa				3							
		Baumea teretifolia				4							
		Caustis flexuosa	Curly Wig			2	3	2	2				X
		Caustis recurvata					2			2			
		Cyathochaeta diandra				2	2			2	2		X
	*	*Cyperus eragrostis*	Umbrella Sedge										X
		Cyperus polystachyos				1							
		Gahnia sieberiana	Red-fruit Saw-sedge						2				
		Gymnoschoenus sphaerocephalus	Button Grass			2							
		Lepidosperma concavum											X
		Lepidosperma laterale	Variable Sword-sedge			2	2	2					
		Lepidosperma limicola				2							
		Lepidosperma neesii				2							
		Ptilothrix deusta				2	2	2		2			X
		Schoenus brevifolius				5							

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		Schoenus ericetorum				2							
		Schoenus paludosus				3							
Dennstaedtiaceae		*Pteridium esculentum*	Bracken										X
Dicksoniaceae		*Calochlaena dubia*	Rainbow Fern										X
Dilleniaceae		*Hibbertia aspera subsp. aspera*											X
Elaeocarpaceae		*Tetratheca neglecta*											X
Ericaceae		*Brachyloma daphnoides*	Daphne Heath						2	2			
		Epacris microphylla var. *microphylla*	Coral Heath			1	2			2	2		X
		Epacris obtusifolia	Blunt-leaf Heath					2		2	1		
		Leucopogon esquamatus								2			X
		Leucopogon microphyllus var. *microphyllus*						1		1			
		Monotoca scoparia					2	2		2	2		
Euphorbiaceae		*Micrantheum ericoides*								1	1		X
Fabaceae (Caesalpinioideae)	*	*Senna pendula* var. *glabrata*											X
Fabaceae (Faboideae)		*Bossiaea ensata*	Sword Bossiaea										X
		Bossiaea heterophylla	Variable Bossiaea				2	2	2				X
		Bossiaea stephensonii											X
		Daviesia mimosoides											X
		Dillwynia floribunda				2	1		2	2			
		Glycine clandestina	Twining glycine										X
		Glycine tabacina	Variable Glycine										X
		Gompholobium glabratum	Dainty Wedge Pea										X
		Hardenbergia violacea	False Sarsaparilla										X
		Kennedia rubicunda	Dusky Coral Pea										X
		Phyllota phylicoides	Heath Phyllota							2			X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		Pultenaea divaricata				1			2	2			
Fabaceae (Faboideae)		*Pultenaea tuberculata*											X
	*	*Trifolium dubium*	Yellow Suckling Clover									2	
	*	*Trifolium repens*	White Clover									2	
	*	*Trifolium subterraneum*	Subterranean Clover										X
Fabaceae (Mimosoideae)		*Acacia bynoeana*	Bynoe's Wattle	E	V								X
		Acacia echinula	Hedgehog Wattle						2				
		Acacia irrorata subsp. irrorata	Green Wattle										X
		Acacia linifolia	White Wattle			2	3	3	3		3		
		Acacia longifolia subsp. longifolia	Sydney Golden Wattle										X
		Acacia myrtifolia	Red-stemmed Wattle						1				X
		Acacia obtusifolia						3	3				
		Acacia rubida	Red-stemmed Wattle						2				
		Acacia suaveolens	Sweet Wattle					2	2	3			X
		Acacia terminalis subsp. Angustifolia							2				X
		Acacia ulicifolia	Prickly Moses						1				X
Gentianaceae	*	*Centaurium erythraea*	Common Centaury									2	X
Goodeniaceae		*Dampiera stricta*				1		1					X
		Goodenia heterophylla subsp. eglandulosa											X
		Goodenia stelligera	Spiked Goodenia										X
Iridaceae		*Patersonia sericea*	Silky Purple-Flag				2				2		X
Juncaceae		*Juncus continuus*				2							X
		Juncus subsecundus	Finger Rush										X
		Juncus usitatus											X
Lauraceae		*Cassytha glabella*						3					X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		Cassytha pubescens	Downy Dodder-laurel							2			
		Cinnamomum camphora	Camphor Laurel										X
Lindsaeaceae		*Lindsaea linearis*	Screw Fern			1				2			X
Lobeliaceae		*Lobelia dentata*				2							
		Pratia purpurascens	Whiteroot										X
Loganiaceae		*Mitrasacme polymorpha*				1							
Lomandraceae		*Lomandra brevis*											X
		Lomandra filiformis subsp. *coriacea*	Wattle Matt-rush										X
		Lomandra obliqua											X
Malvaceae	*	*Malva parviflora*	Small-flowered Mallow										X
	*	*Modiola caroliniana*	Red-flowered Mallow										X
	*	*Sida rhombifolia*	Paddy's Lucerne										X
Myrsinaceae	*	*Anagallis arvensis*	Scarlet Pimpernel										X
Myrtaceae		*Angophora costata*	Sydney Red Gum						3				X
		Angophora hispida	Dwarf Apple						2	3			X
		Angophora hispida x *Corymbia gummifera*											X
		Baeckea brevifolia				1		2					
		Baeckea imbricata						2					
		Callistemon citrinus	Crimson Bottlebrush			3			3				X
		Callistemon linearis	Narrow-leaved Bottlebrush										X
		Calytrix tetragona	Common Fringe-myrtle										X
		Corymbia gummifera	Red Bloodwood			1	3	3	2	3			X
		Eucalyptus capitellata	Brown Stringybark										X
		Eucalyptus haemastoma	Broad-leaved Scribbly Gum							1			X
		Eucalyptus luehmanniana	Yellow Top Mallee Ash										X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		Eucalyptus oblonga				2				4			X
		Eucalyptus piperita	Sydney Peppermint						3				X
		Eucalyptus punctata	Grey Gum						4				X
		Eucalyptus racemosa subsp. *racemosa*	Narrow-leaved Scribbly Gum				2	2	3	6			X
		Eucalyptus saligna/E. botryoides hybrid											X
		Eucalyptus squamosa	Scaly Bark										X
		Euryomyrtus ramosissima	Rosy Baeckea										X
		Kunzea ambigua	Tick Bush			3	5	4	4	1	3		X
		Kunzea capitata							2				X
		Leptospermum arachnoides				2	2						X
		Leptospermum continentale	Prickly Teatree						2				
		Leptospermum juniperinum	Prickly Tea-tree				2	2		3			
		Leptospermum parvifolium				2		2			1		
		Leptospermum polygalifolium	Tantoon			2							X
		Leptospermum rotundifolium								1			
		Leptospermum squarrosum				1							
		Leptospermum trinervium	Slender Tea-tree							3			X
		Micromyrtus ciliata	Fringed Heath-myrtle			2				1			
Olacaceae		*Olax stricta*				1							
Onagraceae	*	*Ludwigia peruviana*											X
Orchidaceae		*Microtis unifolia*	Common Onion Orchid				1						
Oxalidaceae		*Oxalis perennans*											X
Phormiaceae		*Dianella caerulea* var. *producta*											X
		Dianella revoluta var. *revoluta*	A Blue Flax Lily										X
Phyllanthaceae		*Phyllanthus hirtellus*	Thyme Spurge				1						X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Pittosporaceae		*Billardiera scandens*	Hairy Apple Berry										X
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues									2	X
		Veronica plebeia	Trailing Speedwell										X
Poaceae		*Amphibromus nervosus*	Swamp Wallaby Grass						2	2			
	*	*Andropogon virginicus*	Whisky Grass										X
		Anisopogon avenaceus var. avenaceus	Oat Speargrass			2				2			X
		Aristida vagans	Threeawn Speargrass										X
		Austrodanthonia tenuior	A Wallaby Grass										X
		Austrostipa pubescens											X
		Bothriochloa macra	Red Grass										X
	*	*Briza minor*	Shivery Grass										X
	*	*Bromus catharticus*	Praire Grass										X
	*	*Chloris gayana*	Rhodes Grass										X
	*	*Cortaderia selloana*	Pampas Grass			1							X
		Cynodon dactylon	Common Couch									3	X
		Echinopogon caespitosus var. caespitosus	Tufted Hedgehog Grass										X
	*	*Ehrharta erecta*	Panic Veldtgrass									3	
		Entolasia stricta	Wiry Panic			1							X
	*	*Eragrostis curvula*	African Lovegrass									2	X
		Eragrostis leptostachya	Paddock Lovegrass										X
	*	*Hyparrhenia hirta*	Coolatai Grass										X
		Imperata cylindrica	Blady Grass										X
		Microlaena stipoides var. stipoides	Weeping Grass										X
		Oplismenus imbecillis											X
		Panicum simile	Two-colour Panic										X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
	*	*Paspalum dilatatum*	Paspalum									4	X
	*	*Paspalum urvillei*	Vasey Grass									6	X
	*	*Pennisetum clandestinum*	Kikuyu Grass										X
		Poa affinis								2			
	*	*Poa pratensis*	Kentucky Bluegrass									3	
		Poa sieberiana	Snowgrass										X
		Setaria gracilis				1						3	X
	*	*Sporobolus africanus*	Parramatta Grass									2	
		Themeda australis	Kangaroo Grass										X
Polygonaceae	*	*Acetosa sagittata*	Rambling Dock										X
	*	*Rumex crispus*	Curled Dock										X
Proteaceae		*Banksia ericifolia subsp. ericifolia*				2	2	4	3		4		X
		Banksia marginata	Silver Banksia			2	2	2		2			X
		Banksia oblongifolia	Fern-leaved Banksia					2		3			X
		Banksia paludosa				2							
		Banksia robur	Swamp Banksia			1				1			
		Banksia serrata	Old-man Banksia						2	2			X
		Banksia spinulosa var. *spinulosa*				2							X
		Conospermum longifolium subsp. *angustifolium*					2	2			2		
		Grevillea diffusa subsp. *diffusa*						2		1			
		Grevillea oleoides	Red Spider Flower										X
		Grevillea phylicoides	Grey Spider Flower										X
		Grevillea sericea subsp. *sericea*				2		2	2	2	2		X
		Grevillea sphacelata	Grey Spider Flower				3		2	2	3		X
		Hakea dactyloides	Finger Hakea			2			2	3			X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
		Hakea gibbosa				3	3						X
		Hakea sericea	Needlebush					2					X
		Hakea teretifolia	Needlebush								3		X
		Isopogon anemonifolius	Broad-leaf Drumsticks							2			X
		Isopogon anethifolius	Narrow-leaf Drumsticks							2			
		Lambertia formosa	Mountain Devil				3	3					X
		Lomatia silaifolia	Crinkle Bush							1			X
		Persoonia lanceolata	Lance Leaf Geebung										X
		Persoonia levis	Broad-leaved Geebung							2	3		
		Persoonia linearis	Narrow-leaved Geebung				4	3	2	2	3		X
		Petrophile pulchella	Conesticks										X
		Petrophile sessilis					3			2	3		
		Symphionema paludosum				1							
Rosaceae	*	*Rubus fruticosus* sp. agg.	Blackberry complex										X
Restionaceae		*Chordifex dimorphus*				2							
		Chordifex fastigiatus											
		Empodisma minus				3		2					
		Eurychorda complanata				2							
		Hypolaena fastigiata											X
		Leptocarpus tenax				4							X
		Lepyrodia scariosa				2	2	2		2	2		X
Rhamnaceae		*Cryptandra amara*	Bitter Cryptandra										X
Rutaceae		*Boronia parviflora*	Swamp Boronia			1							
		Crowea saligna					1						
		Eriostemon australasius								1			X

Family	Exotic	Scientific Name	Common Name	TSC Status	EPBC Status	Plot/transect							Opportunistic
						Q1	Q2	Q3	Q4	Q5	Q6	Q7	
Sapindaceae		*Dodonaea triquetra*	Large-leaf Hop-bush						2	2			
Schizaeaceae		*Schizaea bifida*	Forked Comb Fern										X
Scrophulariaceae	*	*Verbascum thapsus* subsp. *thapsus*	Great Mullein										X
Stackhousiaceae		*Stackhousia nuda*				1							
Sterculiaceae		*Rulingia hermanniifolia*											X
		Lasiopetalum rufum											X
Stylidiaceae		*Stylidium graminifolium*	Grass Triggerplant			2							
		Stylidium productum											X
Verbenaceae	*	*Lantana camara*	Lantana										X
	*	*Verbena bonariensis*	Purpletop									2	X
	*	*Verbena rigida* var. *rigida*	Veined Verbena										X
Violaceae		*Hybanthus monopetalus*	Slender Violet-bush						2				
Xanthorrhoeaceae		*Xanthorrhoea resinifera*				3				4			

Key: * introduced, E – endangered, EP – endangered population, V – vulnerabl, X – opportunistic record, relative abundance not recorded.

Cover abundance rankings within each plot/transect:

1 Foliage sparsely or very sparsely present, cover less than 5%;
2 1-5% Plentiful, foliage cover 1-5 %;
3 5-25% foliage cover;
4 26-50% foliage cover;
5 51-75% foliage cover;
6 76-100% foliage cover;

Fa na s e ies re orded

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
BIRDS								
Cracticus tibicen	Australian Magpie			O				O
Aegotheles cristatus	Australian Owlet-nightjar						O	
Pelecanus conspicillatus	Australian Pelican							O
Anthus novaeseelandiae	Australian Pipit			O				
Corvus coronoides	Australian Raven			O			OC	O
Threskiornis molucca	Australian White Ibis			O			K	O
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V						O
Coracina novaehollandiae	Black-faced Cuckoo-shrike							W
Elanus axillaris	Black-shouldered Kite			O				
Gerygone mouki	Brown Gerygone						W	O
Accipiter fasciatus	Brown Goshawk					O	O	O
Coturnix ypsilophora	Brown Quail			O				
Acanthiza pusilla	Brown Thornbill						W	O
Melithreptus brevirostris	Brown-headed Honeyeater							O
Acanthiza reguloides	Buff-rumped Thornbill						W	
Scythrops novaehollandiae	Channel-billed Cuckoo							W
Anas castanea	Chestnut Teal				O			
Phaps chalcoptera	Common Bronzewing							O
Ocyphaps lophotes	Crested Pigeon						O	
Platycercus elegans	Crimson Rosella							O
Taeniopygia bichenovii	Double-barred Finch						O	O

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
Gallinula tenebrosa	Dusky Moorhen				O			
Eudynamys orientalis	Eastern Koel							W
Acanthorhynchus tenuirostris	Eastern Spinebill						O	W
Eopsaltria australis	Eastern Yellow Robin							W
Cacomantis flabelliformis	Fan-tailed Cuckoo							W
Pachycephala pectoralis	Golden Whistler							W
Cracticus torquatus	Grey Butcherbird							W
Rhipidura albiscapa	Grey Fantail							O
Colluricincla harmonica	Grey Shrike-thrush						W	O
Dacelo novaeguineae	Laughing Kookaburra							O
Meliphaga lewinii	Lewin's Honeyeater						W	
Meliphaga lewinii	Lewin's Honeyeater							W
Corvus mellori	Little Raven							W
Anthochaera chrysoptera	Little Wattlebird						O	O
Grallina cyanoleuca	Magpie-lark			O				O
Vanellus miles	Masked Lapwing			O				W
Phylidonyris novaehollandiae	New Holland Honeyeater			O		O	O	O
Philemon corniculatus	Noisy Friarbird					W	W	O
Manorina melanocephala	Noisy Miner							O
Anas superciliosa	Pacific Black Duck				O			
Strepera graculina	Pied Currawong							W
Trichoglossus haematodus	Rainbow Lorikeet							O
Anthochaera carunculata	Red Wattlebird							O
Neochmia temporalis	Red-browed Finch						O	W
Todiramphus sanctus	Sacred Kingfisher							W
Petroica boodang	Scarlet Robin	V						W

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
Chalcites lucidus	Shining Bronze-cuckoo							W
Zosterops lateralis	Silvereye							W
Ninox novaeseelandiae	Southern Boobook						W	
Ninox novaeseelandiae	Southern Boobook							W
Pardalotus punctatus	Spotted Pardalote							W
Acanthiza lineata	Striated Thornbill							O
Cacatua galerita	Sulphur-crested Cockatoo						O	O
Malurus cyaneus	Superb Fairy-wren			O			O	O
Podargus strigoides	Tawny Frogmouth							O
Malurus lamberti	Variegated Fairy-wren							O
Hirundo neoxena	Welcome Swallow			O				O
Sericornis frontalis	White-browed Scrubwren							W
Phylidonyris niger	White-cheeked Honeyeater							O
Lichenostomus leucotis	White-eared Honeyeater							O
Ardea pacifica	White-necked Heron			O				
Cormobates leucophaea	White-throated Treecreeper							W
Rhipidura leucophrys	Willie Wagtail			O				
Acanthiza nana	Yellow Thornbill							W
Lichenostomus chrysops	Yellow-faced Honeyeater						W	O
Calyptorhynchus funereus	Yellow-tailed Black-cockatoo							O
MAMMALS								
Rattus fuscipes	Bush Rat							O
Chalinolobus morio	Chocolate Wattled Bat						Po	
Trichosurus vulpecula	Common Brushtail Possum							O
Pseudocheirus peregrinus	Common Ringtail Possum						OK	O
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V						AD

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
Vespadelus pumilus	Eastern Forest Bat				Po		Po	
Macropus giganteus	Eastern Grey Kangaroo			O			K	
Vulpes vulpes	Fox						KF	
Chalinolobus gouldii	Gould's Wattled Bat				AD		AD	AD
Scoteanax rueppellii	Greater Broad-nosed Bat	V			Po		Po	
Pteropus poliocephalus	Grey-headed Flying-fox	V	V					O
Mus musculus	House Mouse			O				
Vespadelus vulturnus	Little Forest Bat							AD
Nyctophilus sp.	long-eared bat						AD	
Perameles nasuta	Long-nosed Bandicoot						CKF	W
Oryctolagus cuniculus	Rabbit						CK	
Rattus sp.	Rat						K	
Petaurus breviceps	Sugar Glider							O
Wallabia bicolor	Swamp Wallaby			O			O	O
Mormopterus "Species 2"	Undescribed Freetail Bat				Po		Po	
Tadarida australis	White-striped Freetail-Bat							AD
REPTILES								
Vermicella annulata	Bandy-Bandy						O	
Ctenotus taeniolatus	Copper-tailed Skink						O	
Lampropholis delicata	Dark-flecked Garden Sunskink						O	O
Tiliqua scincoides	Eastern Blue-tongue							O
Physignathus lesueurii	Eastern Water Dragon				O			
Eulamprus quoyii	Eastern Water-Skink						O	
Amphibolurus muricatus	Jacky Lizard							O
Varanus varius	Lace Monitor						C	
Oedura lesueurii	Lesueur's Velvet Gecko							O

Scientific Name	Common Name	TSC Status	EPBC Status	GHD 2014/2015 surveys				GHD 2010 surveys
				Landfill	Dams	Swamp	Woodland	
Rankinia diemensis	Mountain Dragon						O	
FROGS								
Litoria latopalmata	Broad-palmed Frog				O			
Limnodynastes peronii	Brown-striped Frog					W	W	W
Crinia signifera	Common Eastern Froglet						W	W
Uperoleia fusca	Dusky Toadlet							O
Limnodynastes dumerilii	Eastern Banjo Frog							W
Litoria fallax	Eastern Dwarf Tree Frog				OW			O
Litoria peronii	Peron's Tree Frog				W			
Uperoleia laevigata	Smooth Toadlet				W			W
Uperoleia tyleri	Tyler's Toadlet							W

Key: * - introduced; V – vulnerable; AD – anabat (definite); Po – anabat (possible); F – tracks; K – dead; O – observed; W – heard.

Appendix E *Prostanthera saxicola* expert report

SITA Australia Pty Ltd

Lucas Heights Resource Recovery Park EIS

Expert report: *Prostanthera saxicola* endangered population

May 2016

Limitations

This report: has been prepared by GHD for SITA Australia Pty Ltd and may only be used and relied on by SITA Australia Pty Ltd for the purpose agreed between GHD and the SITA Australia Pty Ltd as set out in section 1.2 of this report. GHD otherwise disclaims responsibility to any person other than SITA Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 2 and 4.1 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by SITA Australia Pty Ltd and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

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Appendices

1. Introduction

1.1 Background

SITA Australia (SITA) is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights (referred to in this report as 'the proposal'). The following activities are proposed at the LHRRP:

- Reprofiling of the landfill
- Relocation and expansion of the existing Garden Organics (GO) facility
- Construction and operation of a fully enclosed advanced resource recovery technology (ARRT) facility.

The proposal is being assessed as a major project in accordance with the requirements of Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (the EP&A Act).GHD Pty Ltd has prepared a Biodiversity Assessment Report (BAR) in accordance with the Framework for Biodiversity Assessment to support the environmental impact statement (EIS). Certain impacts on biodiversity values of a major project require further consideration by the consent or approval authority. The Secretary's Environmental Assessment Requirement's (SEARs) identified impacts on the endangered *Prostanthera saxicola* population in Sutherland and Liverpool local government areas as requiring further consideration and provision of the information specified in s9.2 of the Framework for Biodiversity Assessment. As no targeted surveys have been conducted in the flowering season of the species, the Office of Environment and Heritage (OEH) requested either an expert report be prepared or a survey be conducted between July and October for this species.

1.2 Purpose of an expert report

Under section 6.6.2 of the Framework for Biodiversity Assessment, an expert report may be obtained instead of undertaking a threatened species survey at a development site. An expert report can only be used instead of survey for species to which species credits apply.

The purpose of the expert report is to determine that either:

- the species is unlikely to be present on the development site, in which case no further assessment is required, or
- the species is likely to be present on the development site, in which case the expert report must provide an estimate of the number of individuals or area of habitat to be impacted by the development (according to the unit of measurement identified in the credit calculator). The area of the species polygon is to be determined in accordance with section 6.5 of the BBAM/FBA.

This expert report is for the former, that is, the species (in this case *Prostanthera saxicola*) is unlikely to be present on the site.

An expert report must:

- identify the relevant species or population,
- justify the use of an expert report,
- indicate and justify the likelihood of presence of the species or population,
- estimate the number of individuals or area of habitat (as identified in the calculator) for the development site (giving consideration to the requirements outlined in this appendix),

- include the information considered in relation to the determination made in the report; and
- identify the expert and provide evidence of their credentials.

1.3 Qualifications and expertise of the expert

An expert report must only be prepared by a person who is accredited by the Chief Executive of OEH under section 142B(1)(b) of the TSC Act, or a person who, in the opinion of the Chief Executive of OEH possesses specialised knowledge based on training, study or experience to provide an expert opinion in relation to the biodiversity values to which an expert report relates.

This expert report has been prepared by Gary Leonard. GHD's nomination of Gary Leonard as an expert on the endangered *Prostanthera saxicola* in the Sutherland and Liverpool LGAs. was accepted by OEH on 11 March 2016. A CV for Gary Leonard is provided in Appendix A.

2. Subject species information

2.1 Conservation status

The *Prostanthera saxicola* population in Sutherland and Liverpool local government areas was listed as an endangered population under the TSC Act on 30 May 2014, for several reasons, including:

- **Taxonomy**: The variety occurring in the Sutherland-Liverpool area is described as *Prostanthera saxicola* var. *saxicola* (see Plantnet 2016). "…The taxonomic status of the currently recognized varieties is under review. It is expected that at least some of these taxa will be recognized as distinct species. The distribution of the varieties requires further investigation..." (Conn, in Harden 1992). In the Determination for listing the Sutherland-Liverpool population, the observation is made that "...Due to complex morphological variations it is not possible to attribute individuals of the population of *P. saxicola* in the Sutherland and Liverpool local government areas to a particular variety at this time..." (OEH 2015).
- **Distribution**: The geographic distribution of the Sutherland-Liverpool population is "…very highly restricted…", to an estimated area of occupancy of 8 km².
- **Habitat loss**: "….Much of the habitat in the Sutherland and Liverpool local government areas has already been cleared for urbanisation…. Part of the population occurs on a roadside reserve and is likely to be disturbed by road maintenance and road widening activities associated with urban development. Habitat loss and fragmentation is also expected as a result of rubbish dumping and use of trail bikes and off -road vehicles in the area…" (OEH 2015).
- **Lack of information**: "…There is little information available on the ecology of this species, including longevity and seed biology. This species is considered to be killed by fire (NPWS Fire Response Database 1.2 2002). The current number of individuals in the population is unknown…" (OEH 2015).

2.2 Ecology

Prostanthera saxicola grows as a spreading to mat-forming shrub to 0.2m high. The branches vary from glabrous to "…moderately covered with white appressed antrorse hairs…", with linear to elliptic leaves and axillary white to mauve flowers from September to December (see Benson and McDougall 1997 and OEH 2015)

This species has been recorded on rocky ridges and creek beds, in full sun or in light shade, on skeletal sandy soil to sandy loam over sandstone, at a range of altitudes from 0 to 1200m in areas with rainfall from 1000 to 1200 mm. The distribution extends "…throughout the Central Coast, South Coast, Northern Tablelands, Central Tablelands, Southern Tablelands, North Western Slopes and Central Western Slopes botanical subdivisions of NSW…" (OEH 2015), although as stated above, it is possible that this species will eventually be divided into several species.

Prostanthera saxicola occurs in eucalypt forest and heath e.g. with *Hakea dactyloides, Brachyloma daphnoides, Banksia spinulosa, Baeckea brevifolia, Epacris pulchella, Acacia myrtifolia, A. ulicifolia*; closed heath e.g. with *Allocasuarina nana, Lepidosperma viscidum*. (Benson and McDougall 1997).

2.3 Distribution

The *Prostanthera saxicola* population in Sutherland and Liverpool local government areas occurs mainly between Holsworthy station and Sutherland station, north from Lucas Heights and south of the Georges River (OEH 2016). Five records of the species are mapped in the Atlas of NSW Wildlife. Four records are located north of the subject site in land adjacent to Heathcote Road, and one is located to the east at Woronora Heights (OEH 2016). The closest record is located over 1 km to the north of the subject site.

Prostanthera saxicola was not included in a species list for Holsworthy Military Area (see French, Pellow and Henderson 2001), nor does its occurrence appear in descriptions by OEH (2013), NSW NPWS (2003) or Tozer *et al.* (2010) of the vegetation types that occur on the subject site.

3. Site description

3.1 Geology, soils and geomorphology

Regional-scale Mapping of Soil Landscape Groups by Hazelton and Tille (1990) indicates the occurrence of soils derived from the Lucas Heights Residual Soil Landscape Group. Soils of the Lucas Heights Group are derived from the Mittagong Formation, which is mostly shallow, and located between the Ashfield Shale and Hawkesbury sandstone. “Minor areas of Hawkesbury Sandstone and Ashfield Shale sporadically form surface soil materials within this landscape” (Hazelton and Tille 1990). Soils in the proposal site are generally dry, with few damp areas.

The LHRRP is located on the dissected Hawkesbury Sandstone of the Woronora Plateau, which was uplifted during the Triassic Period such that it now dips in a northerly direction and forms part of the Sydney Basin.

The dominant surface geology is made up of Hawkesbury Sandstone, which is approximately 200 m thick in the Lucas Heights region. It is a medium to coarse grained sandstone and consists of a series of lenticular (and therefore laterally discontinuous) beds of quartz sandstones. Although the dominant lithology is Hawkesbury Sandstone, the formation also includes significant minor components of Ashfield Shale and Siltstone. The shales and siltstones generally occur in relatively thin units frequently interbedded with sandstones.

3.2 Vegetation

A large proportion of the proposal footprint and surrounding study area comprises cleared land or exotic grassland on highly modified landforms which are an artefact of previous excavations and landfilling. Much of the area proposed to be developed as the ARRT facility and the GO facility has been previously disturbed and is currently vegetated with regrowth and, in several locations planted vegetation. A range of vehicular and animal tracks pass through this area. Small patches of apparently complete, continuous native vegetation occur, although they are mostly restricted to fence-lines and property boundaries.

One native vegetation type as described in NSW NPWS (2003) is present in the proposal footprint: Red Bloodwood - Scribbly Gum heathy woodland on sandstone plateaux (ME 014). This vegetation type occurs as both moderate to good (medium) and moderate to good (poor) condition.

This vegetation type approximates the description of Sydney South Exposed Sandstone Woodland S-DSF05 as described by OEH 2013. OEH (2013) comments that “The original extent of the community has been diminished by clearing for urban development between Heathcote and Sutherland although a far greater proportion still remains within protected areas on the Woronora Plateau. Frequent fire represents the greatest threat, particularly in Royal NP. Other impacts are likely to be highly localised including rubbish dumping, illegal bike trails, weed infestations near urban edges and clearing”. Patches of this vegetation type have been mapped in Royal, Heathcote, Garawarra and Dharawal reserves (see OEH 2013).

Red Bloodwood - Scribbly Gum heathy woodland

Red Bloodwood - Scribbly Gum heathy woodland occurs in small patches in the western portion of the proposal footprint. A linear patch is present as a narrow strip along the boundary with Heathcote Road, extending into the SICTA land to the north (Photograph 1). A second patch is present along the boundary fence between SITA and SICTA. A small patch of this vegetation type is also present south of the nearby dam (Photograph 2). This vegetation type is also the most commonly-occurring vegetation type surrounding the proposal footprint.

Canopy species are low and broadly spreading, varying in height from 6m to 14m. Trees are well-spaced (>5m apart) and rarely occur in thickets. Common canopy species include Red Bloodwood (*Corymbia gummifera*), Scribbly Gum species *Eucalyptus racemosa* subsp. *racemosa* at the northern end of the ARRT facility area and, less commonly *Eucalyptus haemastoma* at the southern end of the GO facility. Other canopy species include Sydney Peppermint (*Eucalyptus piperita*), Narrow-leaved Stringybark (*Eucalyptus oblonga*) and Scaly Bark (*Eucalyptus squamosa*). Over-mature, hollow-bearing trees are not present, and it is likely that most of the canopy species are less than 40 years old. A number of small hollows (~5 cm diameter) were observed in some mature Scribbly Gums.

The shrub layer is variable in height and density, possibly in response to previous disturbances and fire. Common shrub species include Dwarf Apple (*Angophora hispida*), Banksia species (*Banksia ericifolia, B. spinulosa, B. marginata* and *B. serrata*), Oak species (*Allocasuarina littoralis* and *A. distyla*), Wattle species (*Acacia longifolia* subsp. *longifolia*, *A. myrtifolia*, and *A. suaveolens*), Mountain Devil (*Lambertia formosa*), Geebungs (*Persoonia lanceolata* and *P. levis*) and Grevillea species (*Grevillea sphacelata*, *G. sericea* subsp. *sericea* and *G. phylicoides*). Patches of the endangered population of *Allocasuarina diminuta* subsp*. mimica* occur along the boundary fence adjacent to Heathcote Road.

Groundcover is sparse, with only Lesser Flannel Flower (*Actinotus minor*) forming mats, while grasses, including *Anisopogon avenaceus, Entolasia stricta, Rytidosperma tenuius, Austrostipa pubescens, Poa sieberiana* and *Themeda triandra,* generally occur as single clumps.

Photograph 1: Red Bloodwood - Scribbly Gum heathy woodland near the boundary fence alongside Heathcote Road

Photograph 2: Red Bloodwood - Scribbly Gum heathy woodland south of the dam. Note uneven surface, which is probably an artefact of previous infilling

Red Bloodwood - Scribbly Gum heathy woodland (regenerating and planted)

Red Bloodwood - Scribbly Gum heathy woodland (regenerating and planted) occurs over much of the area proposed for the ARRT and GO facilities, as well as adjacent areas of the existing landfill, and along much of the alignment of Mill Creek. This vegetation type varies from the self-recruiting sandstone heath-woodland described above, in response to previous disturbance and supplementary planting (Photograph 3, Photograph 4). Planting was carried out historically around 15-20 years ago in the area near the dam by the Department of Lands. Provenance of these species is not known (L. Hedges, on-site nursery co-ordinator, pers. comm.). More recent planting has been carried out along the riparian corridor of Mill Creek, using specimens of local provenance (L. Hedges, on-site nursery co-ordinator, pers. comm.). The canopy is generally no more than 8 m in height and often less than 4 m. Trees may be spaced up to 10 m apart and the shrub layer is also sparse.

Species which are common in this vegetation include Dwarf Apple (*Angophora hispida*), Black Oak (*Allocasuarina littoralis*), Scrub Oak (*Allocasuarina distyla*), *Allocasuarina diminuta* subsp. *diminuta*, Grey Gum (*Eucalyptus punctata*), Smooth-barked Apple (*Angophora costata*) and Bottlebrushes (*Callistemon citrinus* and *Callistemon linearis*). Within this vegetation type is one individual of (possibly) an inter-generic hybrid *Corymbia gummifera* x *Angophora hispida*. Samples of foliage, flowers and capsules have been submitted to the National herbarium, Sydney.

Black Oak (*Allocasuarina littoralis*), occurs in large monotypic patches over the sections of this vegetation type. It is likely that these monotypic patches, rather than a more complete suite of species, are a response to several factors, especially compaction caused by vehicles during infilling, a mingling of topsoil with subsoil components and altered moisture regimes. It is also possible that the Black Oak regrowth occurred soon after a fire and quickly developed a dense thicket, at the expense of other species (see Whelan 1995).

Two individuals of the regionally rare Yellow-top Ash (*Eucalyptus luehmanniana*) occur in a patch of this community north-west of the dam, although it is likely that these specimens have been planted, along with several adjacent individuals of Grey Gum (*Eucalyptus punctata*). A small patch of the endangered population of *A. diminuta* subsp*. mimica* listed under the TSC Act occurs along a disturbed track margin in this community in the proposal footprint, as well as in a disturbed area in SICTA land to the north.

Weed species occur in this vegetation type, particularly within constructed batters of Mill Creek. Noxious and invasive species include Peruvian Primrose *Ludwigia peruviana*, Lantana (*Lantana camara*), Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*), Crofton Weed (*Ageratina adenophora*), Moth Vine (*Araujia sericifera*), Pampas Grass (*Cortaderia selloana*), Vasey Grass (*Paspalum urvillei*) and *Cyperus eragrostis*.

The patch of this vegetation type in the SICTA land (the northern portion of the proposed ARRT facility) is regularly trittered or partially cleared during shot vacuuming operations. Trees are scarce and are mostly < 20 years old. Black Oak (*Allocasuarina littoralis*) occurs in dense thickets throughout this area. Ground cover is sparse to absent.

Photograph 3: Red Bloodwood - Scribbly Gum heathy woodland (regenerating), with dense stand of *Allocasuarina* in background

Photograph 4: Red Bloodwood - Scribbly Gum heathy woodland (regenerating) on SICTA land

oti rassland

This vegetation type mainly consists of a dense groundcover of mostly exotic grasses and forbs. Dominant species include Paspalum (*Paspalum dilatatum*), Kikuyu (*Pennisetum cladestinum*), Brome Grass (*Bromus* spp.), Whisky Grass (*Andropogon virginicus*), Fireweed (*Senecio madagascariensis*), Cotton weed (*Gomphocarpus fruticosus*) and Thistle (*Cirsium* *vulgare*).There are also occasional plantings of trees, including River Oak (*Casuarina cunninghamiana*) and Sydney Blue Gum (*Eucalyptus saligna*).

This vegetation does not constitute a native vegetation type.

leared land

Areas of cleared land, including the landfill, roads and buildings are also present. These include some areas of planted vegetation, particularly near the existing site buildings. These do no constitute a native vegetation type. Cleared land provides minimal habitat for native biota.

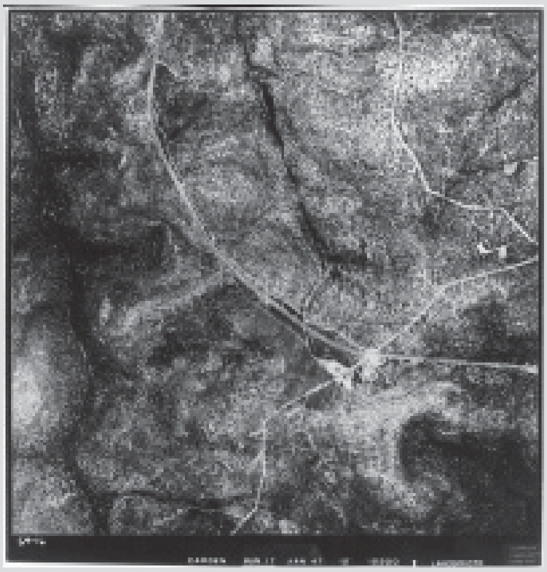
3.3 Disturbance

The LHRRP originally opened in 1987, based on a development consent received in 1985 permitting waste disposal operations. A development application was submitted and approved in 1999 which permitted the expansion of waste disposal operations and also the development of composting and other resource recovery operations at the site.

Historical aerial photographs show that the GO facility and ARRT facility area were vegetated in the earliest available photograph (1947) (Photograph 5) before being largely cleared of vegetation at some stage between 1947 and 1961 (Photograph 6). The GO facility and ARRT facility area remained predominantly cleared until the 1984 photograph where vegetation can be seen (Photograph 7, Photograph 8).

Mill Creek originally flowed further to the east of the proposed GO facility and ARRT facility area, within the area currently occupied by the landfill. The creek-line was realigned to its present alignment in the late 1980s. Its original alignment shows up as a dark line running from south to north in the photographs.

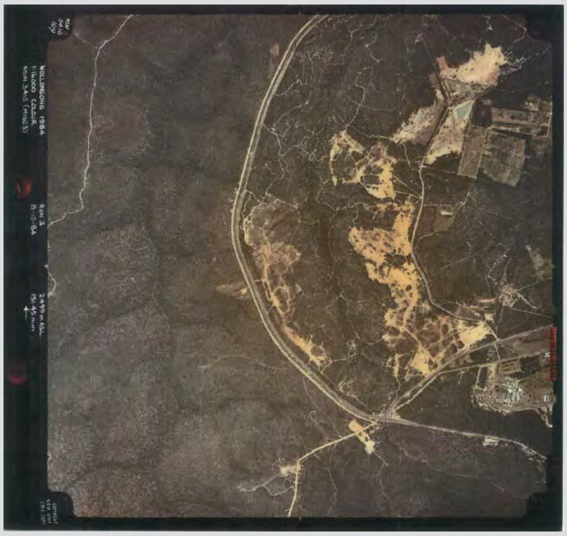
Historical Aerial photographs are provided below.



Photograph 5: 1947 aerial photo

Photograph 6: 1961 aerial photo

Photograph 7: 1970 aerial photo



Photograph 8: 1984 aerial photo

4. Expert assessment

4.1 Site surveys

A number of surveys and assessments have been conducted by GHD within the study area over recent years. These have included an ecological constraints assessment of the proposal footprint in November 2012, detailed surveys for this proposal in December 2014 and January and March 2015, and a follow-up targeted survey in areas of potential *Prostanthera saxicola* habitat on February 18 2016. These are described below.

onstraints assess ent

A constraints assessment was conducted by one ecologist for one day in the proposal footprint in November 2012. The focus of this survey was to identify vegetation types and determine if any threatened ecological communities were present in the area identified for the ARRT and GO facilities (current proposed location near Heathcote Road). Surveys for threatened flora species and potential habitat for threatened flora species were carried out. This survey focussed in particular on searches for individuals of the threatened species *Acacia bynoeana, Eucalyptus camfieldii* and *Melaleuca deanei*, which have previously been recorded within or in close proximity to the proposal footprint. Searches for other threatened flora species that could potentially occur were also conducted. Occurrences of *Acacia bynoeana* and *Melaleuca deanei* were confirmed in the LHRRP and relevant staff were informed of their locations. Note that the individual *Acacia bynoeana* that was identified in the proposal site has since died. No *Melaleuca deanei* or *Eucalyptus camfieldii* were identified in the proposal site.

S s r e s

Pre-existing vegetation mapping (eg Tozer *et al.* 2010, OEH 2013) and vegetation mapping from the constraints assessment (GHD 2012) were ground-truthed in the field via systematic walked transects across the entire proposal footprint and by walking the boundary of vegetation units. Necessary adjustments were made by hand on aerial photographs of the study area. The site was divided into relatively homogenous or discrete zones for assessment based on observed vegetation structure, species composition, soil type, landscape position and condition.

Plot and transect surveys were conducted on site in accordance with the FBA to confirm vegetation types, assess site condition and where required to calculate biodiversity credits. The site value was determined by assessing ten site condition attributes against benchmark values. Benchmarks are quantitative measures of the range of variability in condition in vegetation with relatively little evidence of alteration, disturbance or modification by humans since European settlement. Cover abundance data were also collected for each species within the 20 metre x 20 metre portion of each plot/transect.

Additional vegetation survey effort was used to supplement the plot/transect surveys and help describe the vegetation of the study area. Area searches within both native vegetation and exotic grassland were conducted in the proposal footprint to compile a more exhaustive species list for the proposal footprint.

Threatened plant surveys were conducted in areas of potentially suitable habitat in the proposal footprint during surveys in November 2012, January 2015 and March 2015. Habitat for these species was identified based on OEH threatened species profiles and the experience and judgement of GHD ecologists. Areas of potential threatened plant habitat (i.e. near-intact native vegetation and areas with apparently natural topsoil) were systematically traversed on foot and inspected for threatened plants.

Follo   s r e

In response to communications from OEH, a targeted survey for individuals of *Prostanthera saxicola* var. *saxicola* was carried out on 18 February 2016. Reference was made to survey techniques and survey effort requirements outlined in OEH (2016) and Thompson (2013). All areas that were inspected had been previously surveyed on at least one other occasion. Target patches included areas of more-or-less complete, continuous native vegetation, as well as disturbed areas. Disturbed areas were included in order to take into account the possibility that *Prostanthera saxicola* var. *saxicola* is either disturbance-facultative or disturbance-obligate, as appears to be the case with other local threatened species, e.g. *Epacris purpurascens* var. *purpurascens, Darwinia grandiflora* and *Grevillea parviflora* subsp. *parviflora* (G. Leonard pers. obs.; see also Fairley 2004).

Mr Robert Miller, a botanist who has carried out extensive surveys for *Prostanthera saxicola* var. *saxicola* in the Sutherland and Liverpool LGAs was interviewed, in order to ascertain current information about the distribution and extent of the population and to define appropriate search areas.

All surveyed areas had evidence of Hawkesbury Sandstone, from large boulders, to partially exposed plates, to areas of coarse sand. Note that large rocky outcrops present in the proposal site appear to be material relocated as a result of excavation of the realigned Mill Creek. All surveyed areas included vegetation patches which had at least one of the following species: *Eucalyptus squamosa, Eucalyptus racemosa* subsp. *racemosa* or *E. haemastoma, Corymbia gummifera, Angophora hispida, Allocasuarina nana*, *Hakea dactyloides, Brachyloma daphnoides, Banksia spinulosa, Baeckea brevifolia, Epacris pulchella, Acacia myrtifolia, A. ulicifolia* or *Lepidosperma spp*. In larger patches, linear transects, no more than 5m apart were followed. In smaller patches, circular transects were followed, beginning from the outside and diminishing inwards.

On the same day, the adjacent property, currently leased from SUEZ to three gun clubs was also searched for occurrences of *Prostanthera saxicola* var. *saxicola.* The vegetation along the higher portion of the sites was of particular interest, because the topsoil appears to be mostly undisturbed, and because there were patches in which *Eucalyptus squamosa* and *Angophora hispida* were common.

4.2 Results of surveys

No individuals of *Prostanthera saxicola* var. *saxicola* were recorded during these targeted surveys, either in the proposal site or in the adjacent gun club sites. In addition, no individuals of other *Prostanthera* species were recorded. No individuals of *Prostanthera saxicola* var. *saxicola* were recorded in previous surveys in and adjacent to the LHRRP (GHD 2011 and GHD 2012). It is likely that the *Prostanthera saxicola* var. *saxicola* endangered population does not extend into the proposal site or adjacent areas. Lists of species recorded during the various surveys in and adjacent to the proposal site are provided in Appendix B.

4.3 Potential habitat

It is recognised that parts of the proposal site, as well as the higher parts of the adjacent gun club land could be described as potential habitat for the *Prostanthera saxicola* var. *saxicola* endangered population in Sutherland and Liverpool LGAs, because of a range of factors, including:

- Proximity to the known population;
- Similar soil type, topography and altitude; and
- Similar vegetation type.

Factors which may, however, differ between the proposal site and the site of the known population include:

- Different moisture regimes. (Conn, in Harden [1992] comments that this species often occurs in wet areas). Soils in the proposal site are generally shallow and dry, with minimal wet areas recorded.
- Different nutrient regimes;
- Different soil characteristics. It is apparent that the soil in much of the proposal area has been compacted and may consist of a mixture of topsoil and subsoil. It is possible that *Prostanthera saxicola* var. *saxicola* requires a specific mycorrhizal association for healthy growth, seed production and seed germination.
- Presence/absence of a specialist pollination agent (see Dafni 1992); and
- Different disturbance history, especially in the context of fires.

4.4 Likelihood of occurrence

No individuals of *Prostanthera saxicola* var. *saxicola* were recorded, either during the most recent, targeted survey, or during previous surveys in the proposal footprint and adjacent areas. It is understood that large areas of appropriate habitat in the Menai-Lucas Heights area have been surveyed and no extensions to the *Prostanthera saxicola* var. *saxicola* endangered population have been recorded. It is therefore likely that, although appropriate habitat for the *Prostanthera saxicola* var. *saxicola* endangered population occurs within the proposal site and adjacent areas, there are no occurrences of individuals of *Prostanthera saxicola* var. *saxicola* in the proposal site or in adjacent patches of native vegetation.

Vegetation to be removed as a result of the proposal is located alongside the existing landfill and Heathcote Road. The proposal will not isolate any potential habitat for *Prostanthera saxicola* var. *saxicola*.

The proposal is unlikely to increase threats or result in indirect impacts on the known *Prostanthera saxicola* var. *saxicola* endangered population, given the closest record is located over 1 km from the proposal site.

5. Conclusion

The patch of vegetation at the SUEZ Lucas Heights Resource Recovery Park which will require removal has been surveyed on at least five occasions by GHD ecologists. A specific, targeted survey for individuals of *Prostanthera saxicola* var. *saxicola* within and adjacent to the proposal site was carried out in February 2016, and no individuals were recorded. In addition, no individuals of any *Prostanthera* species were recorded. No *Prostanthera saxicola* var. *saxicola* were recorded in any of the earlier surveys in and near the LHRRP (GHD 2011 and GHD 2012).. It is also noted that the species was not recorded in the nearby Holsworthy Military Area (see French *et al*. 2002).

It is understood that large areas of appropriate habitat in the Menai-Lucas Heights area have been surveyed (R. Miller, pers. comm.) and no extensions to the *Prostanthera saxicola* var. *saxicola* endangered population have been recorded. It is therefore likely that, although appropriate habitat for the *Prostanthera saxicola* var. *saxicola* endangered population occurs within the proposal site and adjacent areas, there are no occurrences of individuals of *Prostanthera saxicola* var. *saxicola* in the proposal site or in adjacent patches of native vegetation.

6. References

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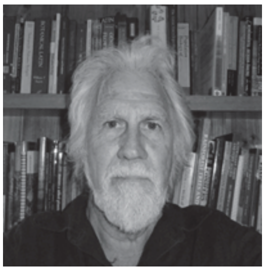
Appendices

Appendix A – Curriculum Vitae: Gary Leonard

Curriculum Vitae

Gary Leonard
Senior Ecologist



Discipline. Botany, Ecology

Qualified. Masters of Science (in progress), Diploma of Education, National Diploma of Horticulture, Horticulture Certificate

Connected. Member of Australian Network for Plant Conservation, National Arborists Association of Australia (now ISA), Coast and Wetlands Society, Australia. Founder member of Urban Biodiversity Inc.

Relevance to project.

Gary is a Senior Ecologist with GHD's Ecology Service Line. He is a highly experienced botanist, with over 40 years working as a horticulturist, environmental consultant and teacher. Gary has published a number of books and journal articles.

Before joining GHD, Gary most recently worked as the Senior Biodiversity Officer at Wollongong Council and, prior to that was Senior Biodiversity with Coffs Harbour Council. With both Councils, Gary provided advice in environmental management of Council assets and proposed development areas. He was required to carry out searches for threatened plant species, including *Daphnandra johnsonii, Pterostylis gibbosa*, and *Cynanchum elegans* in Wollongong and *Phaius australis, Amorphospermum whitei, Zieria prostrata* and *Thesium australe* in Coffs Harbour. Gary also refined and added to mapping of the threatened ecological community *Themeda* grassland on seacliffs and coastal headlands.

Gary was co-author of Whelan and Leonard (1994) "Draft Conservation Research Statement and Research Plan for *Zieria baeuerlenii*, and carried out field work for QEM (1994) Conservation Research Statement and Species Recovery Plan for the Illawarra Greenhood (*Pterostylis gibbosa*).

Survey work for threatened species in the Sutherland LGA includes searches for *Syzygium paniculatum* at Bundeena and *Melaleuca deanei, Pterostylis saxicola, Persoonia nutans, P. hirsuta, Lomandra fluviatilis, Grevillea longifolia* and *Dillwynia tenuifolia* at Holsworthy Military Base and *Eucalyptus camfieldii* and the threatened population of *Allocasuarina nana* at Lucas Heights.

Gary has carried out targeted surveys for threatened species throughout NSW. For example, he has conducted searches in several vegetation patches of the Somersby area for the threatened *Prostanthera junonis* and has mapped occurrences and located meta-populations.

Gary also carried out a peer review of various flora studies for Edmondson Park for the Commonwealth DSEWPaC, with Biosis Research (2009).

A selection of relevant project experience is provided below.

Relevant Experience

- Searches for *Eucalyptus camfieldii* and vegetation mapping, including mapping of EECs, land adjacent to ANSTO, Lucas Heights with GHD (2014)
- Searches for threatened plant species and populations, vegetation mapping at various sites proposed for development, SITA land, Lucas Heights, with GHD (2014-2016)
- Mapping of occurrences of the threatened population of *Allocasuarina diminuta* subsp. *mimica* within SITA, Lucas Heights and adjacent areas, with GHD (2015)
- Vegetation mapping and searches for threatened plant species, tree study and preparation of a VMP at Oyster Bay Road, Oyster Bay, with Ecoplanning (2014)
- Vegetation mapping and searches for threatened plant species, ADF land at Voyager Point, with Ecobiological (2013)
- Vegetation mapping and searches for threatened plant species, Holsworthy ADF sites, with Biosis Research (1998)
- Tree study and searches for threatened plant species, Glenfield Scout Activity Centre; for Scouting Australia (1998)
- Development of protection protocols for populations of the threatened orchid *Pterostylis gibbosa* which occur in a transmission line corridor at Yallah. 2003 for Pacific Power (now Transgrid).
- Searches for populations of the Illawarra Greenhood in the Illawarra, Hunter and Shoalhaven. Data collection and mapping for populations as a component of the Conservation Research Statement and Recovery Plan for this species. 1994 for QEM.
- Monitoring of Upland Swamps, Metropolitan Special Area: Long-term monitoring of various patches of Upland Swamps for impacts of long-wall mining subsidence, with QEM and Biosis Research (1991 -2010).
- Vegetation mapping and route selection for the Karuah Bypass, including assessment of potential offsetting sites, with Gunninah Environmental Consultants (1999-2001). Surveys and reporting including mapping of populations of *Angophora inopina* and *Tetratheca juncea*.
- Mapping of vegetation, including threatened species (including *Diuris* 'Byron Bay', *Geodorum densiflorum, Allocasuarina simulans* and *A. defungens* and the TEC Low Coastal Heath on Clay Soil at Paterson Street Byron Bay, with Gunninah Environmental Consultants (2001-4)
- Mapping of patches of *Angophora inopina* and *Angophora inopina/A. floribunda* hybrids, Bulahdelah Bypass, for Gunninah Environmental Consultants (2003).
- EPBC Referral and Offsetting, Orange: preparation of EPBC Act Referral for a proposed development at Orange Hospital involving the occurrence of a TEC and a viable population of a threatened fauna species, and assessment of offset sites on adjacent Council land, with Ecobiological (2013).
- Pacific Highway Upgrade Tintenbar to Ewingsdale: Assessment of Significance for Hairy Jointgrass *Arthraxon hispidus*, with Biosis Research (2009)
- Pacific Highway, north of Woolgoolga, mapping of occurrence of a population of *Quassia* sp. Moonee Creek, for GHD (2014).
- Vegetation mapping and Monitoring, Tomago RAMSAR Wetlands. Baseline vegetation mapping and establishment of survey points for long-term monitoring, for NSW OEH (2013).
- Targeted surveys for the threatened Charmhaven Orchid (*Corunastylis* sp. 'Charmhaven') to assess development capability of various properties. 2014 for TfNSW.
- Botanical Surveys, proposed geothermal power station at Takara, Vanuatu including recommendations for vegetation management and rehabilitation, with SLR (2013).
- Surveys carried out for threatened orchid species, endangered ecological communities and

Curriculum Vitae

threatened tree and shrub species in areas proposed for establishment of storage facilities, at various sites in the Wyong LGA (2014-15).

- Searches for the threatened plant species *Swainsona recta* along old railway easement, adjacent to Old Cooma Road, for Biosis Research (2011). This survey was carried out for NSW NPWS during the flowering period for this species. Numbers of populations were recorded and located. In addition, other threatened species, including *Diuris aequalis* and *Rutidosis leptorynchoides*, which were recorded during the surveys were also included in the final mapping.
- Searches for the threatened grass species *Bothriochloa biloba* along road reserve near Muswellbrook, 2013 for GHD

Other related experience

- Experience with vegetation mapping and flora searches
- Experience in environmental assessment
- Expert knowledge of flora species identification
- Extensive experience in ecological field surveys in NSW.
- Detailed knowledge and understanding of biodiversity conservation and planning legislation at both a State and Commonwealth level.
- Expert witness in the Land and Environment Court.
- Biodiversity Offsetting

Publications

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Appendix B – Species lists

S e ies re orded in the de elo ent site an ar

Family	Exotic	Scientific Name
Apiaceae	*	*Foeniculum vulgare*
Apiaceae		*Platysace linearifolia*
Apiaceae		*Xanthosia tridentata*
Apocynaceae	*	*Araujia sericifera*
Asparagaceae	*	*Asparagus aethiopicus*
Asteraceae	*	*Ageratina adenophora*
Asteraceae	*	*Ageratina riparia*
Asteraceae	*	*Bidens pilosa*
Asteraceae	*	*Cirsium vulgare*
Asteraceae	*	*Conyza bonariensis*
Asteraceae	*	*Conyza sumatrensis*
Asteraceae	*	*Hypochaeris radicata*
Asteraceae	*	*Lactuca serriola*
Asteraceae		*Ozothamnus diosmifolius*
Asteraceae		*Pseudognaphalium luteoalbum*
Asteraceae	*	*Senecio madagascariensis*
Asteraceae	*	*Sonchus oleraceus*
Asteraceae	*	*Taraxacum officinale*
Basellaceae	*	*Anredera cordifolia*
Brassicaceae	*	*Capsella bursa-pastoris*
Brassicaceae	*	*Hirschfeldia incana*
Caryophyllaceae	*	*Cerastium glomeratum*
Casuarinaceae		*Allocasuarina torulosa*
Casuarinaceae		*Casuarina cunninghamiana* subsp. *cunninghamiana*
Commelinaceae	*	*Tradescantia fluminensis*
Convolvulaceae		*Dichondra repens*
Cyperaceae	*	*Cyperus eragrostis*
Cyperaceae		*Lepidosperma concavum*
Dennstaedtiaceae		*Pteridium esculentum*
Dicksoniaceae		*Calochlaena dubia*
Dilleniaceae		*Hibbertia aspera subsp. aspera*
Elaeocarpaceae		*Tetratheca neglecta*
Fabaceae (Caesalpinioideae)	*	*Senna pendula* var. *glabrata*
Fabaceae (Faboideae)		*Bossiaea ensata*
Fabaceae (Faboideae)		*Bossiaea stephensonii*
Fabaceae (Faboideae)		*Daviesia mimosoides*
Fabaceae (Faboideae)		*Glycine clandestina*
Fabaceae (Faboideae)		*Glycine tabacina*
Fabaceae (Faboideae)		*Gompholobium glabratum*
Fabaceae (Faboideae)		*Hardenbergia violacea*
Fabaceae (Faboideae)		*Kennedia rubicunda*

Family	Exotic	Scientific Name
Fabaceae (Faboideae)		*Pultenaea tuberculata*
Fabaceae (Faboideae)	*	*Trifolium dubium*
Fabaceae (Faboideae)	*	*Trifolium repens*
Fabaceae (Faboideae)	*	*Trifolium subterraneum*
Fabaceae (Mimosoideae)		*Acacia bynoeana*
Fabaceae (Mimosoideae)		*Acacia irrorata* subsp. *irrorata*
Fabaceae (Mimosoideae)		*Acacia longifolia* subsp. *longifolia*
Gentianaceae	*	*Centaurium erythraea*
Goodeniaceae		*Goodenia heterophylla* subsp. *eglandulosa*
Goodeniaceae		*Goodenia stelligera*
Juncaceae		*Juncus subsecundus*
Juncaceae		*Juncus usitatus*
Lauraceae	*	*Cinnamomum camphora*
Lobeliaceae		*Pratia purpurascens*
Lomandraceae		*Lomandra brevis*
Lomandraceae		*Lomandra filiformis* subsp. *coriacea*
Lomandraceae		*Lomandra obliqua*
Malvaceae	*	*Malva parviflora*
Malvaceae	*	*Modiola caroliniana*
Malvaceae	*	*Sida rhombifolia*
Myrsinaceae	*	*Anagallis arvensis*
Myrtaceae		*Angophora hispida* x *Corymbia gummifera*
Myrtaceae		*Callistemon linearis*
Myrtaceae		*Calytrix tetragona*
Myrtaceae		*Eucalyptus capitellata*
Myrtaceae		*Eucalyptus saligna/E. botryoides hybrid*
Myrtaceae		*Eucalyptus squamosa*
Myrtaceae		*Euryomyrtus ramosissima*
Onagraceae	*	*Ludwigia peruviana*
Oxalidaceae		*Oxalis perennans*
Phormiaceae		*Dianella caerulea* var. *producta*
Phormiaceae		*Dianella revoluta* var. *revoluta*
Pittosporaceae		*Billardiera scandens*
Plantaginaceae	*	*Plantago lanceolata*
Plantaginaceae		*Veronica plebeia*
Poaceae	*	*Andropogon virginicus*
Poaceae		*Aristida vagans*
Poaceae		*Austrodanthonia tenuior*
Poaceae		*Austrostipa pubescens*
Poaceae		*Bothriochloa macra*
Poaceae	*	*Briza minor*
Poaceae	*	*Bromus catharticus*

Family	Exotic	Scientific Name
Poaceae	*	*Chloris gayana*
Poaceae	*	*Cortaderia selloana*
Poaceae		*Cynodon dactylon*
Poaceae		*Echinopogon caespitosus* var. *caespitosus*
Poaceae	*	*Ehrharta erecta*
Poaceae	*	*Eragrostis curvula*
Poaceae		*Eragrostis leptostachya*
Poaceae	*	*Hyparrhenia hirta*
Poaceae		*Imperata cylindrica*
Poaceae		*Microlaena stipoides* var. *stipoides*
Poaceae		*Oplismenus imbecillis*
Poaceae		*Panicum simile*
Poaceae	*	*Paspalum dilatatum*
Poaceae	*	*Paspalum urvillei*
Poaceae	*	*Pennisetum clandestinum*
Poaceae	*	*Poa pratensis*
Poaceae		*Poa sieberiana*
Poaceae	*	*Setaria parviflora*
Poaceae	*	*Sporobolus africanus*
Poaceae		*Themeda australis*
Polygonaceae	*	*Acetosa sagittata*
Polygonaceae	*	*Rumex crispus*
Proteaceae		*Grevillea oleoides*
Proteaceae		*Grevillea phylicoides*
Proteaceae		*Persoonia linearis*
Proteaceae		*Petrophile pulchella*
Restionaceae		*Hypolaena fastigiata*
Rhamnaceae		*Cryptandra amara*
Rosaceae	*	*Rubus fruticosus* sp. agg.
Schizaeaceae		*Schizaea bifida*
Scrophulariaceae	*	*Verbascum thapsus* subsp. *thapsus*
Sterculiaceae		*Lasiopetalum rufum*
Sterculiaceae		*Rulingia hermanniifolia*
Stylidiaceae		*Stylidium productum*
Verbenaceae	*	*Lantana camara*
Verbenaceae	*	*Verbena bonariensis*
Verbenaceae	*	*Verbena rigida* var. *rigida*

S e ies re orded at the S T site n l in Fe r ar

Family	Exotic	Scientific Name
Apiaceae		*Actinotus minor*
Apiaceae		*Actinotus minor*
Apiaceae		*Actinotus minor*
Apiaceae	*	*Foeniculum vulgare*
Apiaceae		*Platysace linearifolia*
Apiaceae		*Platysace linearifolia*
Apiaceae		*Platysace linearifolia*
Apiaceae		*Xanthosia pilosa*
Apiaceae		*Xanthosia tridentata*
Apiaceae		*Xanthosia tridentata*
Apiaceae		*Xanthosia tridentata*
Apiaceae		*Xanthosia tridentata*
Apocynaceae	*	*Araujia sericifera*
Asparagaceae	*	*Asparagus aethiopicus*
Asteraceae	*	*Ageratina adenophora*
Asteraceae	*	*Ageratina riparia*
Asteraceae	*	*Bidens pilosa*
Asteraceae	*	*Cirsium vulgare*
Asteraceae	*	*Conyza bonariensis*
Asteraceae	*	*Conyza sumatrensis*
Asteraceae	*	*Hypochaeris radicata*
Asteraceae	*	*Lactuca serriola*
Asteraceae		*Ozothamnus diosmifolius*
Asteraceae		*Pseudognaphalium luteoalbum*
Asteraceae	*	*Senecio madagascariensis*
Asteraceae	*	*Sonchus oleraceus*
Asteraceae	*	*Taraxacum officinale*
Basellaceae	*	*Anredera cordifolia*
Brassicaceae	*	*Capsella bursa-pastoris*
Brassicaceae	*	*Hirschfeldia incana*
Caryophyllaceae	*	*Cerastium glomeratum*
Caryophyllaceae	*	*Cerastium glomeratum*
Casuarinaceae		*Allocasuarina distyla*
Casuarinaceae		*Allocasuarina littoralis*
Casuarinaceae		*Allocasuarina littoralis*
Casuarinaceae		*Allocasuarina littoralis*
Casuarinaceae		*Allocasuarina littoralis*
Casuarinaceae		*Allocasuarina torulosa*
Casuarinaceae		*Casuarina cunninghamiana* subsp. *cunninghamiana*
Centrolepidaceae		*Centrolepis fascicularis*
Commelinaceae	*	*Tradescantia fluminensis*

Family	Exotic	Scientific Name
Convolvulaceae		*Dichondra repens*
Cyperaceae		*Caustis flexuosa*
Cyperaceae		*Caustis flexuosa*
Cyperaceae		*Caustis flexuosa*
Cyperaceae		*Caustis flexuosa*
Cyperaceae		*Cyathochaeta diandra*
Cyperaceae		*Cyathochaeta diandra*
Cyperaceae		*Cyathochaeta diandra*
Cyperaceae		*Cyathochaeta diandra*
Cyperaceae	*	*Cyperus eragrostis*
Cyperaceae		*Lepidosperma concavum*
Cyperaceae		*Lepidosperma concavum*
Cyperaceae		*Lepidosperma filiforme*
Cyperaceae		*Lepidosperma filiforme*
Cyperaceae		*Lepidosperma filiforme*
Cyperaceae		*Lepidosperma laterale*
Cyperaceae		*Ptilothrix deusta*
Dennstaedtiaceae		*Pteridium esculentum*
Dennstaedtiaceae		*Pteridium esculentum*
Dicksoniaceae		*Calochlaena dubia*
Dilleniaceae		*Hibbertia acicularis*
Dilleniaceae		*Hibbertia aspera* subsp. *aspera*
Elaeocarpaceae		*Elaeocarpus reticulatus*
Elaeocarpaceae		*Tetratheca neglecta*
Ericaceae		*Brachyloma daphnoides*
Ericaceae		*Epacris microphylla*
Ericaceae		*Epacris microphylla*
Ericaceae		*Epacris obtusifolia*
Ericaceae		*Leucopogon ericoides*
Ericaceae		*Leucopogon ericoides*
Ericaceae		*Leucopogon ericoides*
Ericaceae		*Monotoca scoparia*
Ericaceae		*Woollsia pungens*
Euphorbiaceae		*Amperea xiphoclada*
Fabaceae (Caesalpinioideae)	*	*Senna pendula* var. *glabrata*
Fabaceae (Faboideae)		*Bossiaea ensata*
Fabaceae (Faboideae)		*Bossiaea heterophylla*
Fabaceae (Faboideae)		*Bossiaea heterophylla*
Fabaceae (Faboideae)		*Bossiaea heterophylla*
Fabaceae (Faboideae)		*Bossiaea heterophylla*
Fabaceae (Faboideae)		*Bossiaea stephensonii*
Fabaceae (Faboideae)		*Daviesia mimosoides*
Fabaceae (Faboideae)		*Dillwynia floribunda*

Family	Exotic	Scientific Name
Fabaceae (Faboideae)		*Dillwynia floribunda*
Fabaceae (Faboideae)		*Dillwynia retorta*
Fabaceae (Faboideae)		*Glycine clandestina*
Fabaceae (Faboideae)		*Glycine tabacina*
Fabaceae (Faboideae)		*Gompholobium glabratum*
Fabaceae (Faboideae)		*Gompholobium grandiflorum*
Fabaceae (Faboideae)		*Hardenbergia violacea*
Fabaceae (Faboideae)		*Kennedia rubicunda*
Fabaceae (Faboideae)		*Pultenaea tuberculata*
Fabaceae (Faboideae)		*Pultenaea tuberculata*
Fabaceae (Faboideae)		*Pultenaea tuberculata*
Fabaceae (Faboideae)	*	*Trifolium dubium*
Fabaceae (Faboideae)	*	*Trifolium repens*
Fabaceae (Faboideae)	*	*Trifolium subterraneum*
Fabaceae (Mimosoideae)		*Acacia bynoeana*
Fabaceae (Mimosoideae)		*Acacia decurrens*
Fabaceae (Mimosoideae)		*Acacia irrorata* subsp. *irrorata*
Fabaceae (Mimosoideae)		*Acacia linifolia*
Fabaceae (Mimosoideae)		*Acacia linifolia*
Fabaceae (Mimosoideae)		*Acacia linifolia*
Fabaceae (Mimosoideae)		*Acacia longifolia* subsp. *longifolia*
Fabaceae (Mimosoideae)		*Acacia longifolia* subsp. *longifolia*
Fabaceae (Mimosoideae)		*Acacia obtusifolia*
Fabaceae (Mimosoideae)		*Acacia suaveolens*
Fabaceae (Mimosoideae)		*Acacia suaveolens*
Fabaceae (Mimosoideae)		*Acacia suaveolens*
Fabaceae (Mimosoideae)		*Acacia terminalis* subsp. *angustifolia*
Gentianaceae	*	*Centaurium erythraea*
Goodeniaceae		*Goodenia heterophylla subsp. eglandulosa*
Goodeniaceae		*Goodenia stelligera*
Haloragaceae		*Gonocarpus teucrioides*
Iridaceae		*Patersonia sericea*
Juncaceae		*Juncus subsecundus*
Juncaceae		*Juncus usitatus*
Lauraceae		*Cassytha glabella*
Lauraceae		*Cassytha glabella*
Lauraceae		*Cassytha glabella*
Lauraceae		*Cassytha glabella*
Lauraceae	*	*Cinnamomum camphora*
Lindsaeaceae		*Lindsaea linearis*
Lobeliaceae		*Pratia purpurascens*
Lomandraceae		*Lomandra brevis*
Lomandraceae		*Lomandra filiformis* subsp. *coriacea*

Family	Exotic	Scientific Name
Lomandraceae		*Lomandra longifolia*
Lomandraceae		*Lomandra obliqua*
Lomandraceae		*Lomandra obliqua*
Lomandraceae		*Lomandra obliqua*
Malvaceae	*	*Malva parviflora*
Malvaceae	*	*Modiola caroliniana*
Malvaceae	*	*Sida rhombifolia*
Myrsinaceae	*	*Anagallis arvensis*
Myrtaceae		*Angophora costata*
Myrtaceae		*Angophora hispida*
Myrtaceae		*Angophora hispida*
Myrtaceae		*Angophora hispida*
Myrtaceae		*Angophora hispida* x *Corymbia gummifera*
Myrtaceae		*Baeckea imbricata*
Myrtaceae		*Baeckea imbricata*
Myrtaceae		*Baeckea imbricata*
Myrtaceae		*Callistemon linearis*
Myrtaceae		*Callistemon linearis*
Myrtaceae		*Calytrix tetragona*
Myrtaceae		*Corymbia gummifera*
Myrtaceae		*Corymbia gummifera*
Myrtaceae		*Corymbia gummifera*
Myrtaceae		*Corymbia gummifera*
Myrtaceae		*Corymbia gummifera*
Myrtaceae		*Eucalyptus capitellata*
Myrtaceae		*Eucalyptus haemastoma*
Myrtaceae		*Eucalyptus oblonga*
Myrtaceae		*Eucalyptus piperita*
Myrtaceae		*Eucalyptus racemosa*
Myrtaceae		*Eucalyptus racemosa*
Myrtaceae		*Eucalyptus racemosa*
Myrtaceae		*Eucalyptus saligna/E. botryoides hybrid*
Myrtaceae		*Eucalyptus squamosa*
Myrtaceae		*Eucalyptus squamosa*
Myrtaceae		*Euryomyrtus ramosissima*
Myrtaceae		*Kunzea ambigua*
Myrtaceae		*Kunzea ambigua*
Myrtaceae		*Kunzea ambigua*
Myrtaceae		*Kunzea ambigua*
Myrtaceae		*Leptospermum arachnoides*
Myrtaceae		*Leptospermum arachnoides*
Myrtaceae		*Leptospermum arachnoides*
Myrtaceae		*Leptospermum polygalifolium*

Family	Exotic	Scientific Name
Myrtaceae		*Leptospermum polygalifolium*
Myrtaceae		*Leptospermum squarrosum*
Myrtaceae		*Leptospermum trinervium*
Myrtaceae		*Leptospermum trinervium*
Myrtaceae		*Leptospermum trinervium*
Myrtaceae		*Leptospermum trinervium*
Myrtaceae		*Leptospermum trinervium*
Onagraceae	*	*Ludwigia peruviana*
Orchidaceae		*Spiranthes australis*
Oxalidaceae		*Oxalis perennans*
Phormiaceae		*Dianella caerulea* var. *producta*
Phormiaceae		*Dianella caerulea* var. *producta*
Phormiaceae		*Dianella caerulea* var. *producta*
Phormiaceae		*Dianella revoluta* var. *revoluta*
Phyllanthaceae		*Phyllanthus hirtellus*
Pittosporaceae		*Billardiera scandens*
Pittosporaceae		*Billardiera scandens*
Plantaginaceae	*	*Plantago lanceolata*
Plantaginaceae		*Veronica plebeia*
Poaceae	*	*Andropogon virginicus*
Poaceae	*	*Andropogon virginicus*
Poaceae		*Anisopogon avenaceus*
Poaceae		*Anisopogon avenaceus*
Poaceae		*Anisopogon avenaceus*
Poaceae		*Anisopogon avenaceus*
Poaceae		*Aristida vagans*
Poaceae		*Austrodanthonia tenuior*
Poaceae		*Austrostipa pubescens*
Poaceae		*Austrostipa pubescens*
Poaceae		*Bothriochloa macra*
Poaceae	*	*Briza minor*
Poaceae	*	*Bromus catharticus*
Poaceae	*	*Chloris gayana*
Poaceae	*	*Cortaderia selloana*
Poaceae		*Cynodon dactylon*
Poaceae		*Cynodon dactylon*
Poaceae		*Echinopogon caespitosus* var. *caespitosus*
Poaceae	*	*Ehrharta erecta*
Poaceae		*Entolasia stricta*
Poaceae		*Entolasia stricta*
Poaceae		*Entolasia stricta*
Poaceae		*Entolasia stricta*
Poaceae		*Entolasia stricta*

Family	Exotic	Scientific Name
Poaceae		*Eragrostis brownii*
Poaceae	*	*Eragrostis curvula*
Poaceae	*	*Eragrostis curvula*
Poaceae	*	*Eragrostis curvula*
Poaceae	*	*Eragrostis curvula*
Poaceae		*Eragrostis leptostachya*
Poaceae	*	*Hyparrhenia hirta*
Poaceae	*	*Hyparrhenia hirta*
Poaceae		*Imperata cylindrica*
Poaceae		*Microlaena stipoides* var. *stipoides*
Poaceae		*Oplismenus imbecillis*
Poaceae		*Panicum simile*
Poaceae	*	*Paspalum dilatatum*
Poaceae	*	*Paspalum urvillei*
Poaceae	*	*Paspalum urvillei*
Poaceae	*	*Pennisetum clandestinum*
Poaceae	*	*Poa pratensis*
Poaceae		*Poa sieberiana*
Poaceae	*	*Setaria parviflora*
Poaceae	*	*Sporobolus africanus*
Poaceae	*	*Stenotaphrum secundatum*
Poaceae	*	*Stenotaphrum secundatum*
Poaceae		*Themeda australis*
Polygonaceae	*	*Acetosa sagittata*
Polygonaceae	*	*Rumex crispus*
Proteaceae		*Banksia ericifolia* subsp. *ericifolia*
Proteaceae		*Banksia ericifolia* subsp. *ericifolia*
Proteaceae		*Banksia ericifolia* subsp. *ericifolia*
Proteaceae		*Banksia ericifolia* subsp. *ericifolia*
Proteaceae		*Banksia marginata*
Proteaceae		*Banksia marginata*
Proteaceae		*Banksia marginata*
Proteaceae		*Banksia marginata*
Proteaceae		*Banksia oblongifolia*
Proteaceae		*Banksia paludosa*
Proteaceae		*Banksia paludosa*
Proteaceae		*Banksia paludosa*
Proteaceae		*Banksia paludosa*
Proteaceae		*Banksia serrata*
Proteaceae		*Banksia serrata*
Proteaceae		*Banksia serrata*
Proteaceae		*Banksia serrata*
Proteaceae		*Banksia spinulosa* var. *spinulosa*

Family	Exotic	Scientific Name
Proteaceae		*Grevillea buxifolia*
Proteaceae		*Grevillea oleoides*
Proteaceae		*Grevillea phylicoides*
Proteaceae		*Grevillea sericea* subsp. *sericea*
Proteaceae		*Grevillea speciosa*
Proteaceae		*Grevillea sphacelata*
Proteaceae		*Hakea dactyloides*
Proteaceae		*Hakea dactyloides*
Proteaceae		*Hakea sericea*
Proteaceae		*Hakea sericea*
Proteaceae		*Hakea teretifolia*
Proteaceae		*Isopogon anemonifolius*
Proteaceae		*Isopogon anemonifolius*
Proteaceae		*Isopogon anemonifolius*
Proteaceae		*Lambertia formosa*
Proteaceae		*Lambertia formosa*
Proteaceae		*Lambertia formosa*
Proteaceae		*Lomatia silaifolia*
Proteaceae		*Persoonia lanceolata*
Proteaceae		*Persoonia lanceolata*
Proteaceae		*Persoonia lanceolata*
Proteaceae		*Persoonia lanceolata*
Proteaceae		*Persoonia lanceolata*
Proteaceae		*Persoonia levis*
Proteaceae		*Persoonia levis*
Proteaceae		*Persoonia levis*
Proteaceae		*Persoonia levis*
Proteaceae		*Persoonia linearis*
Proteaceae		*Petrophile pulchella*
Proteaceae		*Petrophile pulchella*
Proteaceae		*Petrophile pulchella*
Proteaceae		*Petrophile pulchella*
Restionaceae		*Chordifex dimorphus*
Restionaceae		*Hypolaena fastigiata*
Restionaceae		*Hypolaena fastigiata*
Restionaceae		*Lepyrodia scariosa*
Restionaceae		*Lepyrodia scariosa*
Restionaceae		*Lepyrodia scariosa*
Rhamnaceae		*Cryptandra amara*
Rosaceae	*	*Rubus fruticosus* sp. agg.
Rutaceae		*Eriostemon australasius*
Schizaeaceae		*Schizaea bifida*
Scrophulariaceae	*	*Verbascum thapsus* subsp. *thapsus*
Solanaceae	*	*Solanum mauritianum*

Family	Exotic	Scientific Name
Sterculiaceae		*Lasiopetalum rufum*
Sterculiaceae		*Rulingia hermanniifolia*
Stylidiaceae		*Stylidium productum*
Verbenaceae	*	*Lantana camara*
Verbenaceae	*	*Verbena bonariensis*
Verbenaceae	*	*Verbena rigida* var. *rigida*
Xanthorrhoeaceae		*Xanthorrhoea resinosa*
Xanthorrhoeaceae		*Xanthorrhoea resinosa*

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Family	Exotic	Scientific Name
Acanthaceae		*Brunoniella pumilio*
Acanthaceae		*Brunoniella australis*
Adiantaceae		*Cheilanthes sieberi*
Adiantaceae	*	*Pellaea viridis*
Anthericaceae		*Caesia parviflora*
Anthericaceae		*Laxmannia compacta*
Anthericaceae		*Laxmannia gracilis*
Anthericaceae		*Thysanotus juncifolius*
Anthericaceae		*Tricoryne elatior*
Apiaceae		*Actinotus helianthi*
Apiaceae		*Actinotus minor*
Apiaceae		*Platysace linearifolia*
Apiaceae		*Platysace ericoides*
Apiaceae		*Xanthosia pilosa*
Apiaceae		*Xanthosia tridentata*
Asteraceae	*	*Ageratina adenophora*
Asteraceae	*	*Andropogon virginicus*
Asteraceae	*	*Bidens pilosa*
Asteraceae	*	*Hypochaeris glabra*
Asteraceae	*	*Senecio madagascariensis*
Asteraceae		*Euchiton* sp.
Asteraceae		*Euchiton sphaericus*
Asteraceae		*Lagenophora stipitata*
Asteraceae		*Olearia microphylla*
Asteraceae		*Ozothamnus diosmifolius*
Asteraceae		*Senecio ?diaschides*
Asteraceae		*Vittadinia cuneata*
Campanulaceae		*Wahlenbergia gracilis*
Caryophyllaceae	*	*Cerastium glomeratum*
Casuarinaceae		*Allocasuarina diminuta* subsp. *mimica*
Casuarinaceae		*Allocasuarina distyla*
Casuarinaceae		*Allocasuarina littoralis*
Casuarinaceae		*Allocasuarina torulosa*
Casuarinaceae		*Allocasuarina nana*
Chenopodiaceae		*Einadia hastata*
Clusiaceae		*Hypericum japonicum*
Colchicaceae		*Burchardia umbellata*
Convolvulaceae		*Polymeria calycina*
Cyperaceae		*Baumea rubiginosa*
Cyperaceae		*Baumea* sp.
Cyperaceae		*Caustis flexuosa*
Cyperaceae		*Caustis pentandra*
Cyperaceae		*Cyathochaeta diandra*
Cyperaceae		*Cyperaceae* sp.
Cyperaceae		*Gahnia subaequiglumis*
Cyperaceae		*Lepidosperma concavum*
Cyperaceae		*Lepidosperma gunnii*

Family	Exotic	Scientific Name
Cyperaceae		*Lepidosperma laterale*
Cyperaceae		*Lepidosperma viscidum*
Cyperaceae		*Schoenus ?moorei*
Cyperaceae		*Schoenus ericetorum*
Cyperaceae		*Schoenus villosus*
Cyperaceae		*Tricostularia pauciflora*
Cyperaceae		*Ptilothrix deusta*
Dennstaedtiaceae		*Pteridium esculentum*
Dicksoniaceae		*Calochlaena dubia*
Dilleniaceae		*Hibbertia acicularis*
Dilleniaceae		*Hibbertia aspera*
Dilleniaceae		*Hibbertia monogyna*
Dilleniaceae		*Hibbertia nitida*
Dilleniaceae		*Hibbertia serpyllifolia*
Doryanthaceae		*Doryanthes excelsa*
Droseraceae		*Drosera peltata*
Elaeocarpaceae		*Tetratheca neglecta*
Ericaceae - Styphelioideae		*Epacris microphylla*
Ericaceae - Styphelioideae		*Epacris pulchella*
Ericaceae - Styphelioideae		*Leucopogon appressus*
Ericaceae - Styphelioideae		*Leucopogon microphyllus*
Ericaceae - Styphelioideae		*Lissanthe sapida*
Ericaceae - Styphelioideae		*Lissanthe strigosa*
Ericaceae - Styphelioideae		*Monotoca scoparia*
Fabaceae (Caesalpinioideae)	*	*Senna pendula* var. *glabrata*
Fabaceae (Faboideae)		*Bossiaea ensata*
Fabaceae (Faboideae)		*Bossiaea heterophylla*
Fabaceae (Faboideae)		*Bossiaea stephensonii*
Fabaceae (Faboideae)		*Daviesia mimosoides*
Fabaceae (Faboideae)		*Daviesia ulicifolia*
Fabaceae (Faboideae)		*Dillwynia retorta*
Fabaceae (Faboideae)		*Glycine clandestina*
Fabaceae (Faboideae)		*Glycine microphylla*
Fabaceae (Faboideae)		*Gompholobium glabratum*
Fabaceae (Faboideae)		*Gompholobium grandiflorum*
Fabaceae (Faboideae)		*Gompholobium minus*
Fabaceae (Faboideae)		*Hovea linearis*
Fabaceae (Faboideae)		*Hovea pannosa*
Fabaceae (Faboideae)		*Kennedia rubicunda*
Fabaceae (Faboideae)		*Mirbelia rubiifolia*
Fabaceae (Faboideae)		*hyllota phylicoides*
Fabaceae (Faboideae)		*Pultenaea linophylla*
Fabaceae (Faboideae)		*Pultenaea retusa*
Fabaceae (Faboideae)		*Pultenaea subspicata*
Fabaceae (Faboideae)		*Pultenaea tuberculata*
Fabaceae (Faboideae)		*Pultenaea villosa*
Fabaceae (Mimosoideae)		*Acacia brownii*
Fabaceae (Mimosoideae)		*Acacia falcata*

Family	Exotic	Scientific Name
Fabaceae (Mimosoideae)		*Acacia longifolia*
Fabaceae (Mimosoideae)		*Acacia myrtifolia*
Fabaceae (Mimosoideae)		*Acacia parvipinulla*
Fabaceae (Mimosoideae)		*Acacia suaveolens*
Fabaceae (Mimosoideae)		*Acacia terminalis*
Fabaceae (Mimosoideae)		*Acacia ulicifolia*
Fabaceae (Mimosoideae)		*Banksia ericifolia*
Fabaceae (Mimosoideae)		*Banksia marginata*
Fabaceae (Mimosoideae)		*Banksia paludosa*
Fabaceae (Mimosoideae)		*Banksia serrata*
Fabaceae (Mimosoideae)		*Banksia spinulosa*
Gentianaceae	*	*Centaurium erythraea*
Goodeniaceae		*Coopernookia barbata*
Goodeniaceae		*Dampiera stricta*
Goodeniaceae		*Goodenia hederacea*
Goodeniaceae		*Goodenia heterophylla*
Haloragaceae		*Gonocarpus tetragynus*
Iridaceae		*Patersonia glabrata*
Iridaceae		*Patersonia sericea*
Juncaceae	*	*Juncus cognatus*
Juncaceae		*Juncus continuus*
Juncaceae	*	*Juncus effusus*
Juncaceae		*Juncus subsecundus*
Lauraceae		*Cassytha glabella*
Lindsaeaceae		*Lindsaea linearis*
Lindsaeaceae		*Lindsaea microphylla*
Lobeliaceae		*Pratia purpurascens*
Loganiaceae		*Logania pusilla*
Loganiaceae		*Mitrasacme pilosa*
Lomandraceae		*Lomandra brevis*
Lomandraceae		*Lomandra cylindrica*
Lomandraceae		*Lomandra filiformis subsp. coriacea*
Lomandraceae		*Lomandra glauca*
Lomandraceae		*Lomandra gracilis*
Lomandraceae		*Lomandra longifolia*
Lomandraceae		*Lomandra multiflora*
Lomandraceae		*Lomandra obliqua*
Myrsinaceae	*	*Anagallis arvensis*
Myrtaceae		*Angophora costata*
Myrtaceae		*Angophora floribunda*
Myrtaceae		*Angophora hispida*
Myrtaceae		*Backea* sp.
Myrtaceae		*Callistemon citrinus*
Myrtaceae		*Callistemon linearis*
Myrtaceae		*Calytrix tetragona*
Myrtaceae		*Corymbia gummifera*
Myrtaceae		*Eucalyptus beyeriana*
Myrtaceae		*Eucalyptus camfieldii*
Myrtaceae		*Eucalyptus capitellata*

Family	Exotic	Scientific Name
Myrtaceae		*Eucalyptus consideniana*
Myrtaceae		*Eucalyptus eugenioides*
Myrtaceae		*Eucalyptus fibrosa*
Myrtaceae		*Eucalyptus globoidea*
Myrtaceae		*Eucalyptus haemastoma*
Myrtaceae		*Eucalyptus oblonga*
Myrtaceae		*Eucalyptus piperita*
Myrtaceae		*Eucalyptus punctata*
Myrtaceae		*Eucalyptus resinifera*
Myrtaceae		*Eucalyptus saligna* X *botryoides (hybrid)*
Myrtaceae		*Eucalyptus squamosa*
Myrtaceae		*Euryomyrtus ramosissima*
Myrtaceae		*Kunzea ambigua*
Myrtaceae		*Kunzea capitata*
Myrtaceae		*Leptospermum trinervium*
Myrtaceae		*Leptospermum arachnoides*
Myrtaceae		*Leptospermum polygalifolium*
Myrtaceae		*Melaleuca deanei*
Myrtaceae		*Melaleuca linariifolia*
Myrtaceae		*Syncarpia glomulifera*
Orchidaceae		*Corybas* sp.
Orchidaceae		*Dipodium punctatum*
Orchidaceae		*Microtis unifolia*
Orchidaceae		*Orchidaceae* sp.
Orchidaceae		*Thelymitra* sp.
Oxalidaceae		*Oxalis exilis*
Phormiaceae		*Dianella caerulea*
Phormiaceae		*Dianella longifolia*
Phormiaceae		*Dianella prunina*
Phyllanthaceae		*Phyllanthus hirtellus*
Phyllanthaceae		*Poranthera microphylla*
Picrodendraceae		*Micrantheum ericoides*
Pittosporaceae		*Billardiera scandens*
Poaceae	*	*Briza maxima*
Poaceae	*	*Briza minor*
Poaceae	*	*Briza subaristata*
Poaceae	*	*Setaria italica*
Poaceae	*	*Cynodon dactylon*
Poaceae	*	*Dichelachne micrantha*
Poaceae	*	*Eragrostis curvula*
Poaceae	*	*Imperata cylindrica*
Poaceae	*	*Cortaderia selloana*
Poaceae	*	*Polypogon lutosus*
Poaceae	*	*Vulpia bromoides*
Poaceae		*Anisopogon avenaceus*
Poaceae		*Lachnagrostis aemula*
Poaceae		*Aristida vagans*
Poaceae		*Austrodanthonia tenuior*
Poaceae		*Austrostipa pubescens*

Family	Exotic	Scientific Name
Poaceae		*Cynodon dactylon*
Poaceae		*Dichelachne rara*
Poaceae		*Dichelachne inaequiglumis*
Poaceae		*Entolasia marginata*
Poaceae		*Entolasia stricta*
Poaceae		*Eragrostis brownii*
Poaceae		*Microlaena stipoides*
Poaceae		*Poa affinis*
Poaceae		*Poa sieberiana*
Poaceae		*Tetrarrhena juncea*
Poaceae		*Themeda australis*
Polygonaceae	*	*Acetosa sagittata*
Proteaceae		*Conospermum longifolium subsp. angustifolium*
Proteaceae		*Grevillea phylicoides*
Proteaceae		*Grevillea sericea*
Proteaceae		*Grevillea sphacelata*
Proteaceae		*Hakea gibbosa*
Proteaceae		*Hakea laevipes*
Proteaceae		*Hakea sericea*
Proteaceae		*Isopogon anemonifolius*
Proteaceae		*Lambertia formosa*
Proteaceae		*Lomatia silaifolia*
Proteaceae		*Persoonia levis*
Proteaceae		*Persoonia lanceolata*
Proteaceae		*Persoonia linearis*
Proteaceae		*Petrophile pulchella*
Proteaceae		*Petrophile sessilis*
Proteaceae		*Symphionema paludosum*
Proteaceae		*Xylomelum pyriforme*
Restionaceae		*Hypolaena fastigiata*
Restionaceae		*Lepyrodia muelleri*
Rhamnaceae		*Cryptandra amara*
Rubiaceae		*Opercularia diphylla*
Rutaceae		*Boronia ledifolia*
Rutaceae		*Eriostemon australasius*
Santalaceae		*Exocarpos cupressiformis*
Schizaeaceae		*Schizaea dichotoma*
Scrophulariaceae		*Veronica plebeia*
Smilacaceae		*Smilax glyciphylla*
Solanaceae	*	*Solanum chenopodioides*
Stackhousiaceae		*Stackhousia nuda*
Sterculiaceae		*Lasiopetalum rufum*
Sterculiaceae		*Rulingia ?dasyphylla*
Stylidiaceae		*Stylidium graminifolium*
Stylidiaceae		*Stylidium lineare*
Thymelaeaceae		*Pimelea linifolia*
Verbenaceae	*	*Lantana camara*
Violaceae		*Hybanthus monopetalus*
Xanthorrhoeaceae		*Xanthorrhoea arborea*

Family	Exotic	Scientific Name
Xanthorrhoeaceae		*Xanthorrhoea concava*
Xanthorrhoeaceae		*Xanthorrhoea resinosa*
Zamiaceae		*Macrozamia spiralis*

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Appendix F Aquatic Ecosystem Investigation

SITA Australia Pty Ltd

Lucas Heights Resource Recovery Park
Aquatic Ecosystem Investigation

July 2015

Executive summary

GHD Pty Ltd (GHD) was commissioned to conduct one round of aquatic ecosystem monitoring within Mill Creek, adjacent to and downstream of the SITA Australia Pty Ltd (SITA) Lucas Heights Resource Recovery Park (LHRRP). The principal aims of this project were to establish:

- The presence and condition of aquatic and riparian[1] habitat currently existing within Mill Creek
- The presence and condition of aquatic marcoinvertebrate[2] communities currently existing within Mill Creek

This report presents the monitoring data collected and assessed during this project and provides commentary on its implications. This report is subject to, and must be read in conjunction with, the limitations, assumptions and qualifications contained throughout the report.

This project consisted of the selection and subsequent field sampling / assessment of five monitoring locations present along Mill Creek (one upstream (MCUP, four downstream of the LHRRP – MC1, MC2, MC3 and MC4) for:

- Basic water quality parameters
- Aquatic macroinvertebrates
- Aquatic and riparian habitat condition

Following the completion of these fieldworks, the aquatic macroinvertebrate samples obtained during the fieldwork were identified in a laboratory using a microscope. Following identification of macroinvertebrates, a variety of data analyses were carried out. These analyses provide indices allowing for a broad assessment of the condition or “health” of sites and allow comparison between sites based upon community structure and defined habitat characteristics.

All sites downstream of the LHRRP assessed for the aquatic ecosystem investigation had a mostly natural and continuous riparian vegetation zone with the community almost completely dominated by native species. A healthy mix of ground cover, shrub layer and over story trees was present at all sites. The geomorphic nature of the sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. Habitat condition was generally good, although disturbance to the ground surface associated with recreational vehicle activities was observed at MC3, leading to increased levels of sediment deposition near this site.

A relatively high number of macroinvertebrate taxa were identified across the monitored locations suggesting that physical conditions are sufficient to support diverse macroinvertebrate life. Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present.

Based on the results of the field survey and data analysis, the following conclusions are made:

- Results of the *in situ* water quality monitoring suggested that dissolved oxygen was slightly below the ANZECC assessment criteria at the majority of the monitoring locations. Electrical conductivity and pH were within the recommended ranges. The LHRRP and off-site recreational vehicle users may be having some minor impacts on Mill Creek in

[1] Riparian refers to the narrow strips of land that immediately border creeks, rivers or other watercourses.
[2] Macroinvertebrates are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate).

relation to turbidity values, although turbidity may have been affected by a recent rainfall event.

- Habitat was found to be generally in good condition. The LHRRP may be having some minor impacts on Mill Creek in relatively close proximity to the LHRRP (MC1), as condition here is lower than at the upstream site. Habitat condition improves at MC2. A decline at MC3 is likely to be the result of disturbance caused by recreational vehicle users. Aquatic and riparian habitat at MC 4 (located furthest from the LHRRP) was in a reasonably pristine condition. The recovery of habitat condition at this monitoring location suggests that any impacts of the LHRRP are spatially limited and that the natural condition of the surrounding catchment downstream will ensure minimal impacts to the Georges River receiving environment.
- Macroinvertebrate communities present at the monitoring locations were generally in a healthy condition. Communities were dominated by pollution tolerant taxa, although some sensitive taxa were present. Recent studies of urban streams in the Georges River catchment found few or no pollution-sensitive taxa, suggesting that Mill Creek is one of the better condition streams in the area. Key drivers of losses in taxonomic diversity in Mill Creek are currently unclear and are spatially limited and which may be linked to off-site activities in certain locations (such as recreational vehicle use).
- The proposal should result in a lower potential for impacts on the Mill Creek aquatic environment due to the proposed reprofiling of the site, increasing over time the capped and revegetated areas and via a number of best practice operational controls documented in the OEMPs.
- Further investigation of the habitat condition and macroinvertebrate populations is recommended to confirm the preliminary findings contained within this report. It is recommended that this work be undertaken every three years commencing soon after reprofiling works commence in Area E.

It is noted that River Health Monitoring Program monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates (refer Section 6.6) and that their findings reinforce the conclusions of this report. That is, any impacts of the LHRRP on Mill Creek are spatially limited as further downstream the health of Mill Creek was found to be in an excellent condition.

Glossary

Term	Definition
ANSTO	Australian Nuclear Science and Technology Organisation
AHD	Australian Height Datum; A geodetic datum for altitude measurement in Australia
ARRT facility	Advanced Resource Recovery Technology facility
Assessment criteria	Defined criteria against which physical and biological features of the aquatic ecosystem can be assessed
AUSRIVAS	(Australian River Assessment System) A rapid biological assessment system for streams and rivers that generates region-specific predictions of the invertebrate fauna expected to be present in the absence of environmental stress. Predicted or expected fauna are obtained from modelling data collected from a number of reference sites. The predicted fauna are then compared to the observed fauna lists and the resulting ratio is used to indicate the extent of the anthropogenic impact.
Bankfull width	The width of the channel at the top of the stream banks where subsequent increase in flow results in overflow onto a floodplain
Canopy	The upper layer or habitat zone of a vegetation community, predominantly formed by mature tree crowns but may include other biological organisms.
Class	A taxonomic rank in biological classification, class (Latin: classis). Other well-known ranks are life, domain, kingdom, phylum, order, family, genus, and species, with class fitting between phylum and order. As for the other well-known ranks, there is the option of an immediately lower rank, indicated by the prefix sub-: subclass (Latin: subclassis).
EIS	Environmental Impact Statement
EPA	New South Wales Environment Protection Authority and any successor body
Family	In biological classification, a family (Latin: familia, plural familiae) is a taxonomic rank between order and genus. A family may be divided into one or more subfamiles, intermediate ranks above the rank of genus.
Fauna	Animals especially the animals of a particular country region or time considered as a group or community
Geomorphology	Geomorphology is the scientific study of landscape features created by physical or chemical processes operating at or near the earth's surface. In a riverine setting geomorphology is focused on the shape and structure of the active river channel.
GHD	Gutteridge, Haskins and Davey. Gordon Gutteridge founded the company in 1928 and Gerald Haskins and Geoffrey Davey joined the partnership in 1939.
GO facility	The Garden Organics facility at LHRRP, that undertakes composting of waste including green and garden waste, but excluding waste types such as food waste and biosolids
In situ	A Latin phrase that translates literally to "on site" or "in position". It means "locally", "on site", "on the premises" or "in place" to describe an event where it takes place.
LHRRP	Lucas Heights Resource Recovery Park
Littoral zone	Shallow shoreline area of a body of water; often considered the portion of benthos from zero depth to the deepest extent of rooted plants
Macroinvertebrate	Larger invertebrates (i.e. without backbones) functionally defined as those retained on a 250 µm sieve; their body usually exceeds 1 mm and they are generally observable with the naked eye; includes insects arachnids crustaceans molluscs and annelids.

Term	Definition
Macrophyte	An aquatic plant that is visible to the naked eye but not including filamentous algae mosses or liverworts
Morphology	From the Greek and meaning "study of shape".
Order	In biological classification, the order (Latin: ordo) is a taxonomic rank used in the classification of organisms and recognized by the nomenclature codes. Other well-known ranks are life, domain, kingdom, phylum, class, family, genus, and species, with order fitting in between class and family. An immediately higher rank, superorder, may be added directly above order, while suborder would be a lower rank.
Reach	An expanse of stream or river under study; for standard Victorian rapid bioassessment purposes reach is defined as ten times the average stream width from a minimum of 50 m to a maximum of 150 m however reaches under other programs such the Sustainable Rivers Audit (SRA) and Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) may be defined as much longer than this
Riffle	A rapidly flowing portion of a river or stream where the influence of the bottom can be seen at the surface; a stretch of choppy water in a stream or river caused by shallow fast flows over rocks a shoal or a sandbar; a rapid
Riparian	Relating to or located on the banks of a river or stream; especially in terms of vegetation interacting with the stream
SITA	SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term ‘SITA’ is used to refer to all of these organisations in this report.
Subfamily	In biological classification, a subfamily (Latin: subfamilia, plural subfamiliae) is an auxiliary (intermediate) taxonomic rank, next below family but more inclusive than genus. Standard nomenclature rules end subfamily botanical names with "-oideae", and zoological names with "-inae".
Taxa	Plural of taxon
Taxon	A taxonomic category or group such as a phylum order family genus or species (plural is taxa); the named classification unit to which individuals or sets of species are assigned
Taxonomic	Pertaining to or involving taxonomy or the laws and principles of arranging species or groups into a system exhibiting their relationship to each other and their places in a natural classification

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1. Introduction

1.1 Overview

SITA Australia (SITA)[3] is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP) in Lucas Heights. SITA engaged GHD Pty Ltd (GHD) to prepare an Environmental Impact Statement (EIS) for a proposed expansion to current waste management operations at the LHRRP.

As part of the preparation of the EIS, GHD was retained to undertake a number of specialist studies, including a surface water impact assessment (assessment). To support this assessment, GHD was also retained to undertake one round of aquatic ecosystem monitoring within Mill Creek (a watercourse which rises within and runs through the LHRRP). The principal aims of this investigation were to establish:

- The presence and condition of aquatic and riparian habitat currently existing within Mill Creek
- The presence and condition of aquatic macroinvertebrate communities currently existing within Mill Creek

This report summarises the works completed during this investigation.

1.2 Purpose of this report

The purpose of this report is to document:

- Relevant site information
- The field and laboratory works completed and the monitoring data obtained
- The assessment of the monitoring data
- The conclusions made in relation to the works completed

1.3 Scope of works

GHD undertook the following scope of works:

- Selection and subsequent field sampling and assessment of five monitoring locations along Mill Creek for:
  - Basic water quality parameters
  - Habitat condition
  - Aquatic macroinvertebrate communities
- Identification of aquatic macroinvertebrate samples taken in the field at GHD's laboratory using a microscope
- Selection of appropriate assessment criteria and subsequent assessment of gathered data against these criteria (as relevant, habitat condition assessments generally performed in the field but also referenced against site photographs)

[3] SembSITA Australia Pty Ltd (SembSITA) is the holding company for the SITA Australia (SITA) group of companies in Australia. SembSITA is the parent company of both SITA and WSN Environmental Solutions Pty Ltd (WSN). WSN owns part of the land on which the LHRRP is situated, and leases the remainder from ANSTO. SITA holds the environmental protection licence (EPL), and so is the operator of the facilities at LHRRP. For simplicity, the term 'SITA' is used to refer to all of these organisations in this report.

- Documentation of the works undertaken, the monitoring data obtained and GHD's conclusions and recommendations in a report (i.e. this report)

1.4 Assumptions

During preparation of this report, GHD has made a number of assumptions as identified through the text of this report. These assumptions include (but are not limited to) the following:

- SITA understands that water quality, habitat condition and macroinvertebrate populations are influenced by a number of factors and can vary significantly with both time and space
- SITA understands that this report presents the data and findings from one discrete monitoring round, the results of which may have been influenced by a number of factors including:
  - A significant rainfall event that occurred in the 24 hours prior to the fieldworks commencing
  - The time at which the fieldworks were undertaken[4]
  - The monitoring locations selected
- SITA understands that further works are required to confirm the ongoing ecological conditions within Mill Creek.

1.5 Reliance

The following documents were relied upon in the development of this report:

- ANZECC (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra (ANZECC (2000)
- Brycroft B.M., Coller B.A.W., Deacon G.B., Coleman D.J. and Lake P.S., (1982), Mercury contamination of the Lerderderg River, Victoria, Australia, from abandoned gold field, Environmental Pollution Series A, 28, 135-147
- Chessman B. (1995) Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index, Australian Journal of Ecology 20:122–129
- Chessman B., Growns J.E. and Kotlash A.R. (1997). Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, NSW. Marine and Freshwater Research. 48:159-172
- Chessman B. (2003) New sensitivity grades for Australian river macroinvertebrates. Marine and Freshwater Research, 54: 95-104.
- Chessman B., Williams S. and Besley C. (2007) Bioassessment of streams with macroinvertebrates: effect of sampled habitat and taxonomic resolution. Journal of The North American Benthological Society, 26(3):546–565
- Department of Natural Resources Queensland (2001) Queensland Australian River Assessment System (AUSRIVAS), Sampling and Processing Manual, August 2001. The State of Queensland, Department of Natural Resources 2001 (DNR 2001)

[4] The macroinvertebrate sampling exercise occurred within two weeks of (but still outside) the recommended autumn (March 15 to June 15) or spring (September 15 to December 15) sampling periods as per the AUSRIVAS macroinvertebrate sampling methodology for NSW (Turak et al., 2004)

- Dudka S. and Adriano D.C. (1997) Environmental impacts of metal ore mining and processing: a review. Journal of Environmental Quality, 26, 590-602.
- Faith D.P., Dostine P.L., and Humphrey D.P. (1995) Detection of mining impacts on aquatic macroinvertebrate communities: results of a disturbance experiment and the design of a multivariate BACIP monitoring programme at Coronation Hill, Northern Territory. Australian Journal of Ecology, 20, pp 167-180.
- García-Criado F., Tomé A., Vega F.J. and Antolín C. (1999) Performance of some diversity and biotic indices in rivers affected by coal mining in northwestern Spain . Hydrobiologia, 394, pp 209-217.
- ISO (1983). Water Quality: Methods of Biological Sampling - Handnet Sampling of Aquatic Benthic Macroinvertebrates. Draft ISO International Standard.
- Norris R.H., Lake P.S. and Swain R. (1982) Ecological effects of mine effluents on the South Esk River, north-eastern Tasmania. III. Benthic macroinvertebrates, Australian Journal of Marine and Freshwater Research, 32, 165-173.
- Petersen, R. C. (1992). The RCE: a Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. Freshwater Biology, 27, 295-306.
- Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA) and Bureau of Meteorology (BOM) (2014), SILO weather data (http://www.longpaddock.qld.gov.au/silo) accessed 10 June 2014.
- Tippler C., Hanlon A. and Birtles P. (2014) 2013 – 2014 River Health: Georges River Report Card. Georges River Combined Councils Committee Inc.
- Turak E., Waddell N. and Johnstone G. (2004) New South Wales (NSW) Australian River Assessment System (AUSRIVAS) Sampling and Processing Manual 2004. http://ausrivas.ewater.com.au/ausrivas/index.php/manuals-a-datasheets?id=55

1.6 Limitations

This report has been prepared by GHD for SITA Australia Pty Ltd and may only be used and relied on by SITA Australia Pty Ltd for the purpose agreed between GHD and SITA Australia Pty Ltd as set out in Section 1.2 of this report

GHD otherwise disclaims responsibility to any person other than SITA Australia Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at, or in connection with, specific sample points, and on conditions encountered and information reviewed at the date of preparation of the report. Conditions at or adjacent to other parts of the LHRRP may be different from the conditions encountered at the specific sample points. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that this report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report. GHD disclaims liability arising from any of the assumptions being incorrect.

Investigations undertaken in respect of this report are constrained by the particular site conditions. As a result, not all relevant site features and conditions may have been identified in this report. Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Background information

2.1 LHRPP and Mill Creek locations

The LHRRP is located to the north of the intersection of New Illawarra Road and Heathcote Road in Lucas Height, New South Wales. Mill Creek rises in the south-western corner of the LHRRP, runs along the western boundary of the LHRRP and ultimately discharges into the Georges River.

The locations of the LHRRP and Mill Creek are shown on Figure 2.1 below.

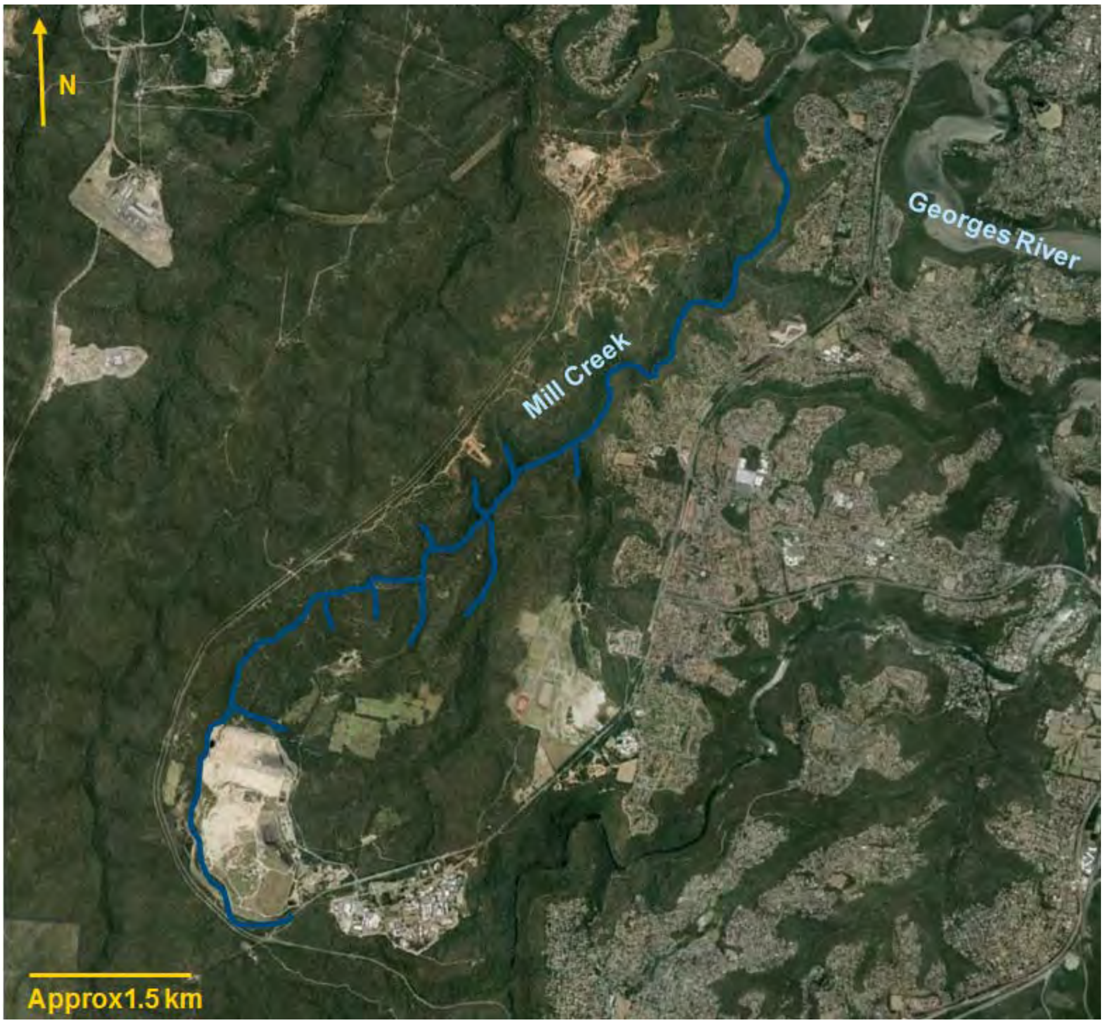


Figure 2.1 Locations of the LHRRP and Mill Creek

2.2 Hydrology

Clean stormwater run-off from the revegetated areas of the LHRRP is shed via sheet flow across the LHRRP's surface towards the perimeter of the LHRRP. Surface water in contact with daily and intermediate cover is diverted to sediment and erosion control measures before this water is released from the site. From there, this water drains off-site into northerly flowing local surface watercourses to the west and east of the LHRRP (including Mill Creek and Bardens Creek). All of these off-site watercourses ultimately drain northwards into the Georges River.

Stormwater run-off that may contain sediment is collected via a series of drains, swales and ponds and directed to the main sediment dam located in the northwestern part of the LHRRP. This dam is designed to allow for settlement of suspended solids before discharging offsite following large rainfall events when stormwater dam has reached its design capacity or via the stormwater treatment plant (following its treatment). These discharged waters flow into Mill Creek.

As shown on Figure 1, Mill Creek originates within the LHRRP and flows northwards along the western boundary of the LHRPP towards the Georges River. Mill Creek drains the majority of stormwater run-off from the LHRRP.

Mill Creek is a perennial water courses. As such, typically it would be expected that base flow for this watercourse would be derived from local groundwater. However, existing groundwater level data for the LHRRP suggests that Mill Creek is only partially recharged by groundwater in the vicinity of the LHRRP with the majority of its flow "fed" by surface water run-off.

2.3 Local climate / meteorology

Review of data from Bureau of Meteorology (BOM, 2014) and data from the Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA, 2014) suggests that a warm temperate climate with strong maritime influence is experienced in the Lucas Heights area. Mean daily temperatures range from 26.0 ^{0}C to 17.0 ^{0}C in February and from 15.8 ^{0}C to 6.6 ^{0}C in July. Frost is not experienced in this area.

Seasonal variations occur in rainfall with a greater proportion being received during summer months. A generally even rainfall distribution is experienced over the region with a mean annual rainfall of 1015 millimetres (mm).

Recent climatic / meteorological conditions are a key consideration in relation to the data obtained during aquatic ecological monitoring as they have the potential to significantly affect:

- The water quality encountered within watercourses
- The presence and condition of aquatic macroinvertebrate communities encountered within watercourses
- The presence and condition of aquatic habitat encountered within watercourses

Section 3 provides information on the sampling and analysis program developed and applied during this project.

3. Sampling and analysis program

3.1 Overview

The sampling and analysis program adopted during this monitoring round consisted of undertaking environmental monitoring at five selected monitoring locations along Mill Creek on 2 March 2015. These works included both fieldworks and subsequent laboratory based works.

The environmental monitoring undertaken at the five monitoring locations consisted of the following:

- Monitoring basic water quality parameters with portable instrumentation
- Visual assessment of habitat condition
- Sampling (and subsequent laboratory identification) of aquatic macroinvertebrate populations

Additional information on the selected monitoring locations and associated monitoring parameters are contained in the following sections.

3.1.1 Environmental monitoring locations

The monitoring locations selected for environmental monitoring are shown on Figure 3.1.

Further details on these monitoring locations are provided in Table 3.1 below.

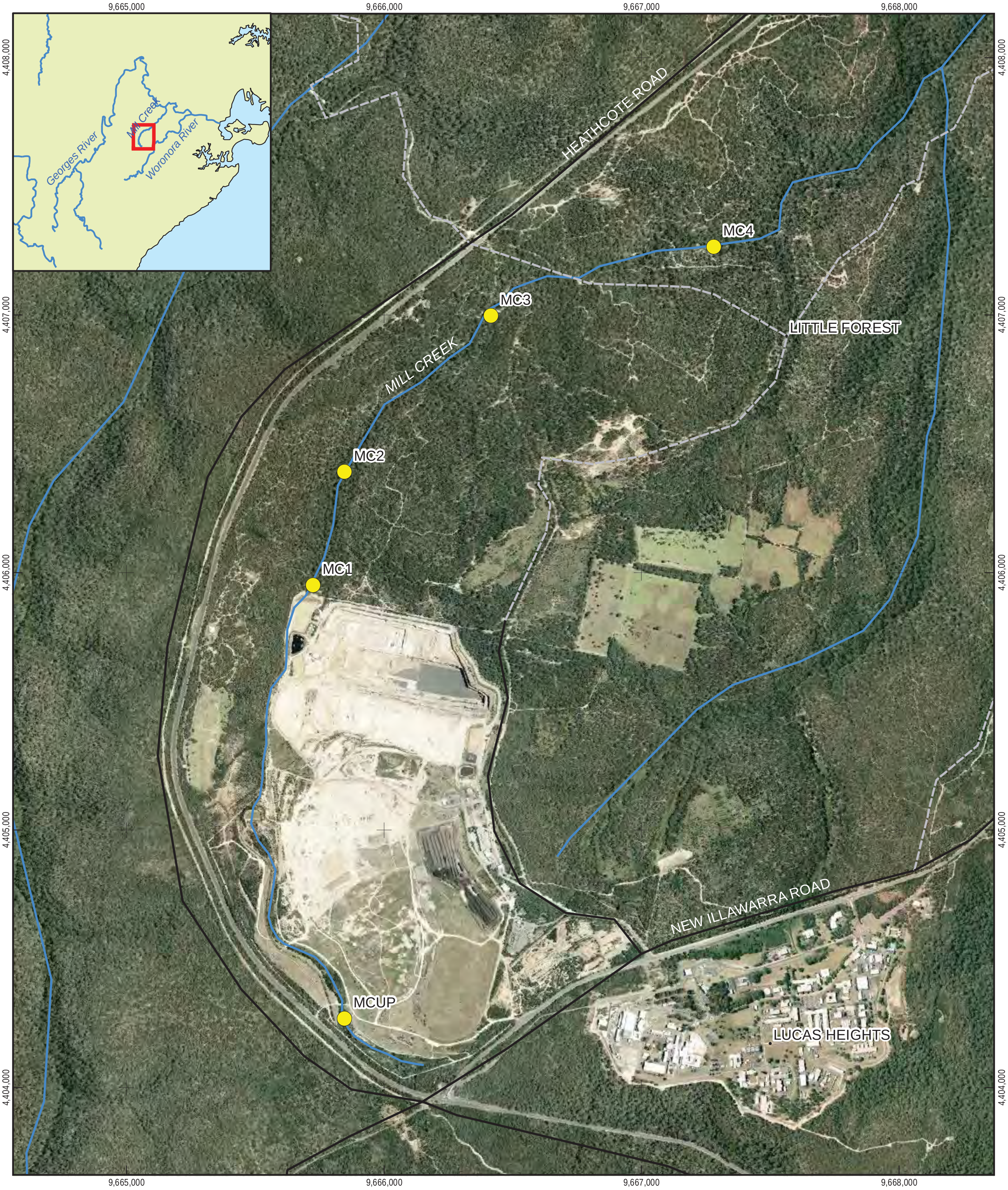
Table 3.1 Location details of environmental monitoring locations

Site code	Site name and location	Latitude	Longitude	Altitude (m AHD)
MCUP	Mill Creek Upstream of Duck Pond	-34.05119	150.96673	175
MC1	Mill Creek Immediately downstream of SITA Lucas Heights	-34.03606	150.96473	105
MC2	Mill Creek Adjacent to MTB track	-34.03205	150.96586	100
MC3	Mill Creek End of Little Forest Rd access track	-34.02638	150.97178	100
MC4	Mill Creek Downstream	-34.02367	150.98104	80

The monitoring locations shown on Figure 3.1 and in Table 3.1 were selected during a field inspection undertaken on 22 January 2015, These locations were selected by GHD with consideration of the need to have an adequate spatial distribution along Mill Creek, the need to have both upstream and downstream monitoring locations (of the LHRRP) and access limitations.

3.2 Environmental monitoring parameters

The environmental monitoring undertaken consisted of monitoring appropriate physical, chemical and biological parameters within Mill Creek at the identified monitoring locations. Further details on the precise parameters monitored are provided in the Section 4.



LEGEND

Aquatic Ecosystem Sampling Site

Waterway

Road

Track

Paper Size A4

0 100 200 300 400 500

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

SITA Support Services
Lucas Heights Landfill

Aquatic Ecosystem
Sampling Sites

Job Number	2120508
Revision	A
Date	09 Mar 2015

Figure 3.1

Level 6, 20 Smith Street Parramatta NSW 2150 Australia **T** 612 8898 8800 **F** 61 2 8898 8810 **E** parramail@ghd.com **W** www.ghd.com

H:\Projects\NSW\Lucas Heights\GIS\Z001_SITA_LucasHeights_AESites_DRAFT.mxd

Data source: GHD, SITA/ProposedAEMonitoringSites Jan2015, Geoscience Australia/SYDNEY Region 100K/I5605 Sydeny.mdb, Google/Sinclair Knight Merz Created by:atdickson

4. Environmental monitoring

4.1 Overview

GHD undertook the environmental monitoring work in accordance with the sampling and analysis program developed for this project. This consisted of:

- Fieldworks to inspect the monitoring locations, undertake in situ water quality monitoring, identify the condition and presence of aquatic and riparian habitat and to sample aquatic macroinvertebrates for subsequent visual identification at GHD's laboratory
- Laboratory works to visually identify macroinvertebrates contained within the samples taken in the field

These works were completed by a professionally qualified and experienced aquatic biologist (Mr. Adrian Dickson of GHD).

The following sections present further information on the fieldwork and laboratory works undertaken as part of this project.

4.2 Fieldworks

4.2.1 Overview

The fieldwork aspects of the investigation were undertaken on 2 March 2015. The fieldworks included:

- Monitoring basic water quality parameters with portable instrumentation
- Visual assessment of habitat condition
- Sampling of macroinvertebrates

Monitoring data obtained during these fieldworks was captured electronically in the field into a Microsoft Access database. The data fields recorded in the specialised database were created with consideration and guidance of field data sheets used for the First National Assessment of River Health (FNARH) and the NSW, QLD and ACT AUSRIVAS Manuals (Turak *et al*., 2004; DNRM, 2001; Nicholls *et al.*, 2000). These documents are widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystems.

4.2.2 In situ water quality

The following in situ water quality parameters were measured just below the water surface adjacent to the stream bank at each of the monitoring locations;

- Temperature (°C)
- pH
- Electrical Conductivity (µS/cm)
- Dissolved Oxygen (mg/L and % saturation)
- Turbidity (NTU)
- Alkalinity (mg/L $CaCO_3$)

Temperature, pH, electrical conductivity, and dissolved oxygen were measured using a YSI 600QS multi-parameter water quality meter. Turbidity was measured in the field using a Hach 2100 Turbidimeter. Both meters were calibrated in accordance with GHD's Quality System requirements and the manufacturer's specifications prior to its use in the field. Alkalinity was measured in the field using a Hach Digital Alkalinity Titration kit. This is a hand held titration kit that is factory set and does not require calibration.

4.2.3 Habitat condition

Assessment of habitat condition is performed in association with water quality and macroinvertebrate sampling as it provides supporting evidence of the site condition and aids in the interpretation of water quality and macroinvertebrate community data.

Visual assessment of the habitat condition at each of the monitoring locations was undertaken. This included recording certain data and completing in-field assessments of habitat condition using several assessment techniques widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystem condition. The habitat condition works included recording andassessment of the following:

- Site location information and photographs
- Visual assessment of geomorphology and Riparian[5] vegetation
- Assessment of disturbances related to human activities (as per NSW AUSRIVAS; Turak *et al.*, 2004)
- Assessment of Modified RCE; Riparian, Channel and Environmental inventory (as per Chessman *et al.,* 1997)
- Assessment against reference condition selection criteria (as per DNR, 2001)

Further information on the four assessment techniques identified above is provided in Section 5.

4.2.4 Macroinvertebrate sampling

Field sampling of marcoinvertebrates was undertaken at each of the monitoring locations using Rapid Bioassessment (RBA) protocols in accordance with the NSW AUSRIVAS[6] Sampling and Processing Manual (Turak *et al.*, 2004).

RBA sampling was conducted using a standard ISO 7828 (1983) design sweep-net with 250 µm mesh. This net was washed thoroughly between sampling events to remove any material retained on it.

At each monitoring location, the littoral or edge habitat was sampled by sweeping the sweep-net along the edge of Mill Creek in areas of little or no current. The net was swept around overhanging terrestrial vegetation, against snags if present, in backwaters, and through beds of macrophytes[7] if present. This process was continued, working upstream against the flow, with the sample covering approximately 10 m of edge. Sampling considered both banks where possible and the quantity of habitat types sampled was approximately proportional, and representative of the quantity of habitat types present at the site.

For each RBA sample taken (one per monitoring location), the collected material was placed into a sorting tray and macroinvertebrates were picked for a minimum of 40 minutes using forceps and pipettes. If new taxa[8] were visually identified between 30 and 40 minutes of sorting, sorting continued for a further 10 minutes. The processing cycle was continued up to a total maximum sorting time of 1 hour.

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[5] Riparian refers to the narrow strips of land that immediately border creeks, rivers or other watercourses.

[6] The AUSRIVAS program is a nationally recognised, standardised sampling protocol used to assess the health of Australian Rivers and developed for Australia’s National River Health Program (NRHP)

[7] A macrophyte is an aquatic plant that grows in or near water and is either emergent, submergent, or floating

[8] Taxa (plural) refers to a group of one or more populations of an organism or organisms seen by taxonomists to form a unit.

The objective of the RBA sorting protocol is to obtain a sample containing as diverse a fauna as possible (and hence provide a useful measure of taxa richness). Attempts were made by GHD to avoid bias towards abundant taxa and to collect all taxa present in the sample, including rare or cryptic animals. Samples were preserved in 70% ethanol and clearly labelled with information including site, habitat, sampling method, date and sampler.

These samples were transported back to GHD's laboratory in Canberra for subsequent macroinvertebrate identification (see following section).

4.3 Laboratory works

Macroinvertebrates contained within the samples were examined using a microscope with a zoom capability between 6 and 50x. Macroinvertebrates present were identified using published taxonomic keys, unpublished working keys and an extensive specimen reference collection maintained by GHD following protocols identified in Hawking (2000).

Most macroinvertebrates present within the samples were identified to Family level[9] with the following exceptions:

- The larvae of flies of the non-biting midges (Chironomidae - Diptera) were identified to sub-family (e.g. Orthocladiinae, Chironominae, and Tanypodinae)
- Groups such as round worms (Nematoda), segmented worms (Oligochaeta) and mites (Acarina) were identified to class or order level
- The Microcrustaceans including seed shrimp (Ostracoda), water fleas (Cladocera) and copepods (Copepoda) were identified to the Order level.

Upon completion of identification, all samples were returned to 100% ethanol for long-term archiving. This process allows samples to be re-examined at a later date if required.

Following completion of the laboratory works, GHD developed a basis for the assessment of certain relevant monitoring data that had not already been assessed during the fieldworks. Further detail on the basis for assessment developed for all relevant monitoring data is provided in the Section 5.

[9] Following standard conventions of the NSW AUSRIVAS sampling and processing manual (Turak *et al.*, 2004).

5. Basis for data assessment

5.1 Overview

In order to adequately assess environmental monitoring data, appropriate assessment criteria must be selected and applied. These assessment criteria must be selected with consideration of potential receptors and their associated sensitivities.

Further information on the assessment criteria that have been selected for the purposes of assessing the monitoring data obtained during this project is provided in the following sections.

5.2 Potential receptors

The following receptors were identified for waterborne contamination potentially entering Mill Creek:

- Local surface water quality within Mill Creek
- Macroinvertebrates living within Mill Creek
- Habitat / plants within Mill Creek

5.3 Nominated assessment criteria

GHD identified and selected a number of relevant reference documents containing appropriate assessment criteria for application against the environmental monitoring data obtained during this project. Further details on these reference documents and associated assessment criteria are contained in the following sections.

5.3.1 Water quality

The ANZECC (2000) assessment criteria for slightly disturbed aquatic ecosystems of south-east Australia has been selected for application in the assessment of the water quality data obtained. In accordance with ANZECC (2000):

- Monitoring locations MC1 to MC4 (which are all below an altitude of 150 metres) have been assessed against the assessment criteria for a lowland river
- Monitoring location MCUP (which is above 150 metres in altitude but less than 1500 metres) has been assessed against the assessment criteria for an upland river

Table 5.1 below identifies the relevant assessment criteria applied to the data obtained during this investigation.

Table 5.1 ANZECC (2000) assessment criteria applied

Eco-type	Temp. (°C)	EC (µS/cm)	pH	DO (%sat)	DO (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)
Upland river	N/A	30-350	6.5-8.0	90-110	N/A	2 - 25	N/A
Lowland river	N/A	125-2200	6.5-8.0	85-110	N/A	6 - 50	N/A

Notes: N/A = not applicable

5.3.2 Habitat condition

Habitat condition was assessed in-field using several assessment techniques widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystem condition. These assessment techniques were as follows:

- Visual assessment
- NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities
- Modified Riparian, Channel and Environmental (RCE) inventory
- Reference condition selection criteria

Descriptions of these assessment techniques applied in-field are provided below.

Visual assessment

Descriptions of aquatic habitat were based on visual estimates of characteristics such as streambed composition (percentage of total composition for each substrate category), aquatic and riparian vegetation cover, amount of in stream organic material, and area of aquatic habitat and canopy cover. Estimates of channel morphology characteristics were made including stream width (wetted width in meters), bank full width (mean width between top of banks), and estimated depth.

Stream reach geomorphology and habitat descriptions were documented as per the NSW AUSRIVAS Sampling and Processing Manual (Turak *et al*, 2004), and include a whole of reach (at least 100 m section of the waterway) assessment, the presence of different instream habitat types, and the structure and condition of riparian vegetation. The information recorded was used to describe the nature of aquatic habitats present within Mill Creek, and identify any areas of potential habitat for threatened aquatic macroinvertebrates.

NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities

This assessment is aimed at summarising evidence available at the site of alteration caused by human activities to different components of the stream ecosystem. Some evidence is objective, easy to identify and valid for all stream types. Other evidence, however, may be specific to the type of river in question and harder to identify. The assessor is required to use knowledge of streams in the nearby area and decide how much this site has changed as a result of human activities.

There are four assessment categories including water quality, instream, riparian zone and catchment. Examples of the types of impacts that should be considered when assessing this are provided below;

- Water Quality - odour, water clarity, disruption of the natural hydrology, presence of foam from detergents, oil
- Instream - change in substrate e.g. rock piles or sedimentation from road construction or other development pipes, rubbish, filamentous algae, alien fish species, invasion by exotic aquatic plants
- Riparian Zone - devegetation, exotic plant invasion, bank degradation, point sources.
- Catchment Assessment - mine, sewage treatment plant, landfill, dam, industry, logging, agriculture, clearing, salinity, grazing, urban development

A ranking is given for each category which has an associated description as provided in

Table 5.2 below.

Table 5.2 NSW AUSRIVAS visual assessment ranking categories

Ranking	Description	Total Visual Assessment Score
0	No evidence of disturbance	0-2
1	Little disturbance	3-5
2	Moderate disturbance	6-8
3	High disturbance	8-11
4	Extreme disturbance	12-16

Using the system outlined in

Table 5.2, a higher score indicates a higher level of anthropogenic impact and a lower score a lower level of impact. By summing these rankings for each site, an overall assessment of anthropogenic impacts can be made with the total possible site score ranging from 0 to 16. By assigning a range for the total score to each descriptive category, an assessment of anthropogenic impacts at the site can be made, allowing for easy comparisons between sites. Following the precautionary principle, a ranking of 4 is given to categories indicating high levels of anthropogenic disturbance.

Modified Riparian, Channel and Environmental (RCE) inventory

The modified Riparian, Channel and Environmental (RCE) inventory was established by Chessman *et al.* (1997) whom modified the RCE (Petersen, 1992) to suit Australian conditions. The modified RCE assesses aquatic and riparian habitats against thirteen categories providing a score ranging from 0 to 4 for each category.

Each score, in each category has a description of habitat condition which provides a consistent basis to descriptively assess and compare individual sites. Higher scores indicate better quality, less disturbed habitats and the total score provides an overall assessment of habitat conditions. This also allows for assessment against categories of recommended actions to address aquatic habitat condition as identified in Table 5.3.

Table 5.3 Modified RCE Total score, status, class and recommended actions

RCE Total Score	RCE Status	RCE Class	Recommended Action
0-11	Poor	V	Complete structural reorganization
12-21	Fair	IV	Major alterations required
22-31	Good	III	Minor alterations needed
32-41	Very Good	II	Selected alterations and monitoring for changes
42-52	Excellent	I	Bio-monitoring and protection of the existing status

Although the RCE scoring system is designed for use in agricultural landscapes, it can provide an indication of the quality of riparian and instream habitat of surveyed sites. Precautions should be taken to ensure results are not used in isolation, but rather in a ‘multiple lines of evidence approach’.

Reference condition selection criteria

An assessment of habitat condition conducted following the reference condition selection criteria (DNR, 2001) rates the level of impact for ten possible impact categories on a scale from extreme impact (1) to no impact (5). These scores are added together to indicate the level of possible anthropogenic impacts at the monitored site. Assessing the resultant score against a range of possible scores provides a means of assessing the condition of the monitored site and its suitability for selection as a reference site. Table 5.4 below provides the range of possible scores and the associated reference site suitability.

Table 5.4 Reference condition selection criteria total scores and reference site suitability

Reference Site Selection Criteria Total Score	Reference Site Suitability
10-23	Poor
24-33	Marginal
34-44	Sub-optimal
44-50	Optimal

5.3.3 Macroinvertebrates

A number of assessment techniques widely used by ecological practitioners in NSW in relation to the assessment of aquatic ecosystem condition were selected for application in the assessment of the macroinvertebrate data obtained. These were as follows:

- Taxa Richness Index
- EPT[10] Taxa Index
- SIGNAL 2 Taxa Richness Index?
- SIGNAL 2 Biotic Index (Chessman, 2003)
- SIGNAL-SF (Sydney Families)
- NSW AUSRIVAS – Autumn Edge Model

Brief descriptions of these analysis techniques are provided in the following text.

Taxa Richness Index

Richness refers to the number of different taxa contained in a sample. Generally speaking higher richness scores indicate better ecological health, although some exceptions do apply to this general rule.

EPT Taxa Richness Index

The EPT taxa index refers to the proportional representation of key macroinvertebrate taxa belonging to the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) groups. These groups are generally recognised to be among the more pollution-sensitive macroinvertebrate taxa. EPT richness refers to the number of EPT families present within a given sample.

SIGNAL 2 (Stream Invertebrate Grade Number – Average Level) – Taxa richness Index and biotic index

SIGNAL 2 is a biotic index based on pollution sensitivity values assigned to aquatic macroinvertebrate families that have been derived from published and unpublished information on their tolerance to pollutants (Chessman, 1995). Each family in a sample is assigned a grade between 1 (most tolerant) and 10 (most sensitive). Recently these grades have been revised in Chessman (2003) with the new version called SIGNAL 2.

Not all macroinvertebrate taxa have been assigned a SIGNAL 2 grade and those without grades are removed from the SIGNAL 2 biotic index calculation. This provides a richness index of taxa with assigned SIGNAL 2 grades further referred to as the SIGNAL 2 taxa richness index.

The SIGNAL 2 biotic index and its associated standard error are calculated as the average for all families present in the sample. The resulting biotic index score can then be interpreted by comparison with reference and/or control sites. The calculation of the SIGNAL 2 biotic index has not been weighted in regards to the abundance of organisms. For easier interpretation, SIGNAL 2 biotic index scores and SIGNAL 2 taxa richness index have been graphed using a quadrant diagram that divides results into four general settings as shown in Figure 5.1 (refer following section).

The boundaries between the four quadrants differ between geographic regions of Australia because of natural variation in macroinvertebrate communities. They also vary according to sampling effort and the types of habitats sampled (Chessman, 2003). After consideration of

[10] In this context, EPT stands for **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies).

suggested NSW interim boundaries, the quadrant boundaries applied to the monitoring data obtained during this project have been set at a SIGNAL 2 biotic index score of 4.00 and a SIGNAL 2 taxa richness index of 15.5.

SIGNAL-SF (Sydney Families)

The SIGNAL-SF was derived by Chessman *et al.* (2007) and although based on SIGNAL 2 biotic index (Chessman, 2003), SIGNAL-SF grades for macroinvertebrate families were derived specifically for the Sydney region. These grades also range from 1 to 10, with higher scores indicative of lower environmental stress (Chessman *et al*., 2007).

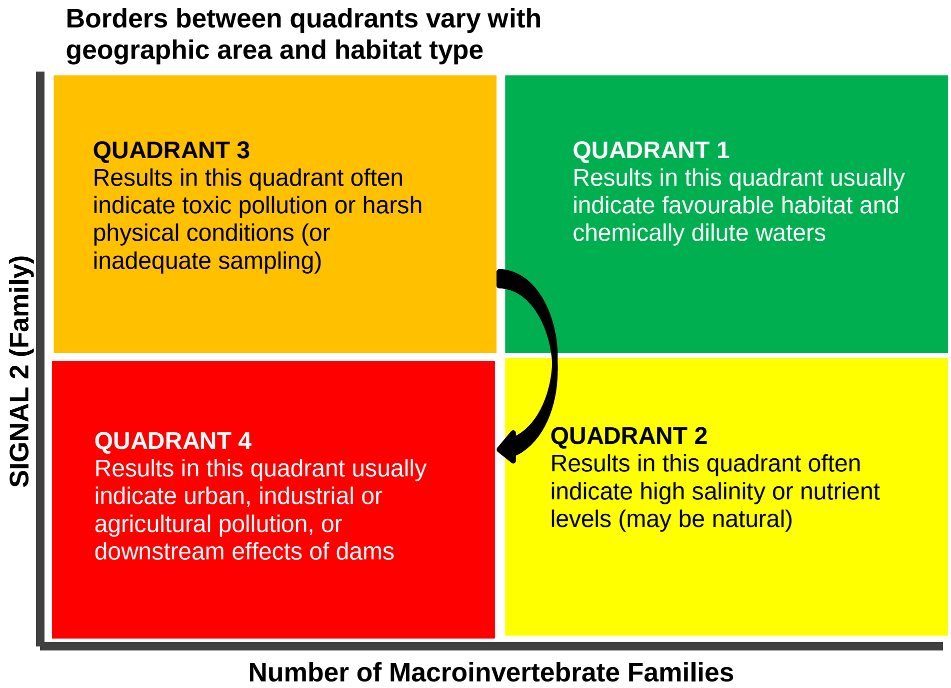

Figure 5.1 An example of the quadrant diagram for interpretation of the SIGNAL 2 and SIGNAL-SF biotic indices

NSW AUSRIVAS – Autumn Edge Model

The NSW AUSRIVAS – Autumn Edge Model generates site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress.

Using this model, the expected fauna from reference sites with a similar set of physical and chemical characteristics to those monitored during an individual project are compared with the observed fauna and an expected fauna to observed fauna ratio derived (O/E ratio). This ratio is used to indicate the extent of potential environmental impact. This ratio ranges from zero (0), when none of the expected fauna are found at a site, to approximately one (1), when all of the expected fauna are present. The value can also be greater than one (1) when more families are found at the site than predicted by the model. The ratio scores are then placed into the bands outlined in in Table 5.5 below.

Table 5.5 Key to AUSRIVAS O/E bands for the NSW autumn edge model

Band Label	Upper Limit	Band Name	Band Description
X	Infinity	More biologically diverse than reference sites	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
A	1.17	Reference condition	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
B	0.81	Significantly impaired	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
C	0.46	Severely impaired	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
D	0.11	Extremely impaired	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

The Band Names and descriptions within Table 5.5 provide a means to describe the scores derived by the AUSRIVAS models and indicate aquatic ecosystem condition. The NSW AUSRIVAS – Autumn Edge model also generates a list of missing taxa from individual sampling sites by comparing observed taxa against expected taxa.

Section 6 presents the monitoring data obtained and assessed during this project.

6. Monitoring data and assessment

6.1 Overview

The environmental monitoring data obtained at each monitoring location investigated during this project is provided in Appendix A. It is noted that the environmental monitoring data presented and assessed in this section represents data from five discrete monitoring locations obtained on one occasion. This data may have been influenced by a number of factors including:

- An elevated rainfall event that occurred in the 24 hours prior to the fieldworks commencing (further information provided in Section 6.2)
- The time at which the fieldworks were undertaken[11]
- The monitoring locations selected

Furthermore, it is noted that no riffle[12] habitat suitable for sampling following the AUSRIVAS protocols was observed during the fieldworks. As such all macroinvertebrate data presented and assessed within this report relates to edge samples only.

The data presented and assessed in the following sections (and associated conclusions and recommendations) should be considered with respect of these facts.

6.2 Rainfall data

In the 24 hours prior to the fieldworks commencing on 2 March 2015, an elevated rainfall event (13.2 mm[13]) occurred in the general vicinity of the LHRRP. This suggests that high stream flows may have occurred in Mill Creek immediately prior to the fieldworks commencing. These high stream flows may have influenced the environmental conditions within Mill Creek and therefore the monitoring data obtained during GHD's fieldworks. This said, the potential significance of this issue on the collected data is considered to be relatively minor by GHD (refer below).

Figure 6.1 presents the mean monthly rainfall[14] for 2010 to 2015 compared to all data (1969 to 2015).

From the data in Figure 6.1, it can be seen that the mean monthly rainfall in the two months preceding the GHD fieldworks:

- Was above the all data figure in January 2015
- Was below the all data figure in February 2015

The February 2015 data suggests that in the period prior to GHD's fieldworks commencing, rainfall and stream flow conditions are likely to have been relatively low and consistent[15]. This would have likely resulted in relatively stable environmental conditions prevailing within Mill Creek prior to the fieldworks commencing (assuming no other influences).

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[11] The macroinvertebrate sampling exercise occurred within two weeks of (but still outside) the recommended autumn (March 15 to June 15) or spring (September 15 to December 15) sampling periods as per the AUSRIVAS macroinvertebrate sampling methodology for NSW (Turak et al., 2004)

[12] A riffle is a short, relatively shallow and coarse-bedded length of stream over which the stream flows at slower velocity but a higher turbulence than it normally does in comparison to a pool

[13] Data from Lucas Heights (ANSTO) Bureau of Meteorology Weather Station, Weather Station Number 066078 at 9.a.m. local clock time on 2 March 2015 (rainfall data is the total rainfall for the preceding 24 hours)

[14] As recorded at Lucas Heights (ANSTO) Bureau of Meteorology Weather Station, Weather Station Number 066078

[15] With the exception of the significant rainfall event observed in the 24 hours immediately prior to the fieldworks commencing

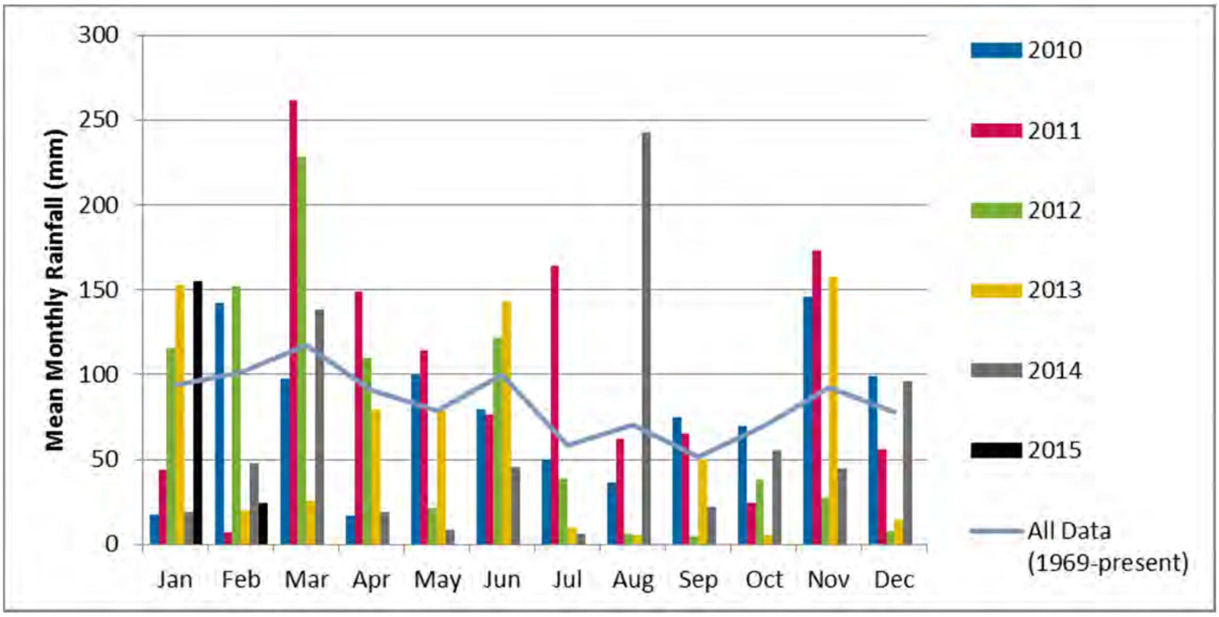


Figure 6.1 Mean monthly rainfall for years 2010 to 2015 and an average for all data available for Lucas Heights (ANSTO) Weather Station

Based on the facts that:

- The conditions in Mill Creek are likely to have been relatively stable prior to the fieldworks commencing; and
- The potential significance of the elevated rainfall event upon the monitoring data is considered to be relatively minor,

It is considered that the environmental conditions encountered during the fieldworks (and associated environmental monitoring data obtained) are likely to be reasonably representative of prevailing conditions within Mill Creek for the time of year monitored.

It is noted that the conditions encountered in Mill Creek during the fieldworks may actually be of a slightly lower quality than may have been encountered if the elevated rainfall event had not occurred.

6.3 In situ water quality

Results of the in situ water quality monitoring are provided in Table 6.1 below. Values outside the ANZECC (2000) assessment criteria for slightly disturbed aquatic ecosystems are highlighted in red.

Table 6.1 Results of *in situ* water quality

Site Code	Eco-Type	Time	Temp. (°C)	EC (µS/cm)	pH	DO (%sat)	DO (mg/L)	Turbidity (NTU)	Alkalinity (mg/L)
MCUP	Upland river	16:10	20.29	207	6.59	39.3	3.85	27.1	44
MC1	Lowland river	13:58	21.42	324	7.66	81.2	7.18	115	42
MC2	Lowland river	13:29	20.66	369	7.59	93.1	8.36	358	74
MC3	Lowland river	11:27	20.77	274	7.15	73.8	6.6	125	38
MC4	Lowland river	10:29	20.61	269	7.34	84.5	7.59	54.5	30.6
ANZECC (2000)	Upland river	N/A	N/A	30-350	6.5-8.0	90-110	N/A	2 - 25	N/A

assessment criteria	Lowland river			125-2200		85-110		6 - 50	

Table 6.1 identifies the following key points:

- Dissolved oxygen (DO) values were below the lower assessment criterions at all monitoring locations except for MC2. At monitoring locations MC1, MC3 and MC4 (all downstream of the LHRRP), DO values were only slightly below the relevant assessment criteria. As such, DO conditions at those locations were unlikely to be an issue of significance in relation to the macroinvertebrate communities and aquatic ecosystem processes in Mill Creek. The low DO value observed at MCUP suggests a reducing environment due to the degradation of organic materials and potentially the oxidation of iron content of the groundwater naturally entering the Creek as baseflow. This is a natural state for a coastal upland swamp environment which this monitoring location resembles due to its limited catchment area and upland coastal location.
- Turbidity values were outside the upper assessment criterions at all monitoring locations As previously mentioned, an elevated rainfall event occurred during the 24 hours prior to the GHD fieldworks commencing. The runoff and increased stream flow during this event is the most likely explanation for these elevated turbidity values. If high turbidity is a consistent condition within Mill Creek, elevated suspended solids and sedimentation are likely to influence macroinvertebrate communities and aquatic ecosystem processes in this watercourse.

6.4 Habitat condition

The habitat condition results and in-field assessments undertaken at each of the monitoring locations are provided Appendix A. These results and assessments are summarised in the following sections.

Visual Assessment

The geomorphic nature of the sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. The active channel was well defined and mode stream width was approximately 4 m in the upper reaches to 6 m in the lower reaches, bank height ranges from 0.5 m to 1.5, and bankfull widths ranged from 10 m to 20 m. Substrates were predominantly a mix of bedrock, boulder, gravel, sand and clay/silt, with the former and the latter dominating across the sites. Flow habitat types were generally half pool and half run with some riffle occurring at the downstream most site (MC4) although this was over bedrock, so not suitable for macroinvertebrate riffle sampling.

The uppermost site MCUP was the exception as it was at approximately 170 m altitude and considered upland (above 150 m). The habitat was similar to that of a coastal upland swamp rather than a true riverine habitat and this was reflected by the comparatively broader channel and lower banks

All sites downstream of the LHRRP had a mostly natural and continuous riparian vegetation zone with the community almost completely dominated by native species. A healthy mix of ground cover, shrub layer and over story tress was present at all sites with the exception of MCUP which had fewer trees above 10 m height and MC3 which had some clearing due to access by recreational users, resulting in lower cover of ground and shrub species. The macrophytes in the riparian zone were generally emergent forms and were predominantly natives with cover ranging between 5-20% of the available habitat across the sites.

NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities

The results from this in-field assessment are summarised in Table 6.2 below.

Table 6.2 Results of NSW AUSRIVAS Visual Assessment of Disturbance Related to Human Activities

Site Code	Water Quality	Instream	Riparian Zone	Catchment	Total Score	Category Description
MCUP	1	1	2	2	6	Moderate disturbance
MC1	2	2	1	4	9	High disturbance
MC2	1	1	1	3	6	Moderate disturbance
MC3	2	2	1	2	7	Moderate disturbance
MC4	1	1	0	1	3	Little disturbance

Notes: A key to the scoring and colour coding system is provided in

Table 5.2

Table 6.2 identifies the following key points:

- Habitat at three of the five sites (MCUP, MC2 and MC3) were assessed to have 'Moderate disturbance'
- Habitat at MC1 (immediately downstream of the LHRRP) was assessed to have 'High disturbance' principally due to the extensive changes to the catchment due to the LHRRP
- Habitat at MC4 (furthest monitoring location downstream from the LHRRP) was assessed to have 'Little disturbance'. Aquatic and riparian habitat at this monitoring location was in a reasonably pristine condition, suggesting that if any impacts are occurring in the Mill Creek catchment, the natural condition of the catchment downstream may provide a good buffer and aid recovery processes.

Modified Riparian, Channel and Environmental (RCE) inventory

The results from this in-field assessment are provided in Table 6.3 below.

Table 6.3 Results of the RCE Assessment

RCE Category	MCUP	MC1	MC2	MC3	MC4
Land-use pattern beyond immediate riparian zone	3	4	4	3	4
Width of riparian strip of woody vegetation	3	4	4	3	4
Completeness of riparian strip of woody vegetation	2	2	3	2	4
Vegetation of the riparian zone within 10 m of channel	3	3	4	4	4
Stream bank structure	3	4	4	4	4
Bank undercutting	4	2	2	2	4
Channel form	2	3	3	3	2
Riffle/pool Sequence	3	2	2	2	3
Retention devices in streams	2	3	3	2	3
Channel sediment accumulation	1	2	2	1	4
Stream bottom	2	2	2	1	3
Stream detritus	3	2	3	2	4
Aquatic vegetation	2	2	2	2	2
RCE Total Score	33	35	38	31	45
RCE Status	Very Good	Very Good	Very Good	Good	Excellent
Recommended Actions	Selected alterations and monitoring for changes	Selected alterations and monitoring for changes	Selected alterations and monitoring for changes	Minor alterations needed	Bio-monitoring and protection of the existing status

Notes: A key to the scoring and colour coding system is provided in Table 5.3.

Table 6.3 identifies the following key points:

- Monitoring locations in close proximity to the LHRRP (MCUP, MC1 and MC2) were assessed as 'Very Good' as the immediate riparian and instream habitats were generally considered to be in good condition
- MC3 was assessed as 'Good' primarily due to disturbance of riparian habitat, the prevalence of stream bank in-stability and associated increases in sedimentation.
- MC4 was assessed as 'Excellent' which is principally due to the near pristine / natural state of the riparian habitat in the immediate riparian zone and the surrounding catchment.

Reference site selection criteria

The results from this in-field assessment are provided in Table 6.4 below.

Table 6.4 Results of Reference Site Selection Criteria Assessment

Reference Condition Selection Criteria	MCUP	MC1	MC2	MC3	MC4
Agriculture and Forestry	5	5	5	5	5
Sand and Gravel Extraction	3	2	4	2	4
Upstream Urban Areas	4	3	4	4	4
Point Source Pollution	5	2	5	3	4
Dams and Weirs	3	2	4	4	4
Flow Regime Alteration	3	2	4	4	4
Vegetation Alteration	3	4	4	3	4
Riparian Zone/Streambank Erosion	4	3	4	2	4
Geomorphic Change	4	3	3	3	4
Instream Habitat Alteration	4	3	3	3	4
Total Score	38	29	40	33	41
Reference Site Suitability	Sub-optimal	Marginal	Sub-optimal	Marginal	Sub-optimal

Notes: A key to the scoring and colour coding system is provided in Table 5.4.

Table 6.4 identifies the following key points:

- Habitat condition at MCUP, MC2 and MC4 was assessed to be 'Sub-optimal'
- Habitat condition at MC1 and MC3 was assessed to be 'Marginal'. At MC1, this was primarily due to the disturbance of the ground surface associated with the LHRRP, associated changes to riparian vegetation and identified sediment deposition. At MC3, this was primarily associated with disturbance to the ground surface associated with recreational vehicle activities. These activities appear to be causing an influence on the integrity of the stream banks and causing increased levels of sediment deposition (eroded from unsealed dirt tracks) in close proximity to this monitoring location.

6.5 Macroinvertebrates

The macroinvertebrate results and subsequent assessments undertaken at / for each of the monitoring locations are provided Appendix A and Appendix B. These results and assessments are summarised in the following sections.

6.5.1 Taxa Richness and SIGNAL Indices

This section presents and assesses the results for the following taxa richness indices:

- Taxa Richness Index
- EPT[17] Taxa Index
- SIGNAL 2 Taxa Richness Index?
- SIGNAL 2 Biotic Index (Chessman, 2003)
- SIGNAL-SF (Sydney Families)

A total of 46 macroinvertebrate taxa were identified across the five monitoring locations (see Appendix B for a complete list). A breakdown of these results is provided in Table 6.5 below.

Table 6.5 Macroinvertebrate indices for Mill Creek monitoring locations

Monitoring Location	Taxa Richness Index	EPT Taxa Richness Index	SIGNAL 2 Taxa Richness Index	SIGNAL 2 (Order) Index	SIGNAL 2 (Family) Index	SIGNAL (Sydney Families) Index
MCUP	24	2	20	3.57	3.05	5.24
MC1	25	4	23	4.00	3.39	5.29
MC2	27	2	24	3.35	3.33	5.05
MC3	20	3	17	4.47	3.59	5.31
MC4	19	4	17	4.83	3.76	6.14

Table 6.5 identifies the following key points:

- MC2 displayed the highest taxa richness (27) and MC4 the lowest (19)
- MC1 displayed the highest (4) EPT taxa richness with MC2 displaying the joint lowest with MCUP (both 2)
- MC2 displayed the highest SIGNAL 2 taxa richness (24) with MC3 and MC4 displaying the joint lowest (17)

Figure 6.2 provides a graphical representation of these results contained in

Table 6.5.

[17] In this context, EPT stands for **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies).

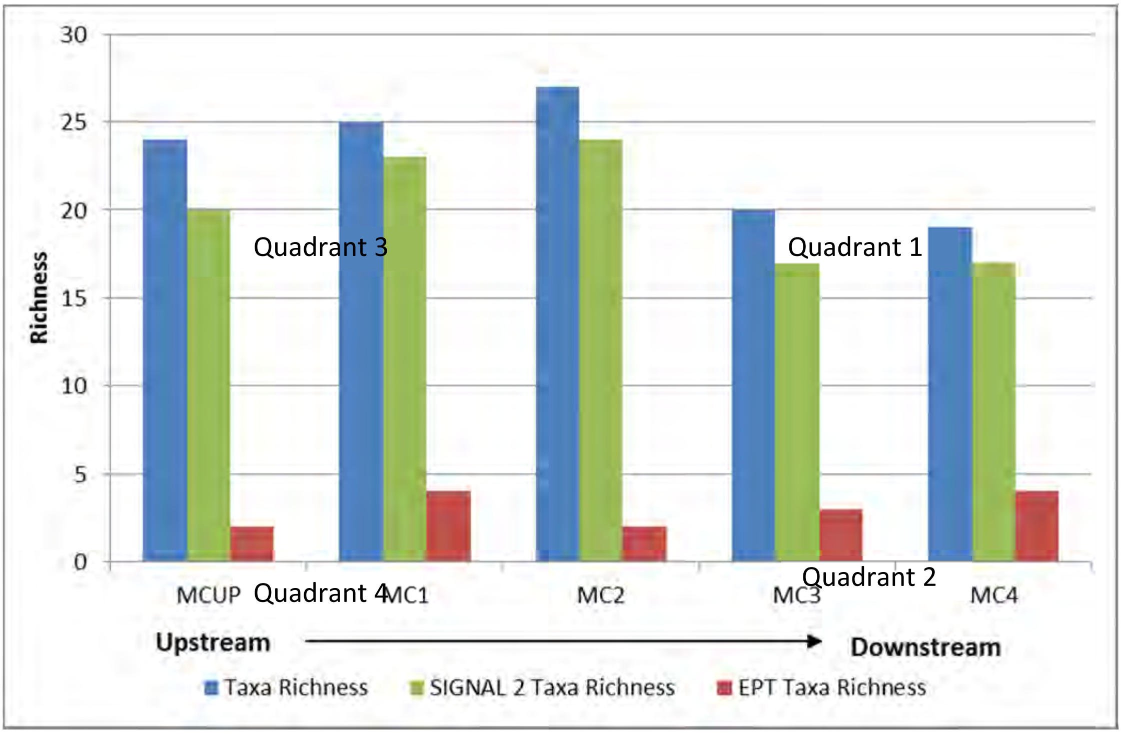


Figure 6.2 Macroinvertebrate richness scores for monitoring locations

6.5.2 SIGNAL

Figure 6.3 below plots SIGNAL 2 scores against richness values and compares results to the interim NSW boundaries according to Chessman (2003).

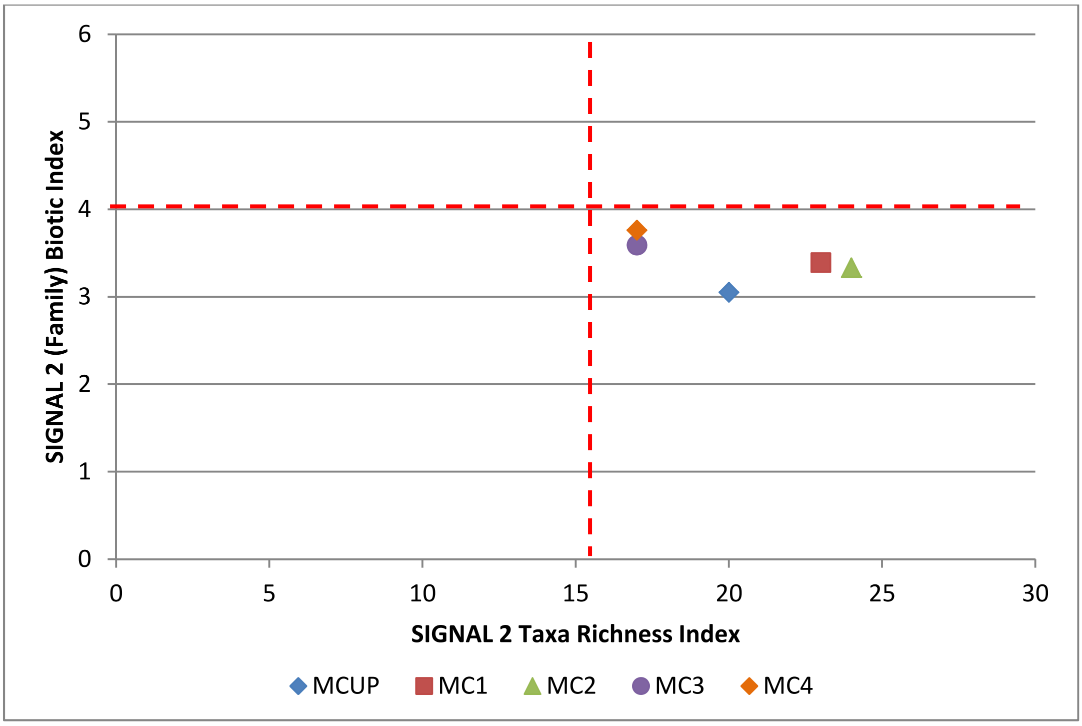


Figure 6.3 SIGNAL 2 biplot for monitoring locations displaying the quadrants according to the interim NSW boundaries

Figure 6.3 identifies the following key points:

- SIGNAL 2 biotic index scores placed all monitoring locations in Quadrant 2 as scores for all locations were below a score of 4.0 and above the richness value of 15.5. Results in Quadrant 2 typically indicate elevated salinity or nutrient levels. These elevated levels may occur naturally or as a result of human activities. Whatever the source, the relatively high number of macroinvertebrate taxa identified across the monitored locations suggests that physical conditions are sufficient to support diverse macroinvertebrate life.
- The Signal 2 taxa richness scores for the three monitoring locations closest to the LHRRP are higher than those for the two locations furthest away from the LHRRP, but the SIGNAL 2 Biotic Index scores were higher at the downstream sites. This demonstrates that the sensitivity to pollution of the taxa at the sites closer to the LHRRP is lower than those further downstream, suggesting some nutrient enrichment may be occurring that could be reducing by dilution downstream

Figure 6.4 below presents the SIGNAL 2 (Order), SIGNAL 2 (Family) and SIGNAL-SF (Sydney Families) results.

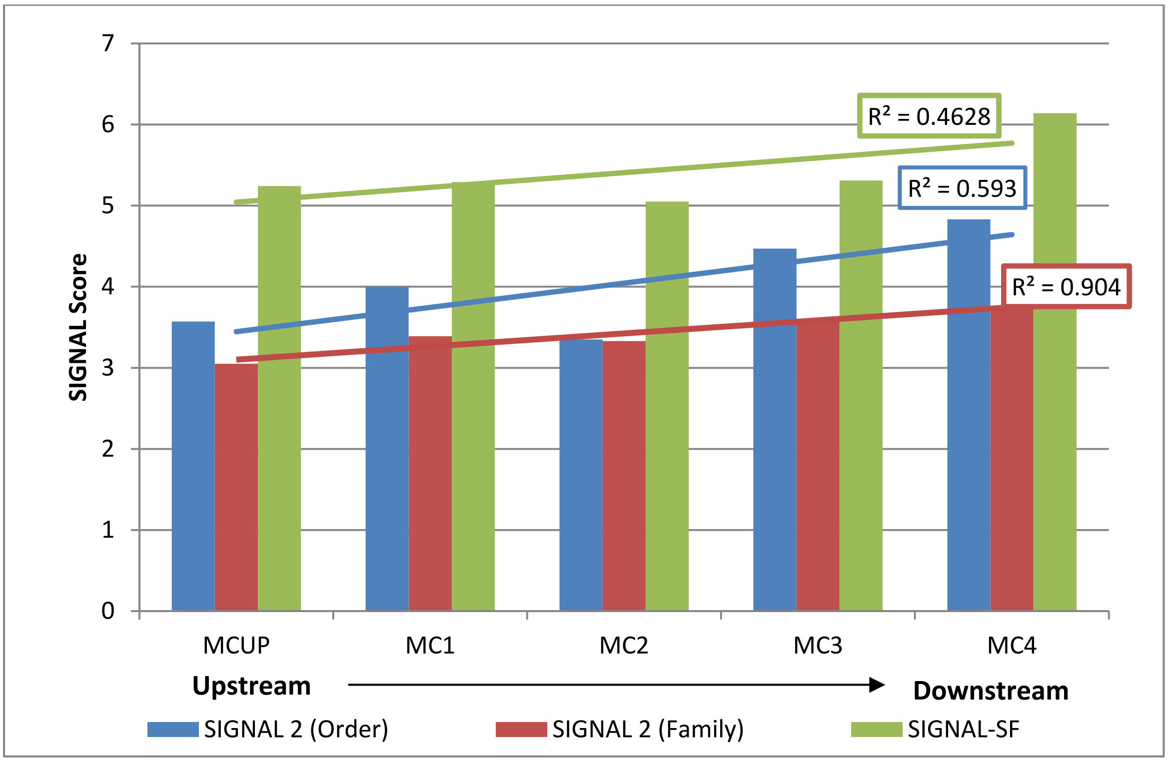


Figure 6.4 SIGNAL results displaying a linear trend line for each of the SIGNAL index scores

Figure 6.4 below identifies that across all SIGNAL indices there was a general trend of increasing scores with increasing distance downstream. A linear trend line demonstrated that the SIGNAL 2 (Family) biotic index correlated most closely with this trend.

These results may suggest that the SIGNAL indices are more responsive to stream discharge (a surrogate of catchment area in rainfall/runoff based streams) rather than indicative of water quality. However; a comprehensive suite of water quality chemical conditions (e.g. total phosphorus, total nitrogen, ammonia) was not measured during this project. The water quality may be influencing the community close to the LHRRP but becoming diluted downstream. Further testing and verification of this assumption would be required to make any significant conclusions to the application of SIGNAL-SF in the vicinity of the LHRRP.

6.5.3 NSW AUSRIVAS – Autumn Edge Model

A summary of AUSRIVAS results is provided in Table 6.6 below.

Table 6.6 Summary of results from NSW AUSRIVAS Autumn Edge Model

Site Code	O/E50	Band	Band Name
MCUP	0.84	A	Reference condition
MC1	0.74	B	Significantly impaired
MC2	0.73	B	Significantly impaired
MC3	0.45	C	Severely impaired
MC4	0.81	B	Significantly impaired

Notes: A key to the scoring and colour coding system is provided in Table 5.5.

Table 6.6 identifies the following key point:

- AUSRIVAS analysis of macroinvertebrate communities revealed the majority of monitoring locations to be rated a Band B indicating they were ‘significantly impaired’. Exceptions to this were MCUP which was assessed as Band A, or ‘reference condition’, and MC3 which was Band C, indicating it was ‘severely impaired’. These results suggest that at the majority of monitored locations, fewer macroinvertebrate families than expected were actually observed. This indicates that potential impact either on water quality or habitat quality or both, has resulted in loss of taxa (refer to note in Section 6.1)

Figure 6.5 below graphically displays the AUSRIVAS results, the upper Band limits and monitoring locations relative to the LHRRP.

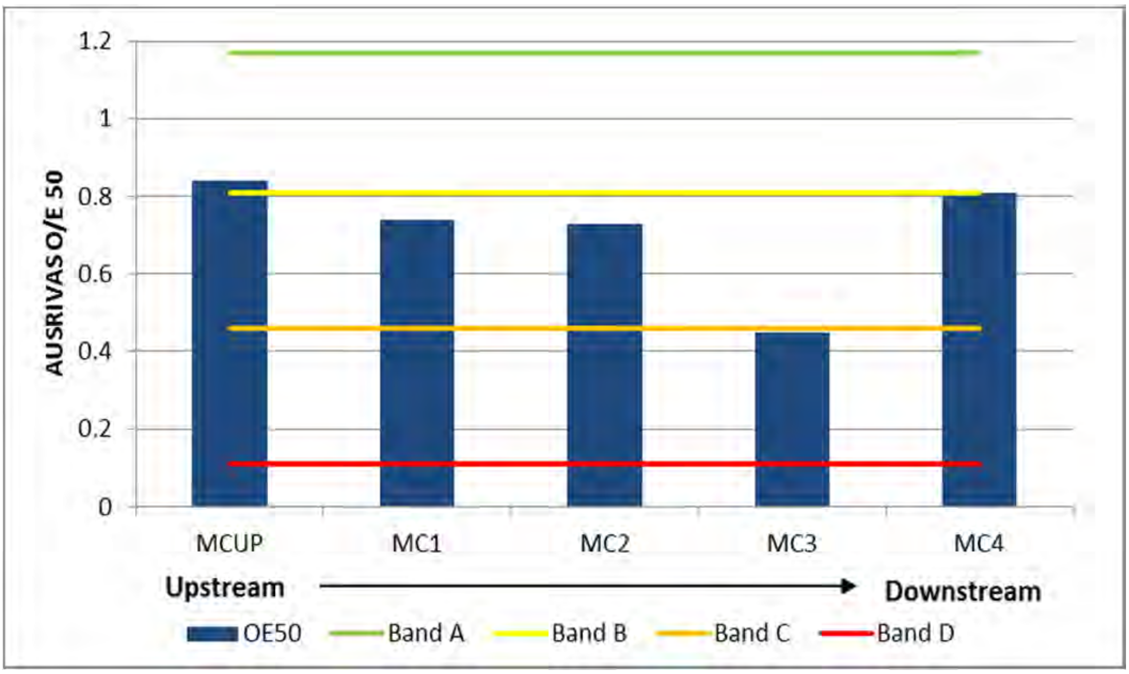


Figure 6.5 AUSRIVAS results displaying the upper Band limits and monitoring locations relative to the LHRRP

Figure 6.5 identifies the following key points:

- The upstream monitoring location (MCUP) was assessed as band A (‘Reference condition’) but the OE50 value was at the lower end of the bandwidth. This monitoring location was located upstream of an artificially created ‘Duck Pond’ dam and the persistent pool at this location may be a result of this dam. As previously mentioned, the aquatic habitat at MCUP more closely resembled a coastal upland swamp than a riverine habitat. The temporal stability of the habitat and its resident macroinvertebrate community may explain the higher OE50 at MCUP, compared to other monitoring locations further downstream. Alternatively, as this site is upland (above 150 m), it would be assessed against a different set of reference sites compared to the other study sites and as such AUSRIVAS results between this upstream site and the downstream study sites may not be effectively compared.

- The monitoring locations that were rated as Band B ('Significantly impaired') (MC1, MC2 and MC4) scored OE50 values just below the upper limit of the bandwidth (0.81). This means that these locations were not far off being classified as Band A ('Reference condition). As this was a one-off sampling event that immediately followed an elevated rainfall event, all macroinvertebrate taxa may not have been captured during the fieldworks. As such, these values could be considered an indication of community composition. These monitoring locations may not be consistently assessed as 'Significantly impaired' and may show improvement in future as further sampling may provide additional taxa and results for the macroinvertebrate communities may oscillate around this value.
- MC3 was assessed as Band Width C ('Severely impaired') suggesting that many fewer families were observed than expected. This implies a loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality. The influence of habitat quality may be a key driver for the reduced OE50 score at this monitoring location as the habitat condition assessments suggested local scale site degradation of habitat, associated with recreational vehicle use.

In addition to the Band widths, AUSRIVAS adds the taxa information for taxa expected to occur at any given sample location (given the environmental variables) for comparison with the observed field taxa at any given sample location.

Appendix C contains a table that identifies the taxa which AUSRIVAS expected to be present at the monitoring locations, but which were not observed during this project. Key points from this table are as follows:

- Approximately 81% of the taxa which were expected but were not observed had a SIGNAL 2 (Family) grade equal to or above 4
- Eighteen taxa that form the sensitive EPT Orders were expected but not observed. The average SIGNAL 2 (Family) grade of these EPT taxa was 7.44, while the SIGNAL-SF was 8.39. This shows that the taxa not observed were dominated by those with high sensitivities to pollution and/or changes to habitat conditions. This is not an unexpected finding and is generally the case for macroinvertebrate communities in urbanised and disturbed landscapes

Further sampling in spring and/or an ongoing macroinvertebrate monitoring program, at each of the locations monitored during this project would allow for a more comprehensive analysis of macroinvertebrate community composition. This would permit analysis using a combined season model which is likely to provide for a more holistic assessment of macroinvertebrate communities and aquatic ecosystem health.

6.6 2013/2014 River health report card

In 2013-14 the River Health Monitoring Program entered its fifth year of monitoring in the Georges River Catchment. River Health monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates. A copy of the River Health Georges River Report Card is contained in Appendix D and also publicly available online <http://www.georgesriver.org.au/>.

For 2013 - 2014, Mill Creek downgradient of the site reported an overall River Health Grade grade of A+ which suggests excellent conditions.

For 2013 – 2014, Barden Creek downgradient of the site received an overall River Health Grade of A+ which suggests excellent conditions.

This corresponds with the findings of this report which are that habitat and macroinvertebrate populations are in general in good condition and that any impacts of the LHRRP on Mill Creek are spatially limited as further downstream the health of Mill Creek was found to be in an excellent condition.

7. Discussion

A multiple lines and levels of evidence approach was used to assess the potential impacts of the LHRRP on the aquatic ecosystem of Mill Creek. *In situ* water quality, aquatic and riparian habitat condition and macroinvertebrate communities were monitored and assessed against relevant guidelines and following standard protocols. It is noted that this section should be read with consideration of the issues previously outlined in Section 6.1.

Results of the *in situ* water quality monitoring suggested that dissolved oxygen was slightly below the relevant assessment criteria at the majority of the monitoring locations with the exception of the upstream site (MCUP) which was well below the relevant assessment criteria. Values slightly below Guidelines are not likely to be a substantial issue for aquatic macroinvertebrates or aquatic ecosystem processes. Furthermore there is little evidence to attribute the dissolved oxygen values to catchment scale landuse changes related to the LHRRP as monitoring locations downstream of the LHRRP displayed dissolved oxygen values that were higher than those observed at the upstream site.

Elevated turbidity levels were recorded across all monitoring locations including the upstream site (MCUP). An elevated rainfall event occurred in the 24 hours prior to the fieldworks commencing which is likely to have been a significant factor in the turbidity levels observed. There was a consistent increase in turbidity levels between MCUP and MC2 and then a consistent decrease in these levels between MC2 and MC4. The reasons for this are currently unclear. However, it is noted that the catchment surrounding Mill Creek downstream of the LHRRP is chiefly a forested natural area criss-crossed by a number of recreational vehicle and mountain bike tracks. Whilst it is likely that runoff from the LHRRP would contain higher sediment loads than under natural conditions, runoff from these recreational tracks may contribute to suspended solids and sediment input into Mill Creek downstream of the LHRRP.

Whilst the aquatic and riparian habitat assessment methods used during this project may be limited in their application to the small coastal catchment that is Mill Creek, they have been consistently applied across all monitoring locations allowing comparisons to be made. The NSW AUSRIVAS assessment of disturbance related to human activities found MC1 to have a ‘High disturbance’ level, but this is not unexpected given the change in catchment landuse associated with the LHRRP. The recovery in this disturbance to ‘Moderate disturbance’ at MC2 and MC3, and ‘Little disturbance’ at MC4 shows that the extent of impacts of the LHRRP may be spatially limited to the immediate habitat.

The results of the assessment of the monitoring locations against the modified Riparian, Channel and Environmental (RCE) inventory categories assessed the monitoring locations in close proximity to the LHRRP as ‘Very Good’ as the immediate riparian and instream habitats were generally considered to be in good condition. MC3 was assessed as ‘Good’ primarily due to disturbance of riparian habitat, the prevalence of stream bank in-stability and associated increases in sedimentation. MC4 was assessed as ‘Excellent’ which is principally due to the near pristine / natural state of the riparian habitat in the immediate riparian zone and the surrounding catchment.

Assessment of site habitat condition against the reference site selection criteria found site suitability for MCUP, MC2 and MC4 to be ‘Sub-optimal’ while MC1 and MC3 were considered ‘Marginal’. At MC1, this was primarily due to the disturbance of the ground surface associated with the LHRRP, associated changes to riparian vegetation and identified sediment deposition. At MC3, this was primarily associated with disturbance to the ground surface associated with recreational vehicle activities not on the LHRRP site. These activities appear to be causing damage to stream banks

The general trends in macroinvertebrate community indices across the monitoring locations were relatively consistent between several of the indices including richness and AUSRIVAS ratings. In a downstream direction from MCUP to MC2 there was a general increase in these indices then an abrupt decline was identified at MC3 (compared to MC2). MC4 displayed a recovery of these AUSRIVAS rating but richness values at this monitoring location remained relatively low.

SIGNAL 2 (Family) values possibly best explain the trends in macroinvertebrate community composition displaying a generally consistent increase with increasing distance downstream (as measured from MCUP) with a high R^2 value (0.904) for the linear line of best fit. Whilst this may suggest that some impact is occurring downstream of the LHRRP, the upstream monitoring location (MCUP) scored the lowest SIGNAL 2 (Family) score and MC2 scored lower than MC1. This trend may suggest that the permanency of aquatic habitat, which is likely to become more permanent with increasing distance downstream, may be a factor in the persistence of macroinvertebrate taxa.

Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present. While this may seem a cause for concern these ratings are relatively good. Recent studies of the Georges River catchment found that urban streams throughout the catchment contain macroinvertebrate communities dominated by pollution tolerant species with little or no pollution sensitive species present (Tippler *et al.*, 2014). This suggests that macroinvertebrate communities present at the monitoring locations were generally in a healthy condition given the extent of catchment disturbance associated with a development such as the LHRRP.

AUSRIVAS assessment of macroinvertebrate communities' revealed MCUP was rated as 'Reference condition' (Band A), MC3 as 'Severely impaired' (Band C) and the remainder as 'Significantly impaired' (Band B). The decline from Band A to Band B immediately downstream of the LHRRP is not unexpected and given that MC1 was at the top end on the bandwidth for Band B, its score could be assessed as relatively high. The decline to Band C at MC3 is likely due to a decline in taxonomic diversity, also displayed in the richness results discussed above. This may be attributed to several factors but is likely due to the decline in aquatic and riparian habitat condition that may be linked to nearby recreational vehicle use.

It is noted that River Health Monitoring Program monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates (refer Section 6.6) and that their conclusions reinforce the statements made above.

8. Conclusions

This report has been prepared to assess the condition of aquatic habitats within and downstream of the LHRRP. Due to climatic conditions and required timing of the fieldworks, the time at which the fieldworks were undertaken is likely to have been below optimal in terms of encountering the monitoring locations along Mill Creek in their highest order condition in relation to water quality, habitat condition and/or macroinvertebrate populations. This said, it is considered that the environmental conditions encountered during the fieldworks (and associated environmental monitoring data obtained) are likely to be reasonably representative of prevailing conditions within Mill Creek for the time of year monitored.

The uppermost site (MCUP) is at approximately 170 m altitude and considered upland (above 150 m). The creek has a comparatively broader channel and lower banks at this location. All sites downstream of the LHRRP had a mostly natural and continuous riparian vegetation zone with the community almost completely dominated by native species. The geomorphic nature of these sites was generally similar and characteristic of a small coastal lowland (below 150 m altitude) catchment. Habitat condition was generally good, although disturbance to the ground surface associated with recreational vehicle activities was observed at MC3, leading to increased levels of sediment deposition near this site.

A relatively high number of macroinvertebrate taxa were identified across the monitored locations suggesting that physical conditions are sufficient to support diverse macroinvertebrate life. Assessment of the pollution tolerances of taxa present found most monitoring locations had communities dominated by pollution tolerant taxa, although some sensitive taxa were present.

Based on the results of the field survey and data analysis, the following conclusions are made:

- Results of the *in situ* water quality monitoring suggested that dissolved oxygen was slightly below the ANZECC assessment criteria at the majority of the monitoring locations. Electrical conductivity and pH were within the recommended ranges. The LHRRP and off-site recreational vehicle users may be having some minor impacts on Mill Creek in relation to turbidity values, although turbidity may have been affected by a recent rainfall event.
- Habitat was found to be generally in good condition. The LHRRP may be having some minor impacts on Mill Creek in relatively close proximity to the LHRRP (MC1), as condition here is lower than at the upstream site. Habitat condition improves at MC2. A decline at MC3 is likely to be the result of disturbance caused by recreational vehicle users. Aquatic and riparian habitat at MC 4 (located furthest from the LHRRP) was in a reasonably pristine condition. The recovery of habitat condition at this monitoring location suggests that any impacts of the LHRRP are spatially limited and that the natural condition of the surrounding catchment downstream will ensure minimal impacts to the Georges River receiving environment.
- Macroinvertebrate communities present at the monitoring locations were generally in a healthy condition. Communities were dominated by pollution tolerant taxa, although some sensitive taxa were present. Recent studies of urban streams in the Georges River catchment found few or no pollution-sensitive taxa, suggesting that Mill Creek is one of the better condition streams in the area. Key drivers of losses in taxonomic diversity in Mill Creek are currently unclear and are spatially limited and which may be linked to off-site activities in certain locations (such as recreational vehicle use).
- The proposal should result in a lower potential for impacts on the Mill Creek aquatic environment due to the proposed reprofiling of the site, increasing over time the capped

and revegetated areas and via a number of best practice operational controls documented in the OEMPs.

- Further investigation of the habitat condition and macroinvertebrate populations is recommended to confirm the preliminary findings contained within this report. It is recommended that this work be undertaken every three years commencing soon after reprofiling works commence in Area E.

It is noted that River Health Monitoring Program monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates (refer Section 6.6) and that their findings reinforce the conclusions of this report. That is, any impacts of the LHRRP on Mill Creek are spatially limited as further downstream the health of Mill Creek was found to be in an excellent condition.

Appendices

Appendix A – GHD Aquatic Ecosystem Database Field Data Report

Site Code	Site Name and Location	Sample Date
MC-1	Mill Creek Immediately downstream of SITA Lucas Heights	2/03/2015

Site/Date Code (PK)	MC-1_02Mar15	Latitude	-34.036060	Longitude	150.964730

Upstream

Downstream

In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)		Turb. (NTU)	Alkalinity (mg/L)
13:58	21.42	7.66	324	81.2	7.18	115	42

Macroinvertebrate Indicies

Total Taxa Richness	25
EPT Richness	4
SIGNAL 2 (Order)	4.00
SIGNAL 2 (Family)	3.39
SIGNAL-SF	5.29

AUSRIVAS Results

O/E 50*	0.74	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band	B	
Band Name	Significantly impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

NSW AUSRIVAS Assessment of Disturbance Related to Human Activities (Turak et al, 2004)

Site Assessment	Ranking	Description
Water Quality	2	Moderate disturbance
Instream	2	Moderate disturbance
Riparian Zone	1	Little disturbance
Catchment	4	Extreme disturbance
Score	9	/ 16
Category	High disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	2
Sand and Gravel Extraction	2	Vegetation Alteration	4
Upstream Urban Areas	3	Riparian Zone/ Stream Bank Erosion	3
Point source Pollution	2	Geomorphic Change	3
Dams and Weirs	2	Instream Habitat Alteration	3

Score 29 / 50

Reference Site Suitability Marginal

Higher scores indicate better quality sites

Site Code	Site Name and Location	Sample Date
MC-1	Mill Creek Immediately downstream of SITA Lucas Heights	2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

Category	Value	Description
Land-use pattern beyond immediate riparian zone	4	Undisturbed native vegetation
Width of riparian strip of woody vegetation	4	More than 30 m
Completeness of riparian strip of woody vegetation	2	Breaks at intervals of 10-50 m
Vegetation of the riparian zone within 10 m of channel	3	Mixed native and exotic trees and shrubs
Stream bank structure	4	Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	2	Frequent along all parts of the stream
Channel form	3	Medium; width:depth ratio 8:1 to 15:1
Riffle/pool Sequence	2	Natural channel without riffle/pool sequence
Retention devices in streams	3	Rocks/logs present; limited damming effect
Channel sediment accumulation	2	Bars of sand and silt common
Stream bottom	2	Bottom heavily silted but stable
Stream detritus	2	Mainly fine detritus mixed with sediment
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	**35**	/52 **Very Good**

Higher scores indicate less disturbances and better site condition

Recommended actions to address riparian condition: **Selected alterations and monitoring for changes**

Habitat, Geomorphology and Flow

Length of reach surveyed	100 (m)		
Pool 50%	Riffle 0%	Run 50%	
	Min	Mean	Max
Stream Widths (m)	1	5	8
Bankfull Width (m)	18		
Flow level during survey	Normal		
Stream Bank Erosion	Little		

Riparian Vegetation

Type	% Cover	Description
Trees >10m	15%	Eucalyptus
Trees <10m	25%	Eucalyptus, Banksia, Casuarina
Shrubs	50%	Native shrubs
Ground Cover	30%	Native grasses and ferns
Est. % Native	90%	Est. % Exotic 10%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	42	LATITUDE	-34.036060
ALTITUDE	107	LOGDFSM	3.347330
BEDROCK	15	LOGSLOPE1KUS	2.602060
BOULDER	0	LONGITUDE	150.964730
COBBLE	0	RAINFALL	950

Site Code	Site Name and Location	Sample Date
MC-1	Mill Creek Immediately downstream of SITA Lucas Heights	2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat Edge Replicate

Method Sweep

Collected By Adrian Dickson

Picked By Adrian Dickson

Sample Depth 30 (cm)

Habitat Feature	% Cover
Blanketing Silt	100%
Shading	60%

Habitat Feature	% Cover
Detritus (leaves/twigs)	35%
Sticks (< 2 cm)	10%
Branches (2-15 cm)	5%
Logs (> 15 cm)	2%
Algae	0%
Macrophytes	15%
Overhanging Habitat	80%

Substrate Composition	% Cover
Bedrock	15%
Boulder (>200 mm)	0%
Cobble (60-200 mm)	0%
Pebble (20-60 mm)	0%
Gravel (2-20 mm)	0%
Sand (0.02-2 mm)	30%
Silt/Clay (<0.02 mm)	55%

Sample Comment

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	1
Microcrustaceans	Crustacea	1
Flies (larvae)	Diptera	4
Mayflies	Ephemeroptera	2
Snails	Gastropoda	1
True Bugs	Hemiptera	5
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	6
Caddisflies	Trichoptera	2
Flatworms	Turbellaria	1

Site Code	Site Name and Location	Sample Date
MC2	Mill Creek Adjacent to MTB track	2/03/2015

Site/Date Code (PK)	MC2_02Mar15	Latitude	-34.032050	Longitude	150.965860

Upstream

Downstream

In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)		Turb. (NTU)	Alkalinity (mg/L)
13:29	20.66	7.59	369	93.1	8.36	358	74

Macroinvertebrate Indicies

Total Taxa Richness	27
EPT Richness	2
SIGNAL 2 (Order)	3.35
SIGNAL 2 (Family)	3.33
SIGNAL-SF	5.05

AUSRIVAS Results

O/E 50*	0.73	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band	B	
Band Name	Significantly impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

NSW AUSRIVAS Assessment of Disturbance Related to Human Activities (Turak et al, 2004)

Site Assessment	Ranking	Description
Water Quality	1	Little disturbance
Instream	1	Little disturbance
Riparian Zone	1	Little disturbance
Catchment	3	High disturbance
Score	**6**	**/ 16**
Category	**Moderate disturbance**	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	4
Sand and Gravel Extraction	4	Vegetation Alteration	4
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	4
Point source Pollution	5	Geomorphic Change	3
Dams and Weirs	4	Instream Habitat Alteration	3

Score **40** **/ 50**

Reference Site Suitability **Sub-optimal**

Higher scores indicate better quality sites

Site Code	Site Name and Location	Sample Date
MC2	Mill Creek Adjacent to MTB track	2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

Category	Value	Description
Land-use pattern beyond immediate riparian zone	4	Undisturbed native vegetation
Width of riparian strip of woody vegetation	4	More than 30 m
Completeness of riparian strip of woody vegetation	3	Breaks at intervals of more than 50 m
Vegetation of the riparian zone within 10 m of channel	4	Native tree and shrub species
Stream bank structure	4	Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	2	Frequent along all parts of the stream
Channel form	3	Medium; width:depth ratio 8:1 to 15:1
Riffle/pool Sequence	2	Natural channel without riffle/pool sequence
Retention devices in streams	3	Rocks/logs present; limited damming effect
Channel sediment accumulation	2	Bars of sand and silt common
Stream bottom	2	Bottom heavily silted but stable
Stream detritus	3	Some wood, leaves, etc. with much fine detritus
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	**38**	/52 **Very Good**

Higher scores indicate less disturbances and better site condition

Recommended actions to address riparian condition: **Selected alterations and monitoring for changes**

Habitat, Geomorphology and Flow

Length of reach surveyed	100 (m)		
Pool 50%	Riffle 0%	Run 50%	
	Min	Mean	Max
Stream Widths (m)	0.3	4	6
Bankfull Width (m)	10		
Flow level during survey	Normal		
Stream Bank Erosion	Some		

Riparian Vegetation

Type	% Cover	Description
Trees >10m	20%	Eucalyptus
Trees <10m	15%	Eucalyptus, Banksia, Casuarina
Shrubs	15%	Native shrubs
Ground Cover	35%	Ferns
Est. % Native	90%	Est. % Exotic 10%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	74	LATITUDE	-34.032050
ALTITUDE	105	LOGDFSM	3.427324
BEDROCK	10	LOGSLOPE1KUS	2.176091
BOULDER	10	LONGITUDE	150.965860
COBBLE	0	RAINFALL	950

Site Code	Site Name and Location	Sample Date
MC2	Mill Creek Adjacent to MTB track	2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge
Replicate	
Method	Sweep
Collected By	Adrian Dickson
Picked By	Adrian Dickson
Sample Depth	20 (cm)

Habitat Feature	% Cover
Blanketing Silt	100%
Shading	25%

Habitat Feature	% Cover
Detritus (leaves/twigs)	40%
Sticks (< 2 cm)	15%
Branches (2-15 cm)	10%
Logs (> 15 cm)	5%
Algae	0%
Macrophytes	5%
Overhanging Habitat	15%

Substrate Composition	% Cover
Bedrock	10%
Boulder (>200 mm)	10%
Cobble (60-200 mm)	0%
Pebble (20-60 mm)	0%
Gravel (2-20 mm)	5%
Sand (0.02-2 mm)	45%
Silt/Clay (<0.02 mm)	30%

Sample Comment

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	2
Microcrustaceans	Crustacea	1
Flies (larvae)	Diptera	3
Mayflies	Ephemeroptera	1
Snails	Gastropoda	3
True Bugs	Hemiptera	6
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	6
Worms	Oligochaeta	1
Caddisflies	Trichoptera	1
Flatworms	Turbellaria	1

Site Code	Site Name and Location	Sample Date
MC3	Mill Creek End of Little Forest access track	2/03/2015

Site/Date Code (PK)	MC3_02Mar15	Latitude	-34.026380	Longitude	150.971780

Upstream

Downstream

In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)		Turb. (NTU)	Alkalinity (mg/L)
11:27	20.77	7.15	274	73.8	6.60	125	38

Macroinvertebrate Indicies

Total Taxa Richness	20
EPT Richness	3
SIGNAL 2 (Order)	4.47
SIGNAL 2 (Family)	3.59
SIGNAL-SF	5.31

AUSRIVAS Results

O/E 50*	0.45	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band	C	
Band Name	Severely impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

NSW AUSRIVAS Assessment of Disturbance Related to Human Activities (Turak et al, 2004)

Site Assessment	Ranking	Description
Water Quality	2	Moderate disturbance
Instream	2	Moderate disturbance
Riparian Zone	1	Little disturbance
Catchment	2	Moderate disturbance
Score	**7**	**/ 16**
Category	**Moderate disturbance**	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	4
Sand and Gravel Extraction	2	Vegetation Alteration	3
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	2
Point source Pollution	3	Geomorphic Change	3
Dams and Weirs	4	Instream Habitat Alteration	3

Score **33** **/ 50**

Reference Site Suitability **Marginal**

Higher scores indicate better quality sites

Site Code	Site Name and Location	Sample Date
MC3	Mill Creek End of Little Forest access track	2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

Category	Value	Description
Land-use pattern beyond immediate riparian zone	3	Mixed native vegetation and pasture/exotics
Width of riparian strip of woody vegetation	3	Between 5 and 30 m
Completeness of riparian strip of woody vegetation	2	Breaks at intervals of 10-50 m
Vegetation of the riparian zone within 10 m of channel	4	Native tree and shrub species
Stream bank structure	4	Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	2	Frequent along all parts of the stream
Channel form	3	Medium; width:depth ratio 8:1 to 15:1
Riffle/pool Sequence	2	Natural channel without riffle/pool sequence
Retention devices in streams	2	Rocks/logs present but unstable; no damming
Channel sediment accumulation	1	Braiding by loose sediment
Stream bottom	1	Bottom mainly loose and mobile sandy sediment
Stream detritus	2	Mainly fine detritus mixed with sediment
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	**31**	/52 **Good**

Higher scores indicate less disturbances and better site condition

Recommended actions to address riparian condition: **Minor alterations needed**

Habitat, Geomorphology and Flow

Length of reach surveyed	100 (m)		
Pool 50%	Riffle 0%	Run 50%	
	Min	Mean	Max
Stream Widths (m)	4	5	12
Bankfull Width (m)	20		
Flow level during survey	Normal		
Stream Bank Erosion	Little		

Riparian Vegetation

Type	% Cover	Description
Trees >10m	35%	Eucalyptus
Trees <10m	25%	Eucalyptus, Banksia, Casuarina
Shrubs	15%	Native shrubs and rushes
Ground Cover	20%	Some ferns
Est. % Native	90%	Est. % Exotic 10%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	38	LATITUDE	-34.026380
ALTITUDE	95	LOGDFSM	3.550228
BEDROCK	20	LOGSLOPE1KUS	2.113943
BOULDER	0	LONGITUDE	150.971780
COBBLE	0	RAINFALL	950

Site Code	Site Name and Location	Sample Date
MC3	Mill Creek End of Little Forest access track	2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	
Method	Sweep		
Collected By	Adrian Dickson		
Picked By	Adrian Dickson		
Sample Depth	30	(cm)	

Habitat Feature	% Cover
Blanketing Silt	100%
Shading	35%

Habitat Feature	% Cover
Detritus (leaves/twigs)	20%
Sticks (< 2 cm)	5%
Branches (2-15 cm)	5%
Logs (> 15 cm)	0%
Algae	0%
Macrophytes	25%
Overhanging Habitat	70%

Substrate Composition	% Cover
Bedrock	20%
Boulder (>200 mm)	0%
Cobble (60-200 mm)	0%
Pebble (20-60 mm)	0%
Gravel (2-20 mm)	10%
Sand (0.02-2 mm)	30%
Silt/Clay (<0.02 mm)	40%

Sample Comment: Adult dragon and damsels observed depositing eggs near macrophyte beds

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	4
Microcrustaceans	Crustacea	1
Flies (larvae)	Diptera	2
Mayflies	Ephemeroptera	2
Snails	Gastropoda	1
True Bugs	Hemiptera	1
Water Slaters	Isopoda	1
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	4
Caddisflies	Trichoptera	1
Flatworms	Turbellaria	1

Site Code	Site Name and Location	Sample Date
MC4	Mill Creek Downstream	2/03/2015

Site/Date Code (PK)	MC4_02Mar15	Latitude	-34.023670	Longitude	150.981040

Upstream

Downstream

In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)		Turb. (NTU)	Alkalinity (mg/L)
10:29	20.61	7.34	269	84.5	7.59	54.5	30.6

Macroinvertebrate Indicies

Total Taxa Richness	19
EPT Richness	4
SIGNAL 2 (Order)	4.83
SIGNAL 2 (Family)	3.76
SIGNAL-SF	6.14

AUSRIVAS Results

O/E 50*	0.81	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band	B	
Band Name	Significantly impaired	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

NSW AUSRIVAS Assessment of Disturbance Related to Human Activities (Turak et al, 2004)

Site Assessment	Ranking	Description
Water Quality	1	Little disturbance
Instream	1	Little disturbance
Riparian Zone	0	No evidence of disturbance
Catchment	1	Little disturbance
Score	3	/ 16
Category	Little disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	4
Sand and Gravel Extraction	4	Vegetation Alteration	4
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	4
Point source Pollution	4	Geomorphic Change	4
Dams and Weirs	4	Instream Habitat Alteration	4

Score 41 / 50

Reference Site Suitability Sub-optimal

Higher scores indicate better quality sites

Site Code	Site Name and Location	Sample Date
MC4	Mill Creek Downstream	2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

Category	Value	Description
Land-use pattern beyond immediate riparian zone	4	Undisturbed native vegetation
Width of riparian strip of woody vegetation	4	More than 30 m
Completeness of riparian strip of woody vegetation	4	Riparian strip without breaks in vegetation
Vegetation of the riparian zone within 10 m of channel	4	Native tree and shrub species
Stream bank structure	4	Bank fully stabilised by trees, shrubs, concrete
Bank undercutting	4	None, or restricted by tree roots or man-made
Channel form	2	Shallow; width:depth ratio greater than 15:1
Riffle/pool Sequence	3	Long pools with infrequent short riffles
Retention devices in streams	3	Rocks/logs present; limited damming effect
Channel sediment accumulation	4	Little or no accumulation of loose sediments
Stream bottom	3	Mainly stones with some cover of algae/silt
Stream detritus	4	Mainly unsilted wood, bark, leaves
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	**45**	**/52** **Excellent**

Higher scores indicate less disturbances and better site condition

Recommended actions to address riparian condition: **Biomonitoring and protection of the existing status**

Habitat, Geomorphology and Flow

Length of reach surveyed	100 (m)		
Pool 15%	Riffle 10%	Run 75%	
	Min	Mean	Max
Stream Widths (m)	0.5	6	8
Bankfull Width (m)	10		
Flow level during survey	Normal		
Stream Bank Erosion	Little		

Riparian Vegetation

Type	% Cover	Description
Trees >10m	35%	Eucalyptus, Casuarina
Trees <10m	50%	Eucalyptus, Acacia, Banksia, Casuari
Shrubs	20%	Native shrubs
Ground Cover	20%	Grasses and ferns
Est. % Native	95%	Est. % Exotic 5%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	30.6	LATITUDE	-34.023670
ALTITUDE	89	LOGDFSM	3.651278
BEDROCK	30	LOGSLOPE1KUS	1.778151
BOULDER	5	LONGITUDE	150.981040
COBBLE	5	RAINFALL	950

Site Code	Site Name and Location	Sample Date
MC4	Mill Creek Downstream	2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge
Replicate	
Method	Sweep
Collected By	Adrian Dickson
Picked By	Adrian Dickson
Sample Depth	30 (cm)

Habitat Feature	% Cover
Blanketing Silt	90%
Shading	60%

Habitat Feature	% Cover
Detritus (leaves/twigs)	30%
Sticks (< 2 cm)	15%
Branches (2-15 cm)	10%
Logs (> 15 cm)	5%
Algae	0%
Macrophytes	15%
Overhanging Habitat	65%

Substrate Composition	% Cover
Bedrock	30%
Boulder (>200 mm)	5%
Cobble (60-200 mm)	5%
Pebble (20-60 mm)	5%
Gravel (2-20 mm)	15%
Sand (0.02-2 mm)	15%
Silt/Clay (<0.02 mm)	25%

Sample Comment

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	3
Microcrustaceans	Crustacea	1
Shrimp, Prawns and Yabbies	Decapoda	1
Flies (larvae)	Diptera	3
Mayflies	Ephemeroptera	2
Snails	Gastropoda	2
Alderflies	Megaloptera	1
Dragonflies and Damselflies	Odonata	3
Caddisflies	Trichoptera	2

Site Code	Site Name and Location	Sample Date
MCUP	Mill Creek Upstream of Duck Pond	2/03/2015

Site/Date Code (PK)	MCUP_02Mar15	Latitude	-34.051190	Longitude	150.966730

Upstream	Downstream
	

In situ Water Quality

Time	Temp. (°C)	pH	EC (µS/cm)	Dissolved Oxygen (% sat, mg/L)		Turb. (NTU)	Alkalinity (mg/L)
16:10	20.29	6.59	207	9.3	0.85	27.1	44

Macroinvertebrate Indicies

Total Taxa Richness	24
EPT Richness	2
SIGNAL 2 (Order)	3.57
SIGNAL 2 (Family)	3.05
SIGNAL-SF	5.24

AUSRIVAS Results

O/E 50*	0.84	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band	A	
Band Name	Reference condition	

* Ratio of Observed taxa/Expected taxa
1 = Reference Condition

NSW AUSRIVAS Assessment of Disturbance Related to Human Activities (Turak et al, 2004)

Site Assessment	Ranking	Description
Water Quality	1	Little disturbance
Instream	1	Little disturbance
Riparian Zone	2	Moderate disturbance
Catchment	2	Moderate disturbance
Score	6	/ 16
Category	Moderate disturbance	

Lower scores indicate less disturbances and better site condition

Reference Site Selection Criteria (DNRM, 2001)

1= Very Major Impact; 5= Indiscernible Impact

Agriculture and Forestry	5	Flow Regime Alteration	3
Sand and Gravel Extraction	3	Vegetation Alteration	3
Upstream Urban Areas	4	Riparian Zone/ Stream Bank Erosion	4
Point source Pollution	5	Geomorphic Change	4
Dams and Weirs	3	Instream Habitat Alteration	4

Score 38 / 50

Reference Site Suitability: Sub-optimal

Higher scores indicate better quality sites

Site Code	Site Name and Location	Sample Date
MCUP	Mill Creek Upstream of Duck Pond	2/03/2015

Modified RCE: Riparian, Channel, and Environmental Inventory (Chessman et al, 1997)

Category	Value	Description
Land-use pattern beyond immediate riparian zone	3	Mixed native vegetation and pasture/exotics
Width of riparian strip of woody vegetation	3	Between 5 and 30 m
Completeness of riparian strip of woody vegetation	2	Breaks at intervals of 10-50 m
Vegetation of the riparian zone within 10 m of channel	3	Mixed native and exotic trees and shrubs
Stream bank structure	3	Banks firm but held mainly by grasses and herbs
Bank undercutting	4	None, or restricted by tree roots or man-made
Channel form	2	Shallow; width:depth ratio greater than 15:1
Riffle/pool Sequence	3	Long pools with infrequent short riffles
Retention devices in streams	2	Rocks/logs present but unstable; no damming
Channel sediment accumulation	1	Braiding by loose sediment
Stream bottom	2	Bottom heavily silted but stable
Stream detritus	3	Some wood, leaves, etc. with much fine detritus
Aquatic vegetation	2	Substantial macrophyte growth; little algal growth
RCE Total Score	33	/52 Very Good

Higher scores indicate less disturbances and better site condition

Recommended actions to address riparian condition: **Selected alterations and monitoring for changes**

Habitat, Geomorphology and Flow

Length of reach surveyed	100	(m)			
Pool	70%	Riffle	0%	Run	30%

	Min	Mean	Max
Stream Widths (m)	3	4	6
Bankfull Width (m)	15		
Flow level during survey	Normal		
Stream Bank Erosion	Little		

Riparian Vegetation

Type	% Cover	Description
Trees >10m	10%	Casuarina
Trees <10m	25%	Casuarina
Shrubs	25%	Native shrubs and rushes
Ground Cover	10%	Native and exotic grasses and herbs
Est. % Native	85%	Est. % Exotic 15%

AUSRIVAS Environmental Variables

Model: NSW - Autumn - Edge

ALKALINITY	44	LATITUDE	-34.051190
ALTITUDE	157	LOGDFSM	2.602060
BEDROCK	0	LOGSLOPE1KUS	1.778151
BOULDER	5	LONGITUDE	150.966730
COBBLE	5	RAINFALL	950

Site Code	Site Name and Location	Sample Date
MCUP	Mill Creek Upstream of Duck Pond	2/03/2015

Macroinvertebrate Sample Data and Summary of Results

Macroinvertebrate Sample Details

Habitat	Edge	Replicate	
Method	Sweep		
Collected By	Adrian Dickson		
Picked By	Adrian Dickson		
Sample Depth	30	(cm)	

Habitat Feature	% Cover
Blanketing Silt	70%
Shading	60%

Habitat Feature	% Cover
Detritus (leaves/twigs)	15%
Sticks (< 2 cm)	5%
Branches (2-15 cm)	5%
Logs (> 15 cm)	0%
Algae	0%
Macrophytes	20%
Overhanging Habitat	40%

Substrate Composition	% Cover
Bedrock	0%
Boulder (>200 mm)	5%
Cobble (60-200 mm)	5%
Pebble (20-60 mm)	5%
Gravel (2-20 mm)	10%
Sand (0.02-2 mm)	15%
Silt/Clay (<0.02 mm)	60%

Sample Comment

Macroinvertebrate Orders Present

CommonName	Class/ Order	N Families
Mites	Acarina	1
Beetles	Coleoptera	3
Microcrustaceans	Crustacea	3
Flies (larvae)	Diptera	4
Mayflies	Ephemeroptera	1
True Bugs	Hemiptera	5
Leeches	Hirudinea	1
Dragonflies and Damselflies	Odonata	4
Caddisflies	Trichoptera	1
Flatworms	Turbellaria	1

Appendix B - Macroinvertebrate Data

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	MCUP	MC1	MC2	MC3	MC4
IF619999	Turbellaria	Dugesiidae	4	1	1	3	
KG059999	Gastropoda	Lymnaeidae			1		
KG069999	Gastropoda	Ancylidae			1		
KG079999	Gastropoda	Planorbidae					1
KG089999	Gastropoda	Physidae		3	7	6	2
LH019999	Hirudinea	Glossiphoniidae	3				
LO999999	Oligochaeta	Oligochaeta			1		
MM999999	Acarina	Acarina	14	1	3	7	13
OG999999	Crustacea	Cladocera	2				
OH999999	Crustacea	Ostracoda	4	5	1	2	2
OJ999999	Crustacea	Copepoda	1				
OR999999	Isopoda	Isopoda				1	
OV019999	Decapoda	Parastacidae					1
QC069999	Coleoptera	Haliplidae				1	
QC099999	Coleoptera	Dytiscidae	11	4	4	4	3
QC109999	Coleoptera	Gyrinidae			1		1
QC119999	Coleoptera	Hydrophilidae	12			3	2
QC209999	Coleoptera	Scirtidae	18				
QC379999	Coleoptera	Psephenidae				1	
QD079999	Diptera	Culicidae	3				
QD099999	Diptera	Ceratopogonidae	2	1	2	1	
QD249999	Diptera	Stratiomyidae		1			
QDAE9999	Diptera	Tanypodinae	1	6	12		4
QDAF9999	Diptera	Orthocladiinae					1
QDAJ9999	Diptera	Chironominae	5	10	7	18	16
QE029999	Ephemeroptera	Baetidae	6	3	3	1	1
QE069999	Ephemeroptera	Leptophlebiidae					6
QE089999	Ephemeroptera	Caenidae		1		1	
QH549999	Hemiptera	Hydrometridae			2		
QH569999	Hemiptera	Veliidae	4	2	4		
QH579999	Hemiptera	Gerridae		2	1		
QH619999	Hemiptera	Nepidae		1			
QH649999	Hemiptera	Gelastocoridae			2	1	
QH659999	Hemiptera	Corixidae	6	6	1		
QH669999	Hemiptera	Naucoridae	13				
QH679999	Hemiptera	Notonectidae	18	12	10		
QH689999	Hemiptera	Pleidae	8				
QM029999	Megaloptera	Sialidae		2	1	1	5
QO029999	Odonata	Coenagrionidae	36	24	5	3	1
QO039999	Odonata	Isostictidae		1	1	1	1

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	MCUP	MC1	MC2	MC3	MC4
QO079999	Odonata	Megapodagrionidae		4	7	3	2
QO129999	Odonata	Aeshnidae	3	7	7		
QO179999	Odonata	Libellulidae	5	10	3	1	
QO309999	Odonata	Hemicorduliidae	2	3	3		
QT089999	Trichoptera	Ecnomidae		5	1		2
QT259999	Trichoptera	Leptoceridae	5	1		3	3

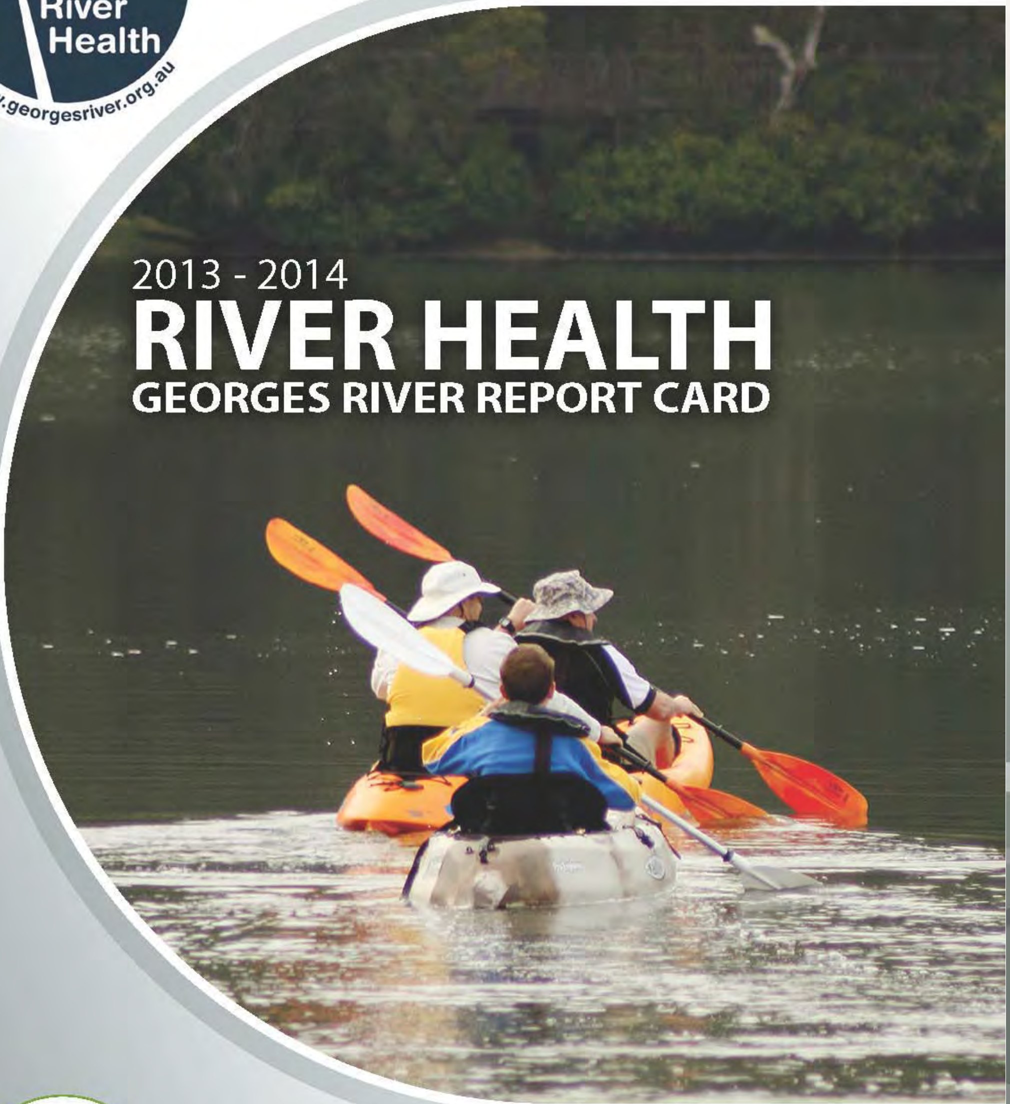
Appendix C - AUSRIVAS Macroinvertebrate Taxa Expected to occur but not Observed

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	SIGNAL 2 Grade (Family)	SIGNAL-SF Grade
IF419999	Turbellaria	Temnocephalidae	5	8
IJ019999	Nematomorpha	Gordiidae	5	6
KG029999	Gastropoda	Hydrobiidae	4	3
KG049999	Gastropoda	Thiaridae	4	
KP029999	Bivalvia	Corbiculidae	4	3
OP029999	Amphipoda	Ceinidae	2	
OP039999	Amphipoda	Eusiridae	7	8
OR129999	Isopoda	Cirolanidae	2	
OT019999	Decapoda	Atyidae	3	6
OT029999	Decapoda	Palaemonidae	4	3
QC089999	Coleoptera	Noteridae	4	1
QC139999	Coleoptera	Hydraenidae	3	6
QC189999	Coleoptera	Staphylinidae	3	
QC349999	Coleoptera	Elmidae	7	7
QD019999	Diptera	Tipulidae	5	7
QD069999	Diptera	Dixidae	7	9
QD109999	Diptera	Simuliidae	5	4
QD119999	Diptera	Thaumaleidae	7	9
QD229999	Diptera	Athericidae	8	8
QDAD9999	Diptera	Podonominae	6	
QE039999	**Ephemeroptera**	**Oniscigastridae**	**8**	**9**
QE059999	**Ephemeroptera**	**Coloburiscidae**	**8**	**8**
QH529999	Hemiptera	Mesoveliidae	2	6
QH539999	Hemiptera	Hebridae	3	5
QL019999	Lepidoptera	Crambidae	3	
QM019999	Megaloptera	Corydalidae	7	7
QO049999	Odonata	Protoneuridae	4	4
QO059999	Odonata	Lestidae	1	7
QO089999	Odonata	Synlestidae	7	7
QO139999	Odonata	Gomphidae	5	6
QO169999	Odonata	Corduliidae	5	5
QP029999	**Plecoptera**	**Austroperlidae**	**10**	**10**
QP039999	**Plecoptera**	**Gripopterygidae**	**8**	**9**
QP049999	**Plecoptera**	**Notonemouridae**	**6**	**8**
QT019999	**Trichoptera**	**Hydrobiosidae**	**8**	**8**
QT039999	**Trichoptera**	**Hydroptilidae**	**4**	**6**
QT049999	**Trichoptera**	**Philopotamidae**	**8**	**8**
QT069999	**Trichoptera**	**Hydropsychidae**	**6**	**6**
QT079999	**Trichoptera**	**Polycentropodidae**	**7**	**10**
QT139999	**Trichoptera**	**Tasimiidae**	**8**	**8**
QT159999	**Trichoptera**	**Conoesucidae**	**7**	**7**
QT179999	**Trichoptera**	**Helicopsychidae**	**8**	**10**
QT189999	**Trichoptera**	**Calocidae**	**9**	**9**
QT219999	**Trichoptera**	**Philorheithridae**	**8**	**9**

AUSRIVAS Taxa Code	Class/Order	Family/Sub-family	SIGNAL 2 Grade (Family)	SIGNAL-SF Grade
QT229999	**Trichoptera**	**Odontoceridae**	**7**	**10**
QT239999	**Trichoptera**	**Atriplectididae**	**7**	**8**
QT249999	**Trichoptera**	**Calamoceratidae**	**7**	**8**
Average SIGNAL Grade			5.66	6.98
% SIGNAL Grade ≥ 4 (Interim NSW SIGNAL 2 Score)			81%	N/A
Total EPT Taxa			18	
Average SIGNAL Grade of EPT Taxa			7.44	8.39

Appendix D – 2013 / 2014 River Health Georges River Report Card

River Health
www.georgesriver.org.au



2013 - 2014
RIVER HEALTH
GEORGES RIVER REPORT CARD

2012 National Landcare Awards WINNER

GRCCC
Georges River Combined Councils' Committee Inc.

B- B OVERALL SCORE GEORGES RIVER

OVERALL RIVER HEALTH

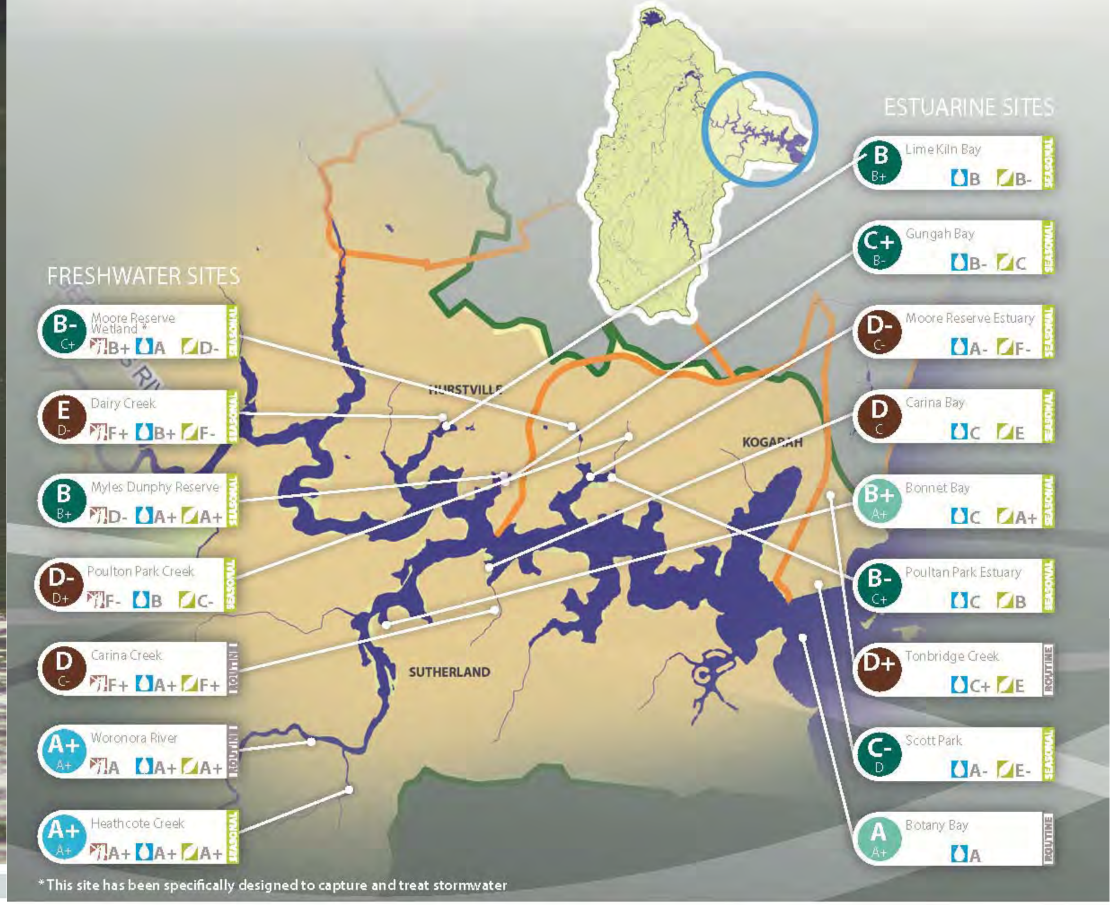
Results from 2013-14 River Health monitoring show the overall grade for the Georges River catchment marginally decreased when compared to the previous year, a result which is likely attributed to severe weather events negatively impacting water quality. However, this result does not indicate significant change and the overall ecological condition of the catchment remained 'Fair'.

After a wet start to the 2013 winter, annual rainfall across the catchment was below average. Warm and dry weather in spring 2013 and autumn 2014 was punctuated by periods of intense rainfall causing flash flooding in many of the urban creeks throughout the catchment. As a result, many of these creeks recorded degraded water quality caused by an influx of stormwater.

Urban stormwater combined with degraded and fragmented riparian vegetation corridors negatively affect macroinvertebrate communities. Urban streams throughout the catchment revealed macroinvertebrate communities dominated by pollution tolerant species with little or no pollution sensitive species present.

This contrasts with waterways in the non-urban areas of the catchment where diverse macroinvertebrate communities rich in pollution sensitive species were recorded. These waterways are not affected by stormwater, and therefore maintain 'Good' to 'Excellent' ecological condition displaying greater resilience to the variable rainfall experienced in 2013-14.

Estuary conditions in the Georges River were 'Fair'. Intense rainfall events of 2013-14 followed by long periods of sunshine resulted in occasional algal blooms. In addition, litter consisting mainly of plastics, was visible throughout the year in the estuarine reaches of the Georges River.



*This site has been specifically designed to capture and treat stormwater

LOWER GEORGES RIVER | 7 FRESHWATER SITES 9 ESTUARINE SITES

NSW GOVERNMENT | Local Land Services Greater Sydney
CooksRiver ALLIANCE
Georges River Environmental Education Centre NSW Department of Education & Training
GRCCC Georges River Combined Councils' Committee Inc.

RIVER HEALTH REPORT CARD 2013 - 2014

A SNAP-SHOT OF RIVER HEALTH

In 2013-14 the River Health Monitoring Program entered its fifth year of monitoring in the Georges River catchment.

River Health monitors three important ecological indicators to provide an assessment of catchment health; water quality, vegetation and macroinvertebrates.

By combining results of ecological indicators a greater understanding of the Georges river system is gained. In particular, River Health is investigating the pressures and impacts of an increasingly urbanised catchment.

River Health encourages participation of community members in monitoring activities. Volunteers work alongside ecologists collecting data integral to assessing the ecological condition of Georges River.

Since 2009, volunteers have contributed over 4,000 hours of field work to the program while gaining a valuable insight into dynamic nature of the Georges River system.

MACROINVERTEBRATES

Macroinvertebrates are small animals without a backbone, such as snails, worms, and dragonfly nymphs. They live in freshwater creeks and streams and are particularly sensitive to changes in water quality. River Health surveys macroinvertebrates in spring and autumn each year. Monitoring these animals provides an increased understanding of how aquatic ecosystems within the Georges River catchment respond to environmental pressures.

WATER QUALITY

Water quality is an important factor to maintaining a healthy ecosystem. River Health monitors water quality in streams, wetlands and estuaries of the Georges River throughout the year. Monitoring water quality is providing us with a better understanding of how urbanisation and changed land use practices are affecting the health of the river estuarine ecosystems.

VEGETATION

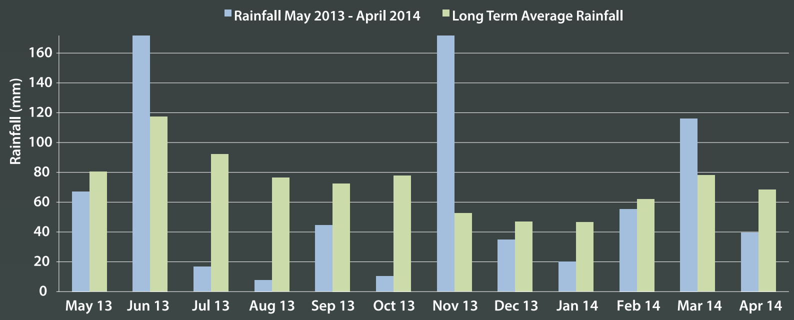
Healthy vegetation communities are important for maintaining a functioning ecosystem. Vegetation plays a major role in providing habitat, nutrient cycling, regulation of temperature and filtration of urban runoff. River Health assesses riparian (stream bank) and estuarine vegetation every three years. By monitoring these communities we are gaining a better understanding of their role in maintaining healthy ecosystems in the Georges River Catchment.

GEORGES RIVER

The Georges River catchment covers an area of approximately 960 km2 and has a population of over 1 million people. It begins its journey 60km south west of Sydney near the town of Appin and flows north towards Liverpool, before turning east at Chipping Norton Lakes and enters the sea at Botany Bay.

The river has a number of important tributaries including Bunbury Curran Creek, Cabramatta Creek, Prospect Creek, Mill Creek and the Woronora River. Land use within the catchment includes industrial, agricultural and mining while approximately 45% remains in natural or near natural condition.

GEORGES RIVER CATCHMENT SEASONAL RAINFALL



Bureau of Meterology 2014

GEORGES RIVER COUNCILS ARE IMPROVING RIVER HEALTH

HURSTVILLE CITY COUNCIL
HURSTVILLE GOLF COURSE

Hurstville City Council has completed the construction of a large scale stormwater harvesting and reuse project to secure the future irrigation needs of the Hurstville Golf Course. The scheme will harvest over 50 ML of stormwater per year and save 21ML of potable water per annum. The improved water quality and enhanced biodiversity which has resulted from the project will provide significant environmental benefits for Lime Kiln Bay, within the Georges River in Sydney.

LIVERPOOL CITY COUNCIL

In 2013-14, Liverpool City Council has undertaken environmental restoration works in the Georges River catchment to the value of $368,000 covering an approximate area of 76,000m2. Council also supports 11 environment groups undertaking bush regeneration, one Streamwatch group and delivers environmental education to the community.

ROCKDALE CITY COUNCIL
HAWTHORNE STREET NATURAL AREA

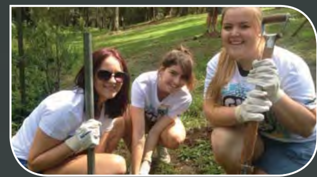
Hawthorne St Natural Area in Ramsgate is a 'show piece' of original flora and fauna of western Botany Bay. Many habitats are present here including Kurnell Dune Forest and Swamp Oak Floodplain Forest – both endangered ecological communities. It also provides habitat to threatened fauna and is key fish breeding habitat. Rockdale Council, along with Bushcare volunteers, corporate groups and Riverkeeper teams are undertaking bush regeneration on-site to rehabilitate bushland and re-establish creek bank vegetation.

KOGARAH CITY COUNCIL
CARSS PARK ENVIRONMENTALLY FRIENDLY SEAWALL

Urban waterways are fragmented environments, resulting in the loss of natural habitats and a decline in biodiversity. The Carss Park seawall project aims to reconnect the foreshore by replicating natural intertidal habitats, including saltmarsh, rocky intertidal and mudflats, through constructing an environmentally friendly seawall. The Carss Park seawall will create diverse, intertidal habitats resulting in the migration of organisms through the Georges River and increasing the biodiversity of the Kogarah foreshore.

CAMPBELLTOWN CITY COUNCIL
DRAIN STENCIL PROGRAM

A community inspired drain stencilling program with local primary schools promotes environmental stewardship through catchment education workshops. Participating schools then apply their learned knowledge to design drain stencils that aim to change community behaviors' to reduce pollutants entering our stormwater and their impacts on our waterways and catchments. The designs are used to produce stencils for stormwater drain lids with messages that promote awareness of the connectivity of the stormwater systems within the natural environment.



SUTHERLAND SHIRE COUNCIL
IMPROVING CARINA CREEK

In 2013-14 Sutherland Shire Council invested $60,000 on works along Carina Creek between Wiak Rd and Carina Bay. This included noxious weed control, bush regeneration and 1,500 seedlings planted. Members of Optus Rockcorps also gave their time to improve riparian vegetation at Carina Bay Reserve. Volunteers and council staff planted 50 x 200mm trees and undertook weed removal in the bushland below Riverview Rd.

BANKSTOWN CITY COUNCIL
LAKE GILLAWARNA

In 2013-14 Bankstown City Council completed a water quality and natural area improvement project at Lake Gillawarna, Georges Hall. The project involved planting 29,000 locally native plants in and around the lake; restoration and rehabilitation of habitat features on the main island within the lake; control of invasive weeds and feral aquatic species such as European Carp; and creating two visitor interaction areas.

FAIRFIELD CITY COUNCIL
BARAGOOLA ST BANK STABILISATION PROJECT

A 46m length of severely eroded creek bank has been stabilised using sandstone rocks, coir logs, in-stream large woody debris and landscaping works. An upstream bund has been constructed to control a localised break out point, resulting in creek flows being held within banks. The woody debris centralises creek flows during minor storm events and provides fauna habitat. Landscaping with native vegetation also provides important habitat for local wildlife and improves diversity, water quality and aesthetics of the area.

WOLLONDILLY SHIRE COUNCIL
1ST APPIN SCOUT GROUP

1st Appin scout group were successful in receiving a grant from Keep Australia Beautiful to implement a program to reduce the problem of litter and waste around Kennedy Creek. They partnered with Wollondilly Shire Council to;

- Setup a public recycling and waste disposal station and signage in the car park
- Install signage identifying the location of the public toilets.
- Engage Appin primary school in council's 'Adopt an Environment' program with a focus on waste reduction, recycling and composting.

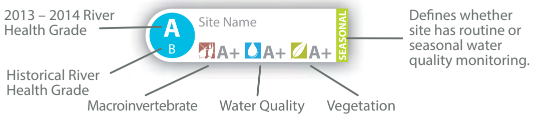
GRADING SYSTEM

River Health indicators are assessed against environmental guidelines allowing the award of a grade between A+ and F-.

GRADE	CONDITION
A+	EXCELLENT
A - B+	GOOD
B - C-	FAIR
D+ - F-	POOR

INTERPRETING GRADING ICONS

This diagram shows an example grading box. Use this example to interpret the results from the individual sub catchments.



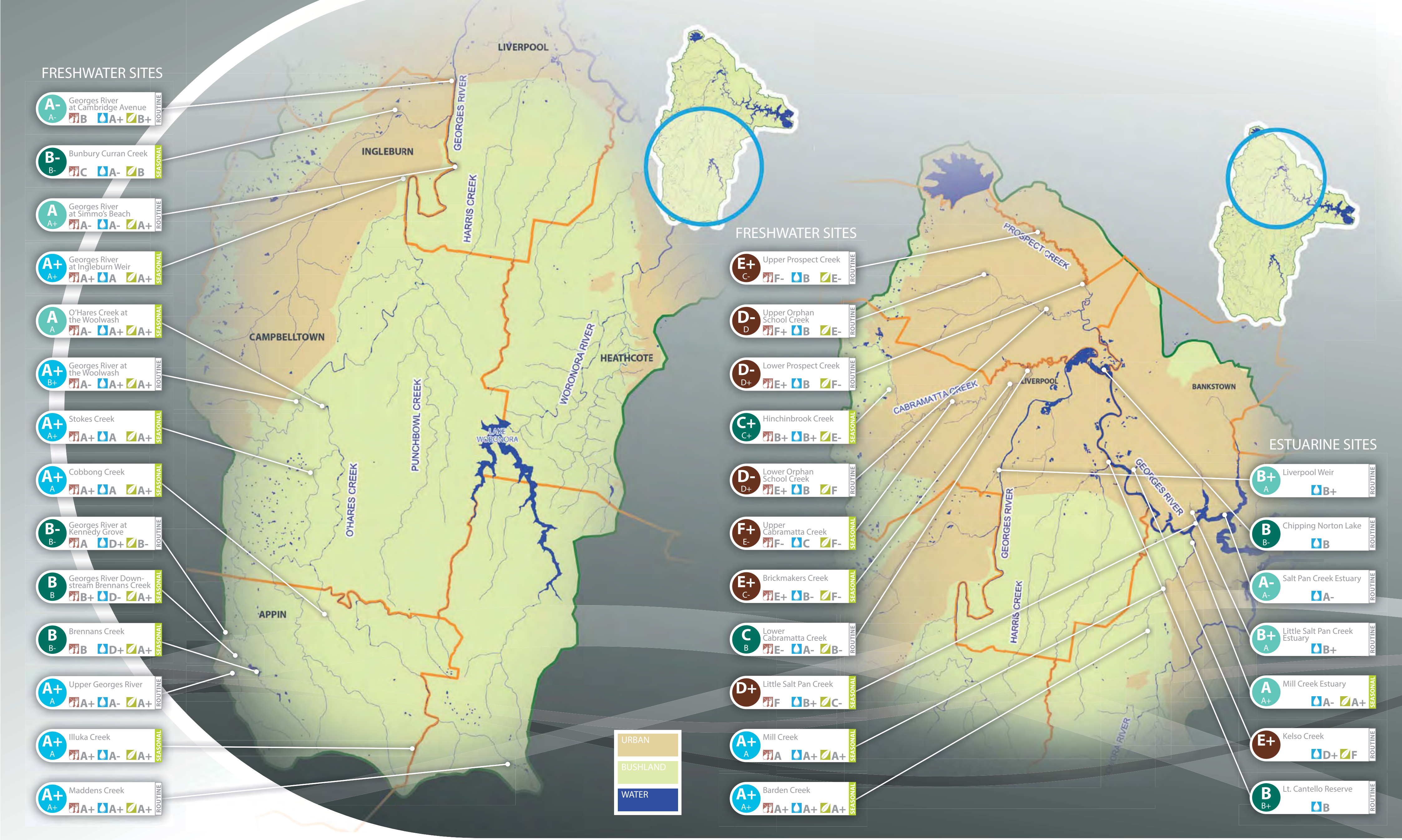
The GRCCC represents member councils in the Georges River catchment of NSW including Bankstown, Campbelltown, Fairfield, Hurstville, Kogarah, Liverpool, Rockdale, Sutherland and Wollondilly.

The River Health Monitoring Program is being undertaken in association with Georges River Environmental Education Centre and the Cooks River Alliance. River Health is funded by the member councils of the GRCCC.

FIND US AT

Georges River, NSW
georgesriver.org.au

Acknowledgments: The River Health Monitoring Program was developed by C. Tippler, A. Hanlon and P. Birtles and is modeled on the following existing programs: 1. EHMP (2008). Ecosystem Health Monitoring Program 2006–07 Annual Technical Report. South East Queensland Healthy Waterways Partnership, Brisbane. Centre for Environmental Management, Central Queensland University. 2. IWC (2009). Cobaki and Terranora Ecosystem Health Monitoring Program. 2009 technical report. International Water Centre, Brisbane. 3. Story A.W, Anderson L.E, Lynas J & Melville F (2007). Port Curtis Ecosystem Health Report Card. Port Curtis Integrated Monitoring Project (PCIMP). Cover Photography by C. Ebejer.



FRESHWATER SITES

Georges River at Cambridge Avenue	A-	A-	B	A+	B+	ROUTINE
Bunbury Curran Creek	B-	B-	C	A-	B	SEASONAL
Georges River at Simmo's Beach	A	A+	A-	A-	A+	ROUTINE
Georges River at Ingleburn Weir	A+	A+	A+	A	A+	SEASONAL
O'Hares Creek at the Woolwash	A	A	A-	A+	A+	SEASONAL
Georges River at the Woolwash	A+	B+	A-	A+	A+	ROUTINE
Stokes Creek	A+	A+	A+	A	A+	SEASONAL
Cobbong Creek	A+	A	A+	A	A+	SEASONAL
Georges River at Kennedy Grove	B-	B-	A	D+	B-	ROUTINE
Georges River Down-stream Brennans Creek	B	B	B+	D-	A+	SEASONAL
Brennans Creek	B	B-	B	D+	A+	SEASONAL
Upper Georges River	A+	A	A+	A-	A+	ROUTINE
Illuka Creek	A+	A	A+	A-	A+	SEASONAL
Maddens Creek	A+	A+	A+	A+	A+	ROUTINE

FRESHWATER SITES

Upper Prospect Creek	E+	C-	F-	B	E-	ROUTINE
Upper Orphan School Creek	D-	D	F+	B	E-	ROUTINE
Lower Prospect Creek	D-	D+	E+	B	F-	ROUTINE
Hinchinbrook Creek	C+	C+	B+	B+	E-	SEASONAL
Lower Orphan School Creek	D-	D+	E+	B	F	ROUTINE
Upper Cabramatta Creek	F+	E-	F-	C	F-	SEASONAL
Brickmakers Creek	E+	C-	E+	B-	F-	SEASONAL
Lower Cabramatta Creek	C	B	E-	A-	B-	ROUTINE
Little Salt Pan Creek	D+		F	B+	C-	SEASONAL
Mill Creek	A+	A	A	A+	A+	SEASONAL
Barden Creek	A+	A+	A+	A+	A+	SEASONAL

ESTUARINE SITES

Liverpool Weir	B+	A	B+		ROUTINE
Chipping Norton Lake	B	B-	B		ROUTINE
Salt Pan Creek Estuary	A-	A-	A-		ROUTINE
Little Salt Pan Creek Estuary	B+	A	B+		ROUTINE
Mill Creek Estuary	A	A+	A-	A+	SEASONAL
Kelso Creek	E+		D+	F	ROUTINE
Lt. Cantello Reserve	B	B+	B		ROUTINE

UPPER GEORGES RIVER | 14 FRESHWATER SITES

MID GEORGES RIVER | 11 FRESHWATER SITES 7 ESTUARINE SITES

Wollondilly Shire Council
campbelltown city council
Liverpool city council creating our future together
Fairfield City Celebrating diversity
Bankstown City of Progress
Hurstville City Council
Kogarah City Council
Rockdale City Council
Sutherland Shire Council
Australian museum
Streamwatch

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