SITA Australia

Lucas Heights Resource Recovery Park Project

Environmental Impact Statement

VOLUME 4 – APPENDICES

October 2015

WATER | ENERGY & RESOURCES | ENVIRONMENT | PROPERTY & BUILDINGS | TRANSPORTATION

SITA Australia is changing brand to SUEZ

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SITA Australia

Lucas Heights Resource Recovery Park Project
Surface Water Assessment

August 2015

Executive summary

SITA Australia (SITA) in conjunction with Sutherland Shire Council (SSC) is proposing a number of activities at the Lucas Heights Resource Recovery Park (LHRRP). This report has been prepared by GHD Pty Ltd (GHD) to provide an assessment of soils and surface water and leachate from the GO and ARRT facilities associated with the proposal as an input to the environmental impact statement. Leachate from the landfilled waste and groundwater assessments are presented in separate reports prepared by GHD.

Key outcomes of this assessment include:

- With the implementation of the measures proposed in this report it is not expected that the proposal would result in an unacceptable impact in terms of sediment discharge to downstream waterways
- It is not expected that the activities associated with the proposal would result in a major increase in potable water demand
- Stormwater discharged from the site is not expected to have any unacceptable impacts on flooding conditions downstream
- Leachate from the GO and ARRT facilities would be utilised for composting the materials and a portion disposed of to sewer, with leachate not expected to be able to be discharged to surface water
- Re-profiling and re-capping of areas would reduce the potential risk of leachate entering the surface water system

Therefore, the proposal is not expected to result in any unacceptable impacts relating to surface waters.

Mitigation measures are proposed to manage risks and achieve these outcomes, with key mitigation measures listed below:

- Separation of clean and sediment laden water with clean water diverted offsite and disturbed area runoff managed in the site surface water management system
- Minimisation of exposed areas at any point in time. In particular, the staging of the landfill would be developed such that the capped and revegetated area of the site would generally increase during the waste reprofiling works with the consequential reduction in the erosion potential of the LHRRP
- Utilisation of the main sediment basin as both a Type D sediment basin in accordance with *Managing Urban Stormwater: Soils and Construction Volumes 1 and 2b* as well as water reuse to limit reliance on potable water
- All surface water from the site would be treated in sediment basins before it is discharged off-site in accordance with the EPA’s guidelines for sediment and erosion control for landfills
- Diversion of surface water in suitably sized stormwater diversion channels and berms
- Lined containment structures to suitably contain leachate from the GO and ARRT facilities
- Re-profiling and re-capping of areas to reduce the potential risk of leachate entering the surface water system

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

- Prevention of surface water contamination
- Minimising sediment generation and transport off the site
- Minimising soil erosion
- No significant impact to downstream flow conditions

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Glossary

Term	Definition
ANSTO	Australian Nuclear Science and Technology Organisation
ARRT facility	Advanced Resource Recovery Technology facility
Disturbed Runoff	Runoff from unsealed areas where mobilisation of sediment is likely
EIS	Environmental Impact Statement
EPA	New South Wales Environment Protection Authority and any successor body
EP&A Act	*Environmental Planning and Assessment Act 1979*
Currently approved landform	The currently approved landform heights and contours outlined in the 1999 EIS
GIS	Geographic Information Systems
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
GLALC	Gandangara Local Aboriginal Land Council
Landform reprofiling	Proposed changes to currently approved landform at the LHRRP.
LHRRP	Lucas Heights Resource Recovery Park
Mitigation	The application of techniques to reduce environmental impacts arising from the proposal
OEMP	Operational Environment Management Plan and all relevant future documents, these will be provided for the landfill, GO and ARRT and will detail how these projects can be managed to meet the environmental outcomes for the site
PCYC Mini-Bike Club	The mini-bike club operated by the Police and Community Youth Clubs NSW Limited (PCYC).
SSC	Sutherland Shire Council
SEAR	Secretary's Environmental Assessment Requirements (formerly known as Director-General’s Requirements or DGRs)
SICTA	Sydney International Clay Target Association and any successor body
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.

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 surface water impacts 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. SITA is the proponent of the proposal and 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, 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 water quality 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:

- Prevention of surface water contamination within and beyond the landfill
- Minimising sediment generation and transport off the site
- Minimising soil erosion
- No significant impact to downstream flow conditions

1.3 Proposal overview

The LHRRP consists of approximately 205 hectares (ha) in two ownerships. 89 ha is 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'. The proposal would not have a significant impact on the community. 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

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[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.

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.

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.

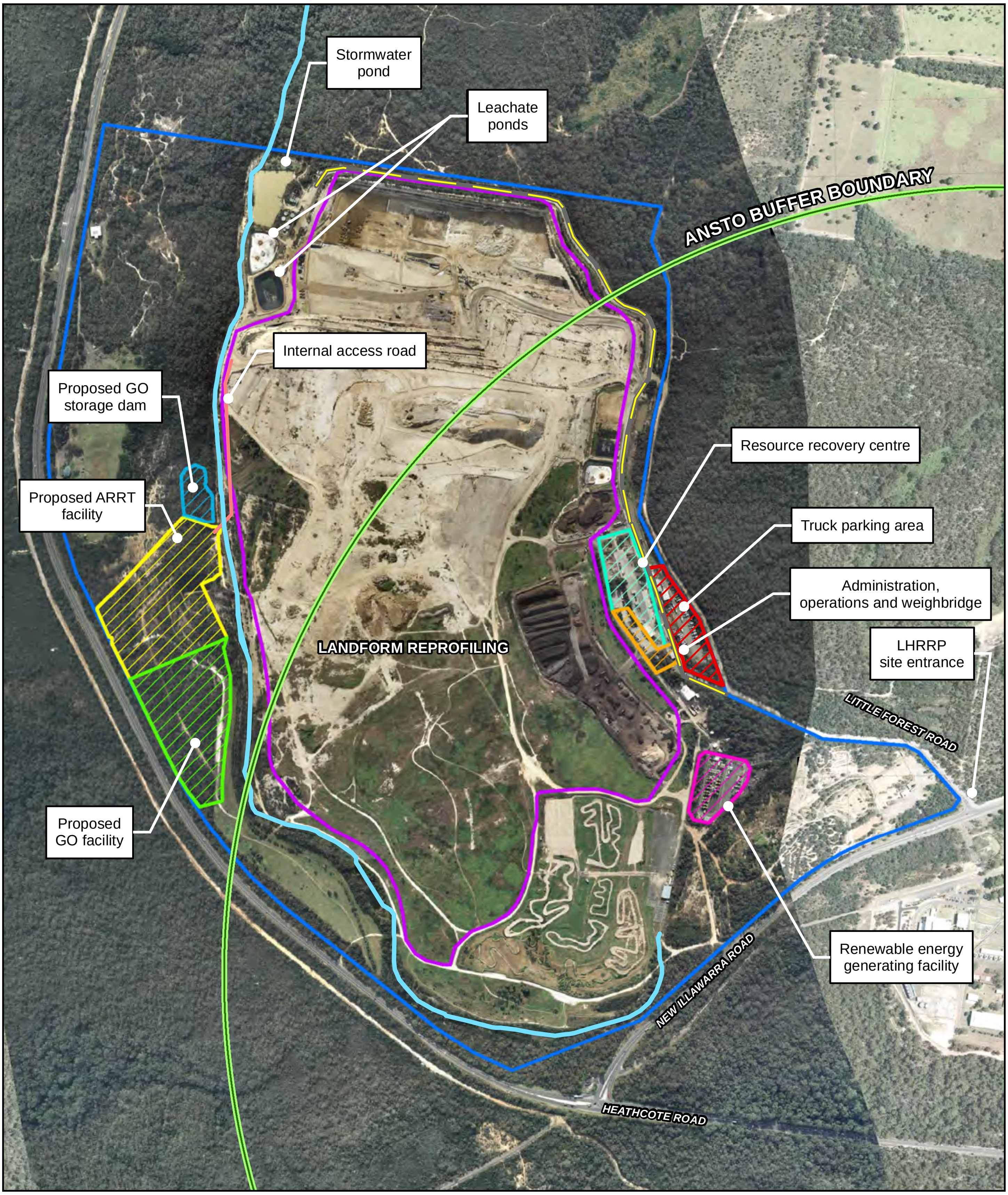
- **Relocation and expansion of the existing garden organics (GO) facility**. The existing garden organics facility would be relocated to the western side of the site adjacent to Heathcote Road. Approval is being sought to increase the approved capacity from 55,000 to 80,000 tonnes of green waste and 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.
- **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.
- **Community parkland**. The landfill reprofiling would increase the area available for future passive recreation following site closure from 124 ha (existing approved parkland) to a total of 149 ha, an increase of approximately 25 ha. Landfilling would cease in 2037 after which time the site would be rehabilitated and converted to a 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.



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

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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

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

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Lucas Heights Resource Recovery Park

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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 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)

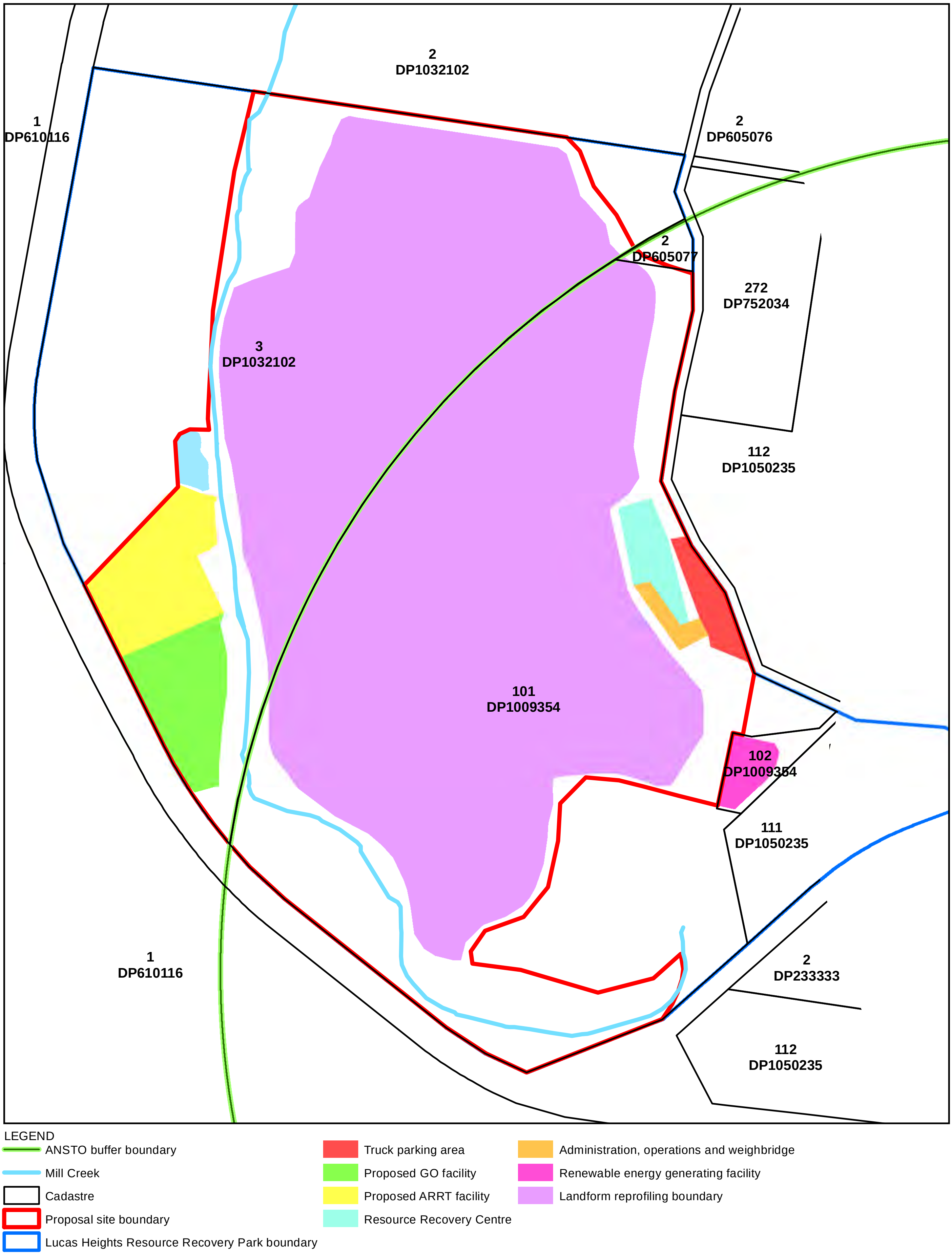
- The Ridge Sports Complex, a major regional sporting facility being developed on the site of the former Lucas Heights Waste and Recycling Centre (approximately 2.5 km to the north east)
- Lucas Heights Conservation Area (immediately to the north of the LHRRP)
- The suburbs of North Engadine (approximately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

Figure 1.3 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 1.3.



Paper Size A4

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Metres

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

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Lucas Heights Resource Recovery Park

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Date	25 Jun 2015

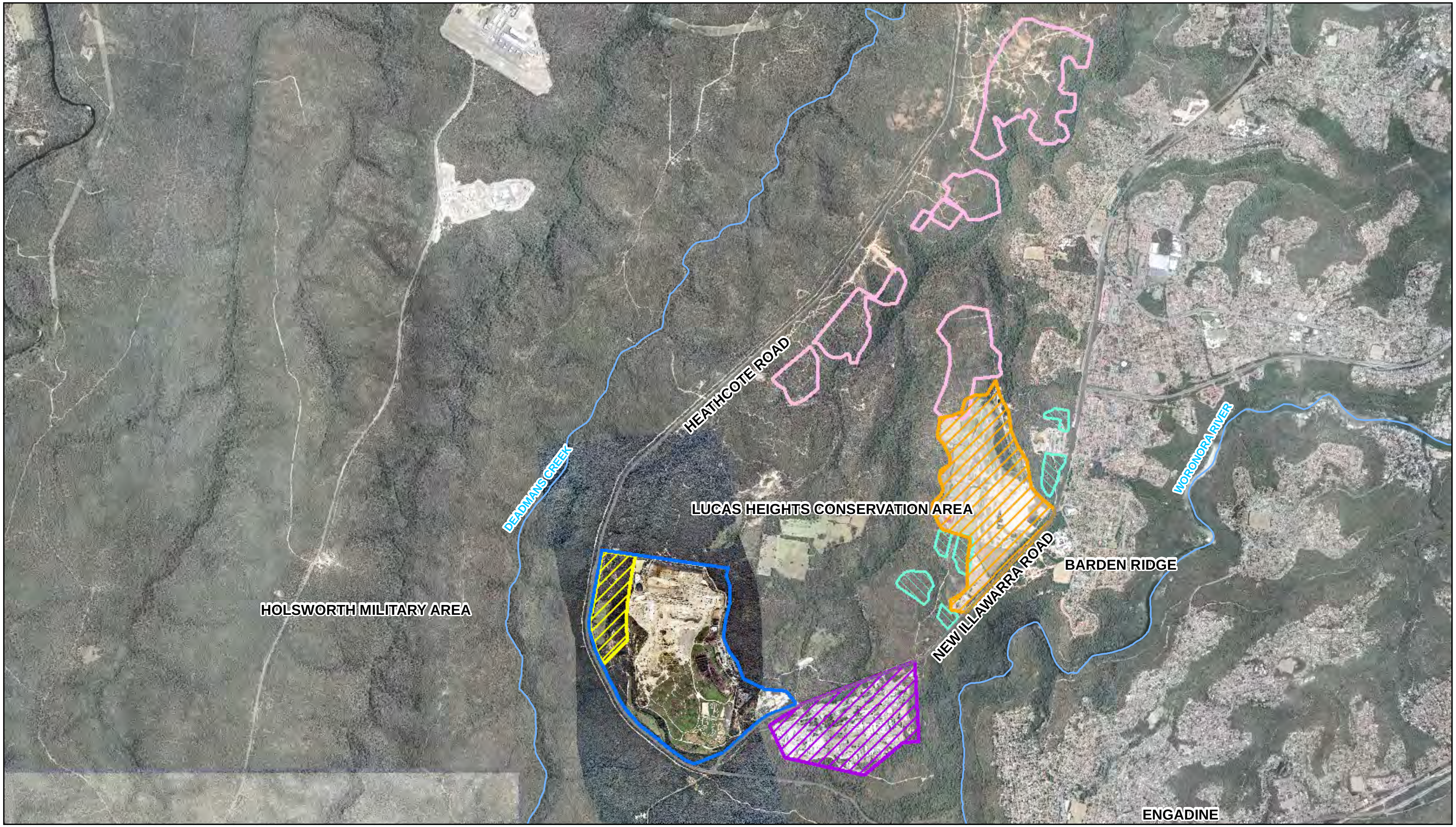
The proposal site

Figure 1.3

G:\21\23482\GIS\Maps\MXD\21-23482-Z059_TheProposalSite.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:afoddy



Paper Size A4

0 250 500 1,000 1,500

Metres

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

N

Legend

- ▭ LHRRP boundary
- ▨ SICTA boundary
- ▨ ANSTO
- ▨ Barden Ridge Sports Complex
- — Potential future receptors
- ▨ Future receptors – Residential

GHD

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Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	B
Date	14 Aug 2015

Surrounding landuses

Figure 1.4

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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: SITA, 2014. Works: GHD/SITA, 2014. Roads: NSW LPMA, 2012. 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
A detailed water balance for the development, outlining the measures to minimise water use and any potential for a sustainable water supply	Section 4.3, Section 6.3, Section 7.2.2
The proposed erosion and sediment controls during construction and operation	Section 4.2, Section 6.2, Section 7.2
The proposed stormwater management system, including the capacity of onsite detention systems, and measures to treat, reuse or dispose of water	Section 6, Section 7
Consideration of the potential salinity, contamination, flooding and acid sulfate soil impacts of the development	Section 4.4, Section 6.4, Section 7.2.3
Agency requirements	
NSW EPA	
Cover letter 6. Assessment of the storm water controls for the landfill and whether the proposed storage capacity is adequate for the proposed additional waste.	Section 2.4, Section 6
B The Proposal Provide details of the project that are essential for predicting and assessing impacts to waters: a) including the quantity and physio-chemical properties of all potential water pollutants and the risks they pose to the environment and human health, including the risks they pose to Water Quality Objectives in the ambient waters (as defined on http://www.environment.nsw.gov.au/ieo/index.htm, using technical criteria derived from the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC 2000) b) the management of discharges with potential for water impacts c) drainage works and associated infrastructure; land-forming and excavations; working capacity of structures; and water resource requirements of the proposal	Section 1.3, Section 2.4, Section 4.5, Section 5, Section 6, Section 7
Outline site layout, demonstrating efforts to avoid proximity to water resources (especially for activities with significant potential impacts eg effluent ponds) and showing potential areas of modification of contours, drainage etc.	Section 6, Section 7
Outline how total water cycle considerations are to be addressed showing total water balances for the development (with the objective of minimising demands and impacts. on water resources). Include water requirements (quantity, quality and source(s) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options	Section 6.3
C The location Describe the catchment including proximity of the development to any waterways and provide an assessment of their sensitivity/significance from a public health, ecological and/or economic perspective. The Water Quality and River Flow Objectives on the website: http://www.environment.nsw.gov.au/ieo/index.htm should be used	Section 1.3, Section 1.4, Section 2, Section 4.5, Section 5, Section 6

to identify the agreed environmental values and human uses for any affected waterways. This will help with the description of the local and regional area.	
E. The Environmental Issues ***Describe baseline conditions*** • Describe existing surface and groundwater quality - an assessment needs to be undertaken for any water resource likely to be affected by the proposal and for all conditions (e.g. a wet weather sampling program is needed if runoff events may cause impacts). *Note: Methods of sampling and analysis need to conform with an accepted standard (e.g. Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC 2004) or be approved and analyses undertaken by accredited laboratories).* • Provide site drainage details and surface run off yield. • State the ambient Water Quality and River Flow Objectives for the receiving waters. These refer to the community's agreed environmental values and human uses endorsed by the Government as goals for the ambient waters. These environmental values are published on the website: http://www.environment.nsw.gov.aulieolindex.htm. The EIS should state the environmental values listed for the catchment and waterway type relevant to your proposal. NB: A consolidated and approved list of environmental values are not available for groundwater resources. Where groundwater may be affected the EIS should identify appropriate groundwater environmental values and justify the choice. • State the indicators and associated trigger values or criteria for the identified environmental values. This information should be sourced from the ANZECC 2000 Guidelines for Fresh and Marine Water Quality (http://www.environment.gov.au/water/publications/guality/nwgms-guidelines-4-vol1.html) (Note that, as at 2004, the NSW Water Quality Objectives booklets and website contain technical criteria derived from the 1992 version of the ANZECC Guidelines. The Water Quality Objectives remain as Government Policy, reflecting the community's environmental values and long-term goals, but the technical criteria are replaced by the more recent ANZECC 2000 Guidelines). • State any locally specific objectives, criteria or targets, which have been endorsed by the government e.g. the Healthy Rivers Commission Inquiries or the NSW Salinity Strategy (DLWC, 2000) (http://www.environment.nsw.gov.au/salinity/governmenUnswstrategy.htm). • Where site specific studies are proposed to revise the trigger values supporting the ambient Water Quality and River Flow Objectives, and the results are to be used for regulatory purposes (e.g. to assess whether a licensed discharge impacts on water quality objectives), then prior agreement from the EPA on the approach and study design must be obtained. • Describe the state of the receiving waters and relate this to the relevant Water Quality and River Flow Objectives (i.e. are Water Quality and River Flow Objectives being achieved?). Proponents are generally only expected to source available data and information. However, proponents of large or high risk developments may be required to collect some ambient water quality / river flow / groundwater data to enable a suitable level of impact assessment. Issues to include in the description of the receiving waters could include: a) lake or estuary flushing characteristics b) specific human uses (e.g. exact location of drinking water	Section 2, Section 5, Section 6

offtake)
c) sensitive ecosystems or species conservation values
d) a description of the condition of the local catchment e.g . erosion levels, soils, vegetation cover, etc.
e) an outline of baseline groundwater information, including, but not restricted to, depth to watertable, flow direction and gradient, groundwater quality, reliance on groundwater by surrounding users and by the environment
f) historic river flow data where available for the catchment.

Assess impacts

- No proposal should breach clause 120 of the Protection of the Environment Operations Act 1997 (i.e. pollution of waters is prohibited unless undertaken in accordance with relevant regulations).
- Identify and estimate the quantity of all pollutants that may be introduced into the water cycle by source and discharge point including residual discharges after mitigation measures are implemented.
- Include a rationale, along with relevant calculations, supporting the prediction of the discharges.
- Describe the effects and significance of any pollutant loads on the receiving environment. This should include impacts of residual discharges through modelling, monitoring or both, depending on the scale of the proposal. Determine changes to hydrology (including drainage patterns, surface runoff yield, flow regimes, wetland hydrologic regimes and groundwater).
- Describe water quality impacts resulting from changes to hydrologic flow regimes (such as nutrient enrichment or turbidity resulting from changes in frequency and magnitude of stream flow).
- Identify potential impacts associated with geomorphological activities with potential to increase surface water and sediment runoff or to reduce surface runoff and sediment transport. Also consider possible impacts such as bed lowering, bank lowering, instream siltation, floodplain erosion and floodplain siltation.
- Identify impacts associated with the disturbance of acid sulfate soils and potential acid sulfate soils.
- Containment of spills and leaks shall be in accordance with the technical guidelines section 'Bunding and Spill Management' of the Authorised Officers Manual (EPA, 1995) (http://www.epa.nsw.gov.au/mao/bundingspill.htm) and the most recent versions of the Australian Standards referred to in the Guidelines. Containment should be designed for no-discharge.
- The significance of the impacts listed above should be predicted. When doing this it is important to predict the ambient water quality and river flow outcomes associated with the proposal and to demonstrate whether these are acceptable in terms of achieving protection of the Water Quality and River Flow Objectives. In particular the following questions should be answered:
  a) will the proposal protect Water Quality and River Flow Objectives where they are currently achieved in the ambient waters; and
  b) will the proposal contribute towards the achievement of Water Quality and River Flow Objectives over time, where they are not currently achieved in the ambient waters.
- Consult with the EPA as soon as possible if a mixing zone is proposed (a mixing zone could exist where effluent is discharged into a receiving water body, where the quality of the water being discharged does not immediately meet water

quality objectives. The mixing zone could result in dilution, assimilation and decay of the effluent to allow water quality objectives to be met further downstream, at the edge of the mixing zone). The EPA will advise the proponent under what conditions a mixing zone will and will not be acceptable, as well as the information and modelling requirements for assessment. Note: The assessment of water quality impacts needs to be undertaken in a total catchment management context to provide a wide perspective on development impacts, in particular cumulative impacts. • Where a licensed discharge is proposed, provide the rationale as to why it cannot be avoided through application of a reasonable level of performance, using available technology, management practice and industry guidelines. • Where a licensed discharge is proposed, provide the rationale as to why it represents the best environmental outcome and what measures can be taken to reduce its environmental impact. • Reference should be made to Managing Urban Stormwater: Soils and Construction (DECC, 2008), Guidelines for Fresh and Marine Water Quality ANZECC 2000), Environmental Guidelines: Use of effluent by Irrigation (DEC, 2004)>. ***Describe management and mitigation measures*** • Outline stormwater management to control pollutants at the source and contain them within the site. Also describe measures for maintaining and monitoring any stormwater controls. • Outline erosion and sediment control measures directed at minimising disturbance of land, minimizing water flow through the site and filtering, trapping or detaining sediment. Also include measures to maintain and monitor controls as well as rehabilitation strategies. • Describe waste water treatment measures that are appropriate to the type and volume of waste water and are based on a hierarchy of avoiding generation of waste water; capturing all contaminated water (including stormwater) on the site; reusing/recycling waste water; and treating any unavoidable discharge from the site to meet specified water quality requirements. • Outline pollution control measures relating to storage of materials, possibility of accidental spills (eg. preparation of contingency plans), appropriate disposal methods, and generation of leachate. • Describe hydrological impact mitigation measures including: a) site selection (avoiding sites prone to flooding and waterlogging , actively eroding or affected by deposition) b) minimising runoff c) minimising reductions or modifications to flow regimes d) avoiding modifications to groundwater.	

1.7 Scope and structure of the report

1.7.1 Scope of report

This report addresses surface water which is defined as the rainwater runoff on the LHRRP which subsequently drains off the LHRRP and does not percolated through the bulk landfill waste mass. The rainwater which percolates through the bulk landfill waste mass is considered ‘landfill leachate’ and is addressed in a separate Leachate Assessment (GHD, 2015b). Landfill leachate is managed through a separate system to leachate generated from the GO facility and ARRT facility.

This report also addresses surface water which comes into contact with the garden organics at the GO facility. This contact water is termed GO facility leachate as rainfall water may come into contact with organic materials.

This report also addresses process leachate generated in the ARRT facility. This refers to the water that comes into contact with the processed waste.

The scope of the report includes:

- A review of information provided by SITA, in particular the existing Soil and Water Management Plan (SITA 2012)
- A review of the proposed landfill staging plans
- A review of the properties of on-site and imported soils in terms of soil type, capping material, soil erosion potential and their potential for subsidence or instability
- A review of the site's existing regulatory requirements (specifically in regard to total suspended solids in surface water discharges from the site)
- An investigation of the existing conditions of on-site surface water including water quantity and water quality, and an assessment of the water requirements
- A description of stormwater management measures and proposed controls, taking into account the potential for flooding during construction, operation and post-closure
- Development of control measures in accordance with *Blue Book Volume 1 (Landcom, 2004) Soils and Construction Managing Urban Stormwater Volume 1* (Blue Book Volume 1 (Landcom, 2004) and *Blue Book Volume 2b (DECC 2008) Managing Urban Stormwater Soils and Construction – Volume 2B – Waste Landfills* (Blue Book Volume 2b (DECC 2008)
- An assessment of the impacts after management measures are put in place

Separate leachate and groundwater assessments were undertaken as part of this proposal, with assessment outcomes documented in individual reports (GHD 2015a, GHD 2015b).

1.7.2 Structure of report

- **Chapter 1 – Introduction** – This chapter introduces the proposal, the proponent and describes the proposal area
- **Chapter 2 – Existing environment** – This chapter describes the existing environmental values of the proposal site relevant to surface water and the assessment
- **Chapter 3 – Existing regulatory requirements** – This chapter provides an overview of the legislation, policies and guidelines relevant to this assessment
- **Chapter 4 – Methodology** – This chapter provides a description of assessment methodology
- **Chapter 5 – Potential impacts** – This chapter examines the potential impacts associated with the proposal
- **Chapter 6 – Impact assessment** – This chapter describes the impact of the proposal
- **Chapter 7 – Mitigation measures** – This chapter provides a description of proposed mitigation measures

- **Chapter 8 – Post-closure impact assessment** – This chapter provides a discussion of the potential impact post-closure
- **Chapter 9 – Conclusions** – This chapter provides a summary of assessment conclusions
- **Chapter 10 – References** – This chapter provides a reference list

2. Existing environment

2.1 Surface water features

Most of the LHRRP site lies within the Mill Creek catchment. Mill Creek originates from the 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.

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 (the landfilled portion) 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 and the administration facilities, which drains to Bardens Creek. As this area is not impacted by this proposal, impacts to Bardens Creek are not assessed in this report. 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.

Figure 2.1 shows the surface water features and environment in the vicinity of the site.

The main sediment and water reuse basin dam located at the north-west corner operates as a sediment retention basin and water reuse basin.

2.2 Geology and soils

Extensive geological characterisation has been completed at the LHRRP as part of previous investigations. This included, review of regional geological data, site drilling investigations, seismic surveys and geological mapping of jointing on exposed surfaces. The findings of these investigations are summarised below.

The LHRRP site is located on the Woronora Plateau which is primarily comprised of Triassic aged Hawkesbury Sandstone of thicknesses approximating 200 m (DP & CPI, 1994). The Hawkesbury Sandstone is comprised of cross bedded massive sandstones, laminates and occasional black shale and claystone lenses (DP & CPI, 1992). The sandstone matrix is often well cemented.

Environ (2006) reported two layers of laminate (2 m thick) and siltstone (2.5 m thick) at elevations of 60 m AHD and 84 m AHD respectively.

DP & CPI (1994) provided the following summary of site conditions after drilling investigations:

- Surficial Clayey SAND/Sandy CLAY ranged in depth from 0 to 2.8 m bgl
- Very low strength weathered Sandstone extending from ground surface or beneath unconsolidated sediments to depths of up to 6.1 m bgl

- Medium to high strength slightly fractured to unbroken Sandstone extending from the base of the low strength sandstone to depths of 60 m bgl (the maximum depth of characterisation). Laminate and siltstone layers were noted in some bores

Geological mapping suggested that locally shale layers tended to dip to the north at between 2 and 5 degrees, however, the regional dip of the geology is considered to be to the north at an overall slope of 1.5 to 2 degrees (DP & CPI, 1994). Regional jointing systems have also affected this environment with surface drainage developing along well developed and relatively continuous jointing systems at spacings of 300 to 400 m (DP & CPI, 1994).

It is inferred that these jointing systems have resulted in the development of the primary surface water features including Mill Creek and Deadmans Creek and Woronora River. On a more local scale jointing spacing of between 1 and 3 m common and can be laterally extensive (up to 100 m being common), however, vertical continuity is generally limited to less than 20 m (DP & CPI, 1994). Geological mapping undertaken by DP & CPI (1992) suggest that local jointing is orientated in NNE and ESE directions.

Surface weathering of the bedrock in the vicinity of LHRRP is generally considered to be less than 2 m (DP & CPI, 1994). DP & CPI (1992) reported that the Hawkesbury Sandstone had been subject to lateritic weathering and that the extent and depth of the weathering is variable across the site. This was confirmed with seismic surveys which also suggested the presence of two to four distinct layers that reflected variation in the type and depth of weathering. Generally, the weathered layers were deeper on the ridges and shallower in the valleys.

LEGEND

Waterways

10 m Contours

Paper Size A4
0 70 140 280 420 560
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	24 Feb 2015

Surface water environment

Figure 2-1

Level 15 133 Castlereagh St Sydney **T** 61 2 9239 7156 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

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Data source: Imagery: SITA. Created by:rgtowner

2.3 Regional water uses

A licence search was undertaken using the NSW Office of Water NSW Water Register. All lots adjacent to the site and adjacent to downstream waterways were input into the register search tool to identify licenced surface water users that could potentially be impacted by activities at the site. This search continued downstream to the confluence with the Georges River, at which point the contribution of flows from the site are not a significant proportion of the overall catchment area.

The only licensed surface water user identified was the Lucas Heights 1 Golf Course. However it is understood that this water use is related to dams installed on the east of the golf course site. The dams are not located downstream of the proposal.

2.4 Site water management

There are a number of surface water features currently in place at the site.

Figure 2.3 shows the location of the key surface water features.

One of the primary objectives for water management is to ensure that controlled discharges from the site are in accordance with the regulatory requirements (refer to chapter 2.5). The strategy employed at the LHRRP (SITA 2012) to deliver this objective comprises the following:

- Stormwater drains are constructed to divert run-off before any clearing and/or excavation
- Stormwater diversion drains are constructed around the perimeter of each section of the landfill
- Bunds are constructed to keep stormwater run-off from working areas, and to ensure that any contaminated surface run-off is contained within the working area
- The refuelling area is bunded, and collection area for paints and household chemicals is roofed and bunded
- Sedimentation dams are operated with an available volume maintained for capture of sediment laden water. This can then be treated through site recirculation or through the stormwater treatment plant. This treatment plant operates by dosing water with flocculant, then allowing suspended sediment in the water to settle out, testing the TSS content of the treated water and discharging if TSS concentrations are less than 50 mg/L. The plant can manage up to 2.5 ML/day
- Sediment traps are put in place to capture the majority of coarse sediment and minimise the rate at which the sediment dam accumulates sediment
- There is maximum use of collected water on site for dust suppression, irrigation, composting, maintenance of haul roads etc.
- Water collected in excavation areas that has not come into contact with waste is pumped to sedimentation dams during or soon after rain events, for settlement of solids. Water that has come into contact with waste (not including cover materials) is deemed contaminated and will be pumped to the leachate collection system and treated as leachate
- Each successive waste lift is covered with compacted earth (or other appropriate cover materials), trimmed and graded to encourage the shedding of rainwater
- Contouring of completed areas has been undertaken to assist water shedding
- All drainage channels and sediment traps are maintained in areas of fill

- Scour protection, lining or vegetating of drains and waterways has been undertaken where high flow velocities are expected
- Bunds are constructed around the existing GO facility, and the runoff from the garden organics processing are diverted into the GO leachate dam located on the eastern side of the LHRRP

2.4.1 Stormwater treatment plant

A stormwater treatment facility is located at the LHRRP which treats sediment laden stormwater in the main sedimentation basin prior to any discharging to Mill Creek. It has a capacity of 2.5 ML/day and 30 L/s. A sludge handling system is used to collect, contain and de-water the suspended solids and precipitates collected by the stormwater treatment system. The treated water is then discharged to Mill Creek (in accordance with the EPL conditions) or reused at the LHRRP (WSN 2004). The operating details would be reflected in the Landfill OEMP (GHD 2014a).

2.4.2 Surface water management works

SITA takes a proactive approach to managing surface water quality at the LHRRP. Since SITA acquired the site, a number of surface water management works have been completed or have been included as part of routine maintenance works, including:

- **Upgrade of main sediment basin** – in order to provide more capacity to deal with large storm events, the main sediment basin was upgraded and enlarged in 2013. As part of the upgrade, the dam was also de-silted. (refer Appendix B for photos of the main sedimentation basin)
- **Establish grassed areas** – grass was established on previously exposed areas to improve stormwater runoff quality.
- **Western perimeter haul road** – silt mesh fencing and siltation traps were installed along the western perimeter haul road to reduce sediments entering the main sedimentation basin. Geotextiles, hay bales and a rock lined drain were also installed to manage flow rates during high rainfall events. (Figure 2.2)

Figure 2.2 Lined drain along western perimeter haul road with siltation traps

In addition to these additional stormwater management works, SITA also has planned further management works including:

- **Improved coagulant for the sedimentation basins** – In order to increase the effectiveness of the sedimentation process, a new coagulant has been trialled and the coagulant product used in sedimentation basins would be revised.
- **Installation of silt fences** – silt fences are progressively installed around active cells, stockpile areas and the western haul road to improve quality and reduce sediment loading of the main sedimentation basin.

2.5 Baseline surface water quality

2.5.1 Aquatic ecosystem survey

To gain an understanding of the existing baseline conditions of water quality of the major water receptor, Mill Creek, GHD undertook a detailed aquatic ecosystem survey (refer Appendix C) in March 2015, which investigated the aquatic ecosystems of Mill Creek. The purpose of the investigation was to examine if any impacts to aquatic macroinvertebrates, a well-known indicator of creek/river health, may be occurring in the habitats downstream of the LHRRP.

The field sampling was conducted on 2 March 2015. The report presents the monitoring data collected and analysis of significant results. The report is contained in Appendix C.

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 would 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.

2.6 Georges River Combined Councils Committee - 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 C 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.

Paper Size A4
0 30 60 120 180 240
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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Job Number	21-23482
Revision	A
Date	12 May 2015

Site surface water features

Figure 2.3

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N:\AU\Sydney\Projects\21\23482\GIS\Maps\MXD\21-23482-Z032_SurfaceWaterFeatures.mxd

Data source: Imagery: SITA and GOOGLE EARTH 2015. Created by:jrichardson

3. Existing regulatory requirements

3.1 Overview

The existing requirements for the LHRRP stem from the development consent (DA No 11-01-99 consent ref R97/00029). In addition to this regulatory instrument there are several environment protection licences (EPLs) for the LHRRP and approvals under the Water Management Act 2000. The relevant requirements under these instruments are summarised below.

3.2 Development consent

Relevant conditions from the development consent (DA No 11-01-99 consent ref R97/00029) and subsequent modifications include:

58. *Except as may be expressly provided in the EPA licence, the Applicants shall comply with section 120 of the Protection of the Environment Operations Act 1997 prohibiting the pollution of waters at LH1 and LHWMC.*

78. *The design, construction, operation, monitoring and rehabilitation of surface water control works at the LHWMC shall be in accordance with the amended EMP and the requirements of the EPA licence.*

There are also a number of other requirements in relation to Mill Creek that are administered by the New South Wales Office of Water (NOW).

3.3 Environment protection licences

The LHRRP currently operates under Environmental Protection Licences (EPLs) 5065, 6345, 13114 and 12520. The relevant EPLs to this proposal are licence 5065, (version dated 05 November 2014) which apples to the whole landfill and 12520, (version dated 19 March 2014) and applies to the garden organics facility. The relevant conditions from these EPLs are reproduced below:

3.3.1 EPL 5065

L1.1 Except as may be expressly provided in any other condition of the licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

L2.1 For each monitoring/discharge point or utilisation area specified in the table\s below (by a point number), the concentration of a pollutant discharged at that point, or applied to that area, must not exceed the concentration limits specified for that pollutant in the table.

L2.2 Where a pH quality limit is specified in the table, the specified percentage of samples must be within the specified ranges.

L2.3 To avoid any doubt, this condition does not authorise the pollution of waters by any pollutant other than those specified in the table\s.

L2.4 Water and/or Land Concentration Limits

Point 1

Pollutant	Units of measure	100 percentile concentration limit
Conductivity	microsiemens per 1500 centimetre	1500
Dissolved Oxygen	milligrams per litre	6
Nitrogen (ammonia)	milligrams per litre	2.5
pH	pH	5.5-8.5
Phenol	milligrams per litre	0.32
TSS	milligrams per litre	50

Point 20,21,22

Pollutant	Units of measure	100 percentile concentration limit
Nitrogen (ammonia)	milligrams per litre	2.5
TSS	milligrams per litre	50

L2.5 The licensee is taken not to have breached the licence total suspended solids concentration limits for Point 1 and Point 22 if:

a) the overflow is caused by a rainfall event; and

b) the licensee has taken all practical measures to avoid or minimise water pollution.

O6.5 Surface waters must be diverted away from any area where waste is being or has been landfilled.

The monitoring points are identified in section P1.3 of the EPL and are follows:

- Point 1 – located in Mill Creek approximately at the northern boundary of the premises
- Point 20 – pumped discharge from the main sedimentation dam to Mill Creek
- Point 21 – pumped discharge from the stormwater treatment plant to Mill Creek
- Point 22 – overflow from the main sedimentation dam into Mill Creek

Appendix E shows the monitoring locations at the LHRRP.

3.3.2 EPL 12520

L1.1 Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.

O5.4 Liquid which has come into contact with stockpiled garden waste, or with composting material must not be discharged to waters.

4. Methodology

4.1 Overview

The following sections detail the methodology used to assess risks of the proposal relating to surface water and to analyse proposed mitigation measures. Key risks related to surface water include:

- erosion and sediment control, include potential discharge of sediment laden water
- water sourcing and security
- flooding
- surface water quality impacts, such as leachate entering the surface water system and being discharged off-site.

The methodology outlined in the following sections was developed to assess and quantify these risks. High level identification of potential mitigation measures was also undertaken.

4.1.1 Critical phases

Different phases were considered to be the ‘critical phase’ for each of the above risks:

- erosion and sediment control – the critical phase is the point in time when the direct catchment area of the basin is the greatest and therefore the largest runoff inflow volume is to be expected. Based on the proposed staging this is expected to be during Phase 5 of the proposal (refer Appendix A). During this stage, some of the capped and revegetated areas are included in the catchment for the sedimentation control basins
- water sourcing and security – the critical phase for water sourcing and security is also Phase 5 as highest water demand is required for dust suppression
- flooding - the final capped scenario was conservatively selected as the critical phase as it has the potential to generate the greatest peak runoff rate from the site, due to it having the greatest catchment area directly contributing to offsite discharges. The currently approved final scenario was also selected as an approved base case, off which to assess impacts
- surface water quality impacts – the water quality is considered throughout the life of the proposal

4.2 Erosion and sediment control

All disturbed and unvegetated areas would have high level of erosion and sediment controls applied to capture and treat any suspended solids in the run-off water. Existing practices are described in section 2.4. The staging of the proposal has also been designed to generally minimise the disturbed areas (by capping and revegetating areas) prior to commencing work in areas that are currently capped and revegetated.

The effectiveness of the current erosion and sediment control practices at the site has been assessed by analysing the total suspended solids concentrations recorded in Mill Creek downstream of the site.

Assessment of potential impacts of the proposal relating to erosion and sediment control was undertaken in accordance with methods outlined in Blue Book Volume 1 (Landcom, 2004) and Blue Book Volume 2b (DECC 2008).

General recommendations from the above-mentioned references were considered. These included those relating to minimising exposed surfaces and proper maintenance and management of the site. Specific aspects of the erosion control strategy were assessed as detailed in the following sections.

4.2.1 Collection of disturbed area runoff and diversion of clean runoff

For effective erosion and sediment control it is necessary to divert upstream clean water around disturbed areas and also to collect sediment laden water from disturbed areas. This would be achieved through constructing open channels and utilising existing clean water channels such as Mill Creek.

According to Table 6.1 of Blue Book Volume 2b (DECC 2008), these drainage channels must be able to convey the critical 20-year Average Recurrence Interval (ARI) rainfall event flow rate. This assessment involved development of preliminary sizing guidelines for these channels such that the proposal would operate in accordance with Blue Book Volume 2b (DECC 2008) in terms of conveyance of clean and sediment laden runoff. These sizing guidelines were then applied to the proposed drainage channels for each stage and preliminary channel sizes presented along with the proposed staging plans.

Specific assessment of channel capacities was also undertaken for existing surface water channel such as Mill Creek and the eastern drainage channel. This involved a capacity check of these specific channels involving either a HECRAS one-dimensional hydraulic model or Manning’s hydraulic calculations.

Advice on sizing was developed based on modifying the XP-RAFTS hydrologic model discussed in Section 4.4.1 to estimate the peak 20-year ARI event peak flow rate for a range of potential catchment areas and then using a Manning’s Calculation to estimate the required channel size for each catchment area. Key parameters for this assessment are listed in Table 4.1.

Table 4.1 Channel sizing parameters

Parameter	Value	Notes
Channel Manning’s n	0.025	Compacted earth
Channel bed slope	1 %	Likely minimum slope
Channel side slope	1V:4H	
Maximum flow depth	Varies (Max 1m)	Based on results of Manning’s calculation for each catchment area
Channel base width	Varies	Based on results of Manning’s calculation for each catchment area

4.2.2 Assessment of the main sediment basin

The required volume and operational strategy of the main sediment basin were quantitatively assessed using the procedures outlined in the above guidelines. Key parameters for the assessment are listed in Table 4.2.

The required erosion and sediment control volume in this basin was assessed for the critical point in time in the proposal. That is the point in time when the direct catchment area of the basin is the greatest and therefore the largest runoff inflow volume is to be expected. This is expected to be during Phase 5 of the proposal, where some of the capped and revegetated areas are included in the catchment for the sedimentation control basins.

The staging of the landfill (refer Appendix A) was developed such that the capped and revegetated area of the reprofiling area is maximised and the disturbed areas are minimised in order to reduce the erosion potential of the site.

Table 4.2 Erosion and sediment assessment parameters

Parameter	Value	Notes
Basin type	Type D	As per *Blue Book Volume 2b (DECC 2008)* Type D should be used where external material could be imported to site.
Design rainfall depth	34.8 mm	90th percentile 2-day depth for Sutherland Shire • 90th percentile selected based on *Blue Book Volume 2b (DECC 2008)* • 2-day management period selected based upon the capacity of the stormwater treatment plant and the size of the settling zone volume required. That is, the capacity of the treatment plant is 2.6 ML/day and would start at the beginning of the rainfall event. The combined rainfall (2-days) and management period (2-days) is 4 days. Over 4 days the stormwater treatment plant can manage a volume of water in excess of the settling zone volume. Therefore, it is expected that the system can re-establish an available capture volume equal to the settling zone volume within a 2-day management period and therefore this was adopted as the management period for the design rainfall event.
Volumetric runoff coefficient	0.64	Based on hydrologic soil type D
Settling zone required volume – per hectare of catchment area	223 m^3/ha	Calculated
Basin catchment area	45 ha	Proposed case for critical phase in proposal (phase 5)
Settling zone required volume	10 ML	Calculated
Sediment accumulation rate in basin	500 m^3/yr	Based on site observations from previous cleanout activities. Majority of sediment captured in upstream sediment traps.
Basin sediment cleanout period	10 years	Conservatively assumed. Likely to be more frequent. To occur when sediment storage zone is 80% full of sediment.
Sediment storage zone required volume	5 ML	Calculated
Required basin volume for erosion and sediment control	15 ML	Calculated The existing main sediment and erosion control basin at the north western corner of the site has a total capacity of 32 ML (as shown by survey).

Results of the water balance (discussed in section 4.3) were also used to verify the erosion and sediment assessment. In particular the frequency of overflows from the sediment basin was assessed.

The Environmental Protection Licence for the Site (EPL 5065) includes licence conditions relating to discharge of total suspended solids (TSS). Generally, the requirement of the licence is that the discharged water from site should not have a concentration of TSS greater than 50 mg/L. However, it is also stated that for discharges from the sediment basin that a discharge of higher concentrations of TSS is not in breach of the licence if the following conditions are met:

1. The overflow is caused by a rainfall event; and
2. The licensee has taken all practical measures to avoid or minimise water pollution.

For this assessment it has been assumed that “all practical measures” corresponds to implementation of the requirements of Blue Book Volume 1 (Landcom, 2004) and Blue Book Volume 2b (DECC 2008) appropriate for the conditions of the site. These measures are reflected in the site’s Operations Environmental Management Plan (SITA 2014) which would be updated following the proposal’s determination to reflect any additional regulatory requirements.

4.2.3 ARRT and GO facilities

During the construction of the ARRT and GO facilities, some temporary disturbed areas of a significant size would be introduced. These have the potential to impact on downstream water quality. Potential impacts and mitigation measures relating to this were estimated based on the procedures outlined in Blue Book Volume 1 (Landcom, 2004).

4.3 Water sourcing and security

4.3.1 Landform

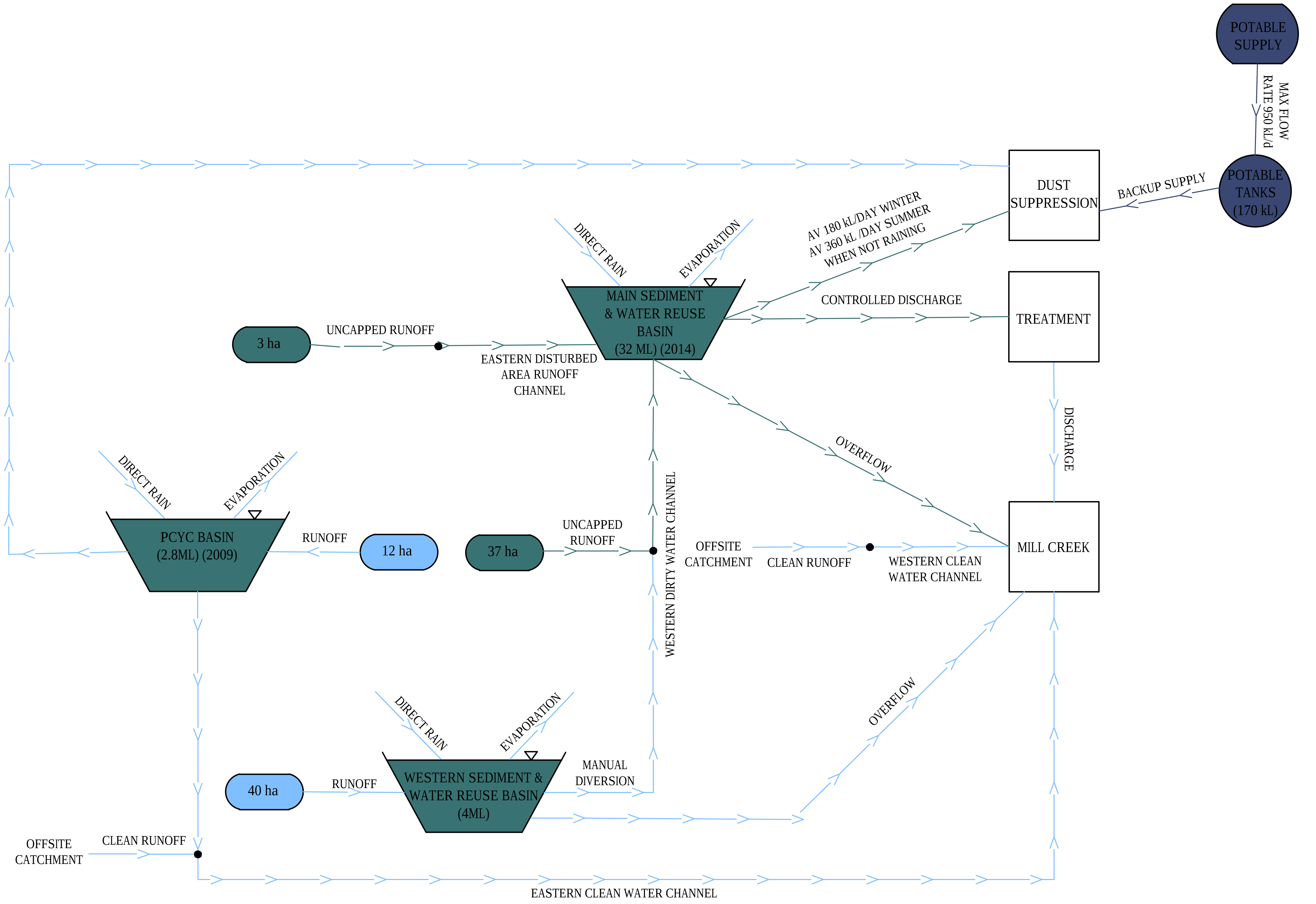
A water balance model was developed to assess the ability of the existing main sediment basin to supply the dust suppression demands for the site through collection of site runoff. The model provided an indication of whether proposed landfilling activities would increase the demand for potable water significantly as dust suppression is the primary water demanding activity for the landfilling activities.

The model was developed using the GoldSim software package, and set up on a daily time step. The model represented a range of meteorological conditions that could be experienced at the site through simulation of a historical rainfall and evaporation time series. The time series was obtained for the period from 1959 to 2013 using the SILO data tool developed by the Queensland Government. This tool interpolates a time series for the site in question based on available data from nearby data stations. A summary of the input meteorological data is shown in Table 4.3

Table 4.3 Meteorological data input

Parameter	Annual Rainfall Depth (mm)	Annual Evaporation Depth (mm)
Minimum	556	1240
10th Percentile	686	1351
Mean	1022	1448
90th Percentile	1315	1546
Maximum	1804	1657

Figure 4.1 shows the site water schematic represented in the water balance.



LEGEND

POTABLE WATER
CLEAN WATER
SITE RUNOFF
LEACHATE
WASTEWATER
XX MEAN ANNUAL FLOW (ML/YEAR)

SITA AUSTRALIA
LUCAS HEIGHTS RRP

WATER BALANCE SCHEMATIC

Job Number	21-23482
Revision	B
Date	JULY 2015

Figure 4.1

Level 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

Plot Date: 3 July 2015 - 2:13 PM Plotted by: Carol Ng Cad File No: G:\21\23482\Technical\Surface Water\Water Balance\Lucas Heights Water Cycle Scematics.dwg

The water balance model was represented such that the time series of meteorological data was simulated for a particular discrete point in time of the proposal. To allow assessment of potential impacts two points in time in the proposal were simulated. These corresponded to the existing case as well as the proposed critical case.

The critical case is the point in time at which the most stress is placed on the basin for water supply. It is expected that this critical point in time would be during Phase 5. During Phase 5 the exposed surface areas, and therefore dust suppression demands are the largest.

The water balance model operates on the principle of mass balance, where the total daily inflow volume for each element in the water cycle is equal to the total daily outflow volume. Inflows and outflows from the model and a summary of how they were estimated are presented in Table 4.4.

Table 4.4 Water balance inflows and outflows - landform

Parameter	Estimation Method
Inflows	
Runoff From Catchment Areas	Based on daily rainfall and a volumetric runoff coefficient estimated based on HELP modelling for the proposal (0.45)
Direct Rainfall on Basins	Based on daily rainfall and basin surface area.
Potable Backup Supply for Dust Suppression	Calculated by the model as the demand for dust suppression when on-site water is not available.
Outflows	
Evaporation from Basins	Based on the daily evaporation value and the dam surface area with a pan evaporation factor of 0.85 based on (T.A McMcmahon et. al, 2012, *Estimation Actual, potential reference and pan evaporation using standard meteorological data)*..
Water Applied for Dust Suppression	Approximate demand information obtained from site for the current site configuration: 360 kL/day in Summer 270 kL/day in Autumn and Spring and 180 kL/day in Winter. It was assumed demand only occurs on days without significant rainfall. For the proposed case this demand was scaled from existing values based on the existing and proposed disturbed area.
Discharge of Water from the Main Basin to the Stormwater Treatment Plant	Based on sediment control strategy discussed in Sections 6.2 and 7.2.
Overflows from Basins	Calculated by the model based on inflows and outflows into the basins.

Operational rules were also set up in the model to represent the management of water on site. These included the following:

- Demand for dust suppression is obtained from the PCYC basin as a first priority, then from the main sediment and water reuse basin.
- Water from the western sediment and water reuse basin can be directed to the main sediment basin for reuse where required. In order to represent site management practices it was nominally assumed that this occurs when the main sediment basin is below 60% capacity and water is available in the western sediment and reuse basin whilst it is in place.
- Runoff entering the existing excavated void area is not suitable for pumping to the main sediment basin and subsequent reuse. In reality some water can be pumped to the basin depending on water quality, however the assumption adopted is conservative from a water security perspective.

After simulation, the model results were extracted and analysed to show the annual average annual flows for the primary elements of the site water cycle under both proposed and existing conditions. In addition to this, complete time series results were also analysed for key results.

4.3.2 ARRT and GO facilities

A water balance was developed (using GoldSim) which took into account the key elements of the water cycle of the western ARRT and GO facilities using the same rainfall data series as the water balance prepared for the landform. This allowed for assessment of the sourcing of water demand for the facilities as well as informing leachate management measures. This component of the water balance included the following elements, as shown on Figure 4.2:

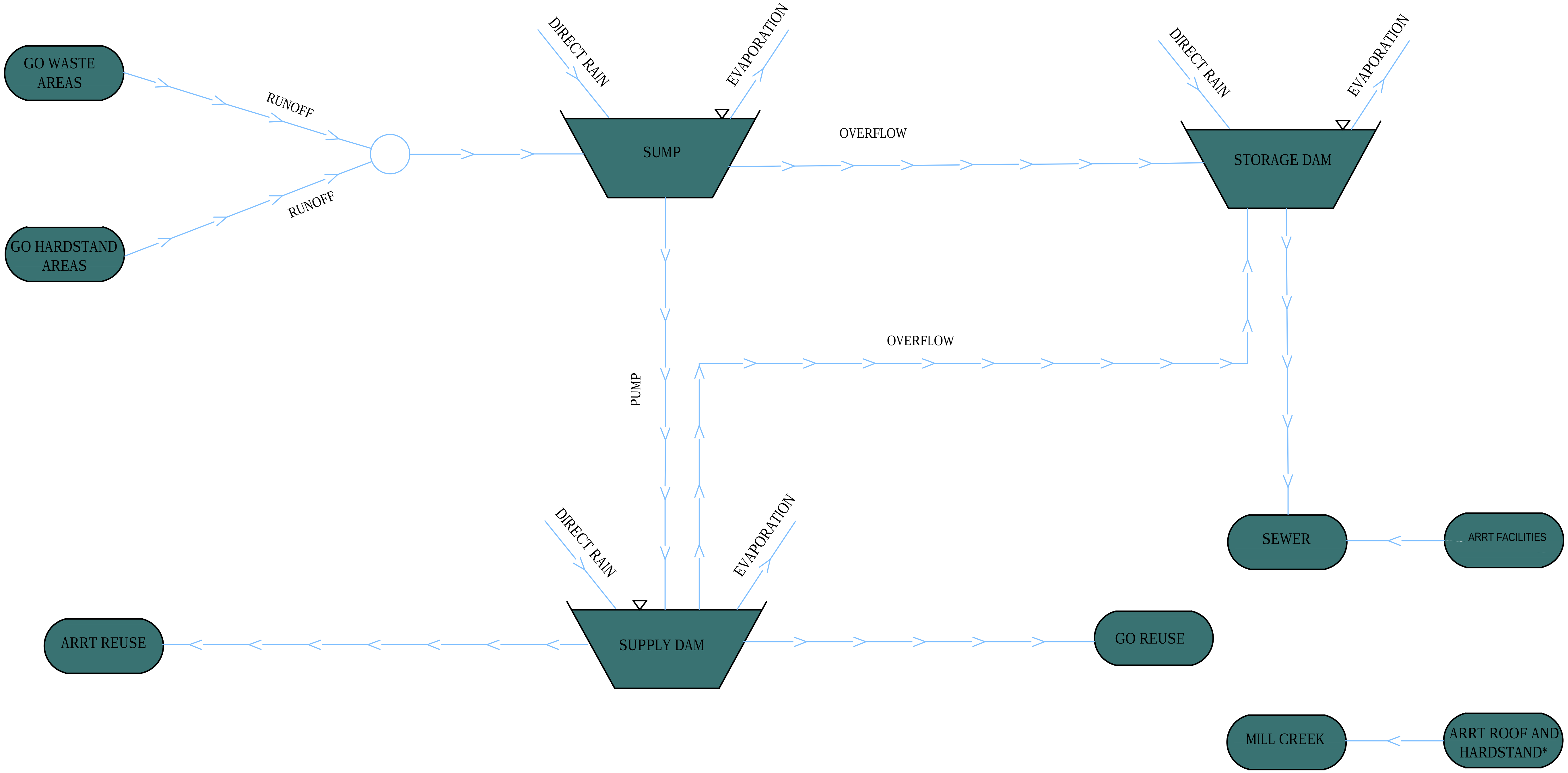
- Runoff from the GO facility
  - A runoff co-efficient of 0.68 was adopted for runoff from compost based on Wilson & Levesque (2004) which is consistent with other literature reviewed (Webber et al., 2010; Coker 2008)
  - For runoff off hardstand areas, an initial loss of 1.5 mm was adopted
- Capture of this runoff in a sump at the north eastern end of the GO facility area, with the sump assumed to have only small capacity – hence water is pumped immediately or overflows
- Pumping of water from this sump to a supply dam at the top of the GO facility area
- Capture of runoff during periods of high rainfall in a storage dam downstream of the ARRT facility, in the event that the runoff from the GO facility cannot be pumped from the sump to the supply dam at the top of the GO facility area
- Disposal of excess water from the storage dam to sewer during high rainfall periods. Maximum disposal capacity of 160 kL a day has been modelled based on existing arrangements with ANSTO.
- Reuse from the supply dam for composting purposes within the GO and ARRT facilities
  - The GO facility is expected to have a water demand of approximately 4.6 ML/year, with the summer months experiencing the greater demand than the cooler months.
  - The ARRT facility is have a water demand of approximately 0.5 ML per year
  - Water reuse estimates were developed based on GHD’s experience with similar composting projects. The total demand for “dirty” water reuse from other sites was obtained and divided by the annual tonnage of waste received to obtain a water use estimate per tonne. This rate was then adjusted for changes in climate conditions between the sample sites and Lucas Heights, and multiplied by the expected minimum throughput at the site to estimate a minimum demand rate. As water reuse is proposed as a method of disposal of contaminated water it was considered appropriate to represent a minimum demand rate

Runoff from the ARRT facility area was not represented in the water balance as it was expected to be clean since all the operations and all materials are contained within buildings. This water would be managed in a separate water system.

- The water balance considered the following configuration of the water management system for the GO facility:
  - Supply Dam Volume: 4.8 ML
  - Storage Dam Volume: 12 ML

  - Surface water from the breathable membrane covers over the concrete bunkers (7,020 m^2) in the GO area would be diverted to the clean surface water system as it would not have come into contact with compost.

The results of the water balance are reported in Section 6.3.2.



* STORMWATER FROM THE ARRT HARDSTAND AREA
WHERE NO WASTE IS STORED

SITA AUSTRALIA
LUCAS HEIGHTS RRP

WATER BALANCE SCHEMATIC
ARRT / GO

Job Number	21-23482
Revision	B
Date	JULY 2015

Figure 4.2

Level 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

Plot Date: 3 July 2015 - 2:10 PM Plotted by: Carol Ng Cad File No: G:\21\23482\Technical\Surface Water\Water Balance\Lucas Heights Water Cycle ScematicsAARTGO.dwg

4.4 Flooding

Impacts of the proposal relating to flooding were assessed both in terms of the potential impacts of the proposal on downstream flood conditions, as well as the potential impacts of floodwaters inundating the site. In particular, inundation of the existing excavated void, the two leachate ponds and the GO/ARRT facility area during a flood event in Mill Creek were considered.

4.4.1 Impact on downstream flow conditions

An XP-RAFTS hydrologic model was developed to estimate the peak design flow rate for flow leaving the site in Mill Creek. The model was simulated for the current approved final scenario as well as the final capped scenario. The final capped scenario was conservatively selected as this has the potential to be the point in time in the proposal when the greatest peak runoff rate from the site occurs, due to it having the greatest catchment area directly contributing to offsite discharges.

The currently approved final scenario was also selected as an approved base case, off which to assess impacts. The primary differences between the two scenarios are the sub-catchment divisions and the catchment slope, as the topography and slope of the final landform is different.

It should be noted that the XP-RAFTS model considers the impact of changing slope in catchment runoff, therefore the impact of the change in profile slope (that is, the proposed final landform) of the site was assessed.

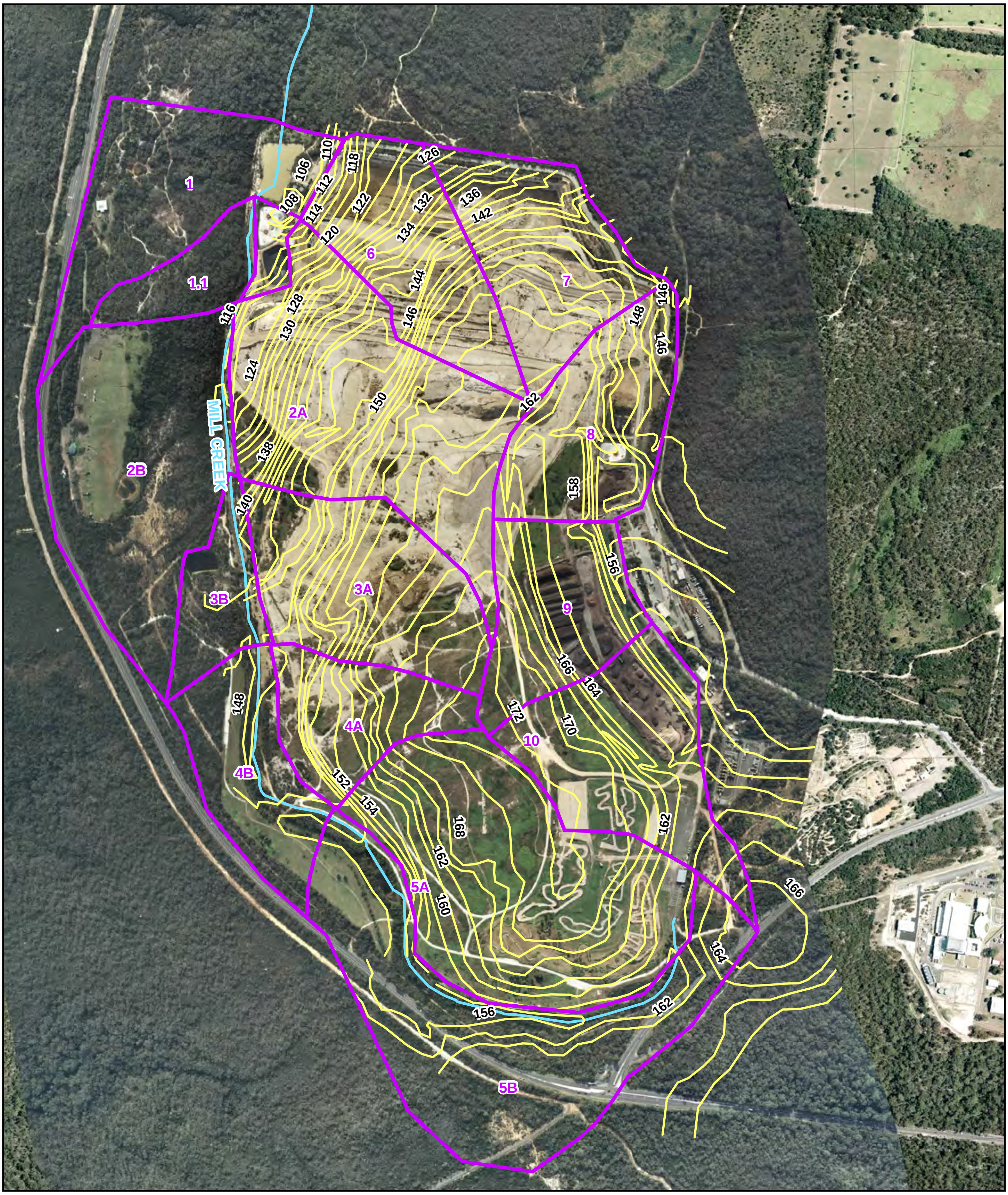
Figure 4.3 and Figure 4.4 show the modelled catchments for the two scenarios, including the downstream locations at which peak flow rates were assessed.

The 5-year ARI and 100-year ARI events were simulated, to represent the range of design events up to the 100-year ARI. Peak flow rates for the critical duration storm for each ARI were extracted and reported from the model with the results analysed to assess potential impacts on downstream flooding conditions.

Key input parameters for the XP-RAFTS modelling are shown in Table 4.4.

Table 4.4 XP-RAFTS key input parameters

Parameter	Value
Catchment areas	See Figure 4.3 and Figure 4.4
Catchment slope	Varies – Estimated based on final landform
Catchment Manning’s n	Natural areas –0.09 Capped areas – 0.03
Catchment % impervious	Natural areas – 5% Capped areas – 80%
Design rainfall losses (initial loss)	Natural areas – 15 mm Capped areas – 5 mm
Design rainfall losses (continuing loss)	Natural areas – 2.5 mm/hr Capped areas – 0 mm/hr



LEGEND

▭ Catchments

— Approved landform contours

— Mill Creek

Paper Size A4
0 37.5 75 150 225 300
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	12 May 2015

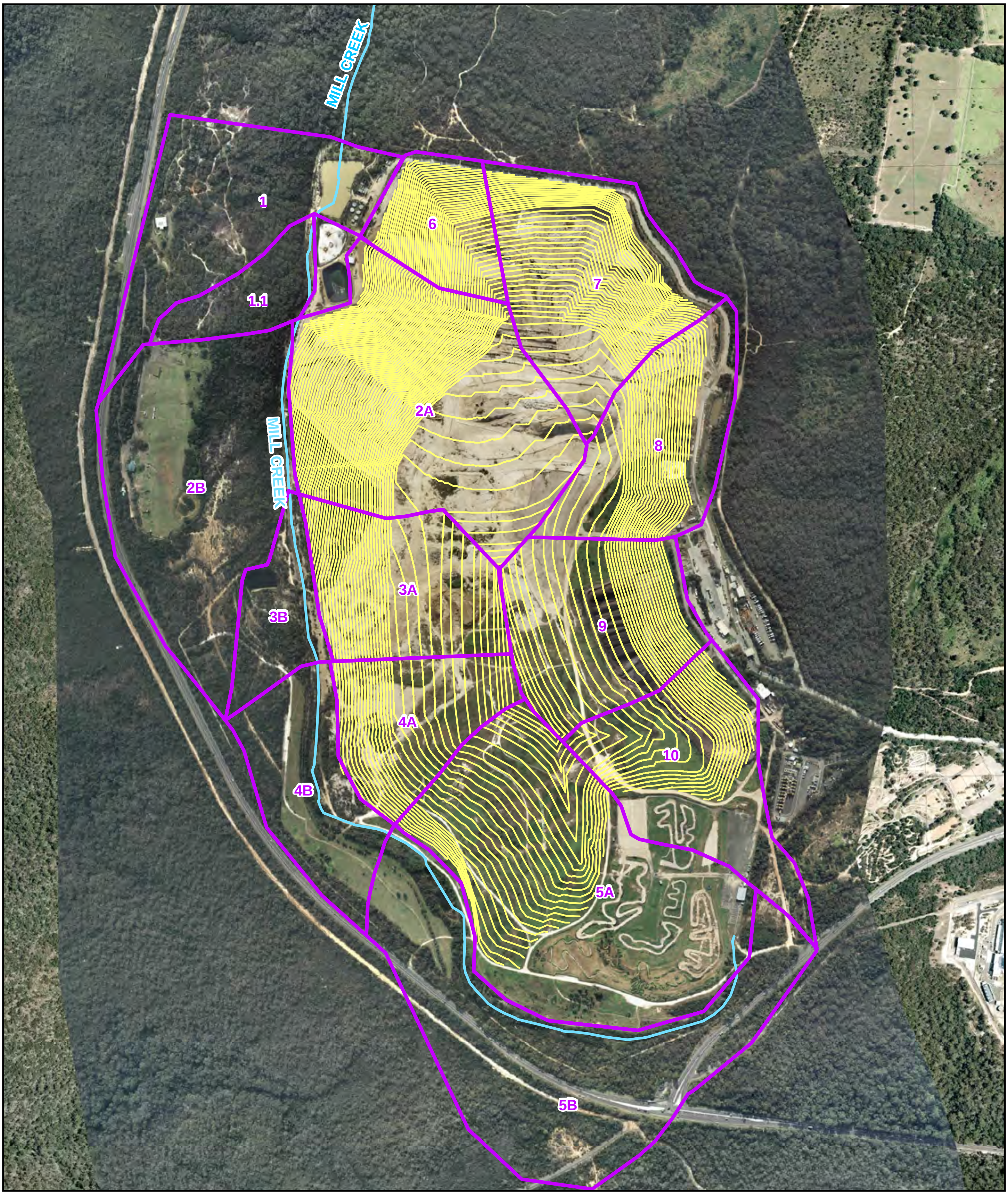
Site catchments – approved final scenario

Figure 4-3

Level 15 133 Castlereagh St Sydney **T** 61 2 9239 7156 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

G:\21\23482\GIS\Maps\MXD\21-23482-Z033_SiteCatchments.mxd

Data source: Imagery: SITA and GOOGLE EARTH 2015. Created by:rgtowner



LEGEND

☐ Catchments

— Proposed landform contours

— Mill Creek

Paper Size A4
0 37.5 75 150 225 300
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	12 May 2015

Site catchments – proposed final scenario

Figure 4-4

Level 15 133 Castlereagh St Sydney **T** 61 2 9239 7156 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

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Data source: Imagery: SITA, GOOGLE EARTH 2015. Created by:rgtowner

4.4.2 Inundation of site features during flood events

In general the gradient of the site is relatively steep with well-defined watercourses or drainage lines. There is also minimal history of inundation from floodwaters at the site. Therefore, in general it is expected that the risk of external floodwaters inundating the site is minimal.

An exception to this is for sensitive features of the site located directly adjacent to drainage lines such as the leachate ponds and the proposed GO and ARRT facilities. Therefore a flood assessment was undertaken to assess the risk of flooding in Mill Creek on these site features.

The flood assessment involved development of a steady state one-dimensional HECRAS hydraulic model of Mill Creek in the vicinity of these features. Design 100-year ARI peak flow rates were extracted from the XP-RAFTS modelling developed as discussed in Section 4.4.1. The flow rates for the final capped scenario were analysed as this is expected to be the point in time for the proposal during which the greatest peak flow rates in Mill Creek are experienced.

Manning's n values adopted were 0.04 for the main channel areas, 0.035 for the short grass overbank areas and 0.07 for forested overbank areas based on Chow, 1959.

Due to the presence of both an outside clean water channel and an inside disturbed area runoff channel in the vicinity of the leachate ponds two separate HECRAS models were developed to represent the potential hydraulic independence of the two channels. Firstly a model was set up to estimate the hydraulic capacity of the outside clean water channel when flowing bank full. This flow rate was subtracted from the total design flow rate with the remaining flow rate routed into the disturbed area runoff channel for estimation of flood levels and extents.

The resultant flood levels and extents were then used to assess the risk of inundation of the landfill and proposed facilities and to inform the design of the proposed GO/ARRT facilities.

The capacity of the perimeter drainage around the east and north of the site was also checked to determine if the peak 100-year ARI event could be conveyed in the drainage line and whether inundation of the existing excavated void from the east and north would occur in this event. Peak flow rates were estimated based on the XP-RAFTS modelling discussed above, with the capacity of the channel calculated using the Manning's normal flow equation.

This was undertaken at several locations to estimate the capacity of the overall length of channel. It is noted that the peak flow rates estimated using the XP-RAFTS model corresponded to the peak flow rate expected for the critical phase of the landfill staging.

4.4.3 Impacts on waterway morphology

Potential impacts on waterway morphology were assessed through the following steps:

- Locations where there is potential for the proposal to impact on waterway morphology were identified, such as where a waterway realignment is proposed.
- For these locations the general features of the waterway are identified, in particular the shape and typical surface geology of the waterway bed and banks identified.
- Proposed flood conditions identified based on hydraulic calculations or modelling.
- Impact assessment and mitigation developed based on the above.

4.5 Surface water quality

The potential surface water quality impacts are from:

- Uncontrolled release of sediment laden water to Mill Creek
- Leachate from the landfill entering surface water and being discharged to Mill Creek

- Leachate from the GO facility entering surface water and being discharged to Mill Creek
- Leachate from the ARRT facilities entering surface water and being discharged to Mill Creek

No uncontrolled release of sediment laden water to Mill Creek

The proposed controls for sediment laden water are in accordance with the EPA's requirements and thereby meet the discharge requirement for sediment laden waters.

No leachate from the landfill entering surface water and being discharged to Mill Creek

The Leachate Assessment (GHD 2015b) details the controls for suitably managing leachate from the landfill component of the Proposal.

In terms of assessing the existing water quality in Mill Creek, the following work was undertaken and detailed in the Aquatic Ecosystem Assessment (refer section 2.5 and Appendix C).

An Aquatic Ecosystem Assessment is considered suitable to assess the site's performance on surface water quality in Mill Creek due to the fact that it involves a detailed assessment of direct indicators of ecosystem health.

Furthermore, as discussed in Section 6.5 the project is expected to suitably manage the risk of elevated concentrations of sediment laden water being discharged off-site and decrease the risk of leachate entering surface water and being discharged to Mill Creek.

No leachate from the GO facility entering surface water and being discharged to Mill Creek

To ensure leachate is not discharged from the GO facility into Mill Creek, there needs to be sufficient capacity in the GO facility leachate storage dam to collect all leachate (stormwater that comes into contact with the garden organics). This is confirmed through a water balance. This is discussed in Section 4.3.2.

No leachate from the ARRT facility entering surface water and being discharged to Mill Creek

Process leachate would be produced within the enclosed operational areas of the ARRT facility, primarily from the composting system and the biofilters, but small volumes of leachate may also be generated during the cleaning and biofilters. Process leachate would also be generated within the composting hall.

An estimated 150 kL per day of process leachate is expected to be generated. All process leachate would be directed to and stored in an aerated 500 kL capacity above ground leachate storage tank arranged for reuse in the composting process. The leachate storage tanks would provide capacity for three days of storage. Bunding would be provided around the leachate storage tank array to prevent discharge of leachate from the site in the unlikely event of failure or during maintenance.

Water is required for application to the composting material in order to accelerate the composting process. The objective is to produce material with 35% moisture content for effective quality control. The estimated water demand to maintain this moisture content is 240 kL per day on the five days per week that turning would operate. Therefore the overall weekly demand for process leachate from the operation of the ARRT facility composting would exceed the volume of process leachate anticipated to be collected from the system. As such, the shortfall in water would be supplied from other sources including stormwater ponds on the site or other parts of the LHRRP site, or potable water.

Water sourcing and security for the ARRT facility is discussed in Section 4.3.2.

Stormwater collected from building roof areas would be collected in rainwater tanks alongside the buildings, and used for general purposes e.g. washing down of equipment, or for addition into the composting processes. Stormwater collected from paved areas within the ARRT facility would be directed to Mill Creek as no waste would be placed on these surfaces.

5. Potential impacts

In order to inform the impact assessment and development of mitigation measures the major potential impacts of the proposal relating to surface water were identified. These included:

- Discharge of waters from the site with high concentrations of suspended solids resulting in negative impacts to the health of downstream waterways. This could be a result of poor erosion and sediment control practices such as insufficiently sized sediment basins, exposure of very large areas of soil or improper design, and poor installation or maintenance of erosion and sediment controls. It is noted that discharge of sediment laden waters during large storms is possible, however the impact of such discharges is minimised through appropriate erosion and sediment control
- 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
- Discharge of leachate through inundation of the leachate infrastructure during flooding conditions as well as the GO/ARRT facility areas and the existing excavated void
- Increasing the demand for potable water for dust suppression; or if potable water is not available in sufficient quantities increase dust generation through lack of available water
- Discharge of leachate influenced surface water into Mill Creek, affecting aquatic ecology.

6. Impact assessment

6.1 Overview

The following sections detail the results of the surface water impact assessment for the proposal. These results inform the mitigation measures required as reported in Section 7.

6.2 Erosion and sediment control

Existing sediment control practices would continue with the proposal, and hence no adverse impact to downstream waterways is expected from the proposal. Notwithstanding this, mitigation measures are proposed in Section 7.2 in accordance with the Blue Book Volume 1 (Landcom, 2005*)* and Blue Book Volume 2b (Blue Book Volume 2b (DECC 2008). These are expected to result in further improvements in erosion and sediment control.

One important aspect of the erosion and sediment control measures is that all sediment laden water would be treated in a settling dam before it is discharged from the site. In addition a large component of the surface water from the disturbed areas would be further treated through the site stormwater treatment plant before it is discharged from the LHRRP, in accordance with the EPA's recommended criteria in Blue Book Volume 2b (DECC 2008) and as detailed in Section 6.1.2 below.

During the construction of the ARRT and GO facilities, some temporary disturbed areas of a significant size would be created that have the potential to impact on downstream water quality. Mitigation measures to manage these risks are outlined in Section 0. Implementation of these measures is expected to prevent significant impacts from occurring.

6.3 Water sourcing and security

6.3.1 Landform

As the LHRRP is progressively reprofiled, capped and revegetated, there is not expected to be a major increase in the demand for water needed for site activities associated with the proposal. The primary demand for water is for dust suppression, which would decrease over time as exposed areas are capped.

Some temporary increases in water demand would occur, due to the commencement of the GO and ARRT facilities and the associated decommissioning of the western sediment and water reuse dam. The amount of water available for site controls would be limited due to the zone of water actively managed for erosion and sediment control in the main sediment and water reuse basin (refer Appendix B).

This water would be treated and discharged off site in accordance with the quality limits applying to the LHRRP, as it would be necessary to make the capacity of the basin available as soon as possible for storage of sediment laden run-off from each future rainfall event.

As discussed in Section 4.3 a water balance was developed for both the existing scenario and the proposed critical scenario (phase 5). Figure 6.1 and Figure 6.2 show the existing and proposed case results of the water balance.

As can be seen from these figures that the backup supply of potable water for dust suppression increases from the existing case to the proposed case from 0.1 ML/year to an average of 0.9 ML/year. This is only approximately 1% of the total water supplied for dust suppression and 2% of the total site annual potable water demand. In addition to this potable water is required only 7 times during the modelled time period of 55 years.

Therefore, it is not expected that the activities associated with the proposal would result in a significant increase in potable water demand. As mentioned previously, additional retention basins would be constructed if required.

It should be noted that the capacity of the main sediment and water reuse basin has recently been increased significantly. No shortages of water for dust suppression have been experienced since that time. However, it is noted that a dry period has not occurred during this time period.

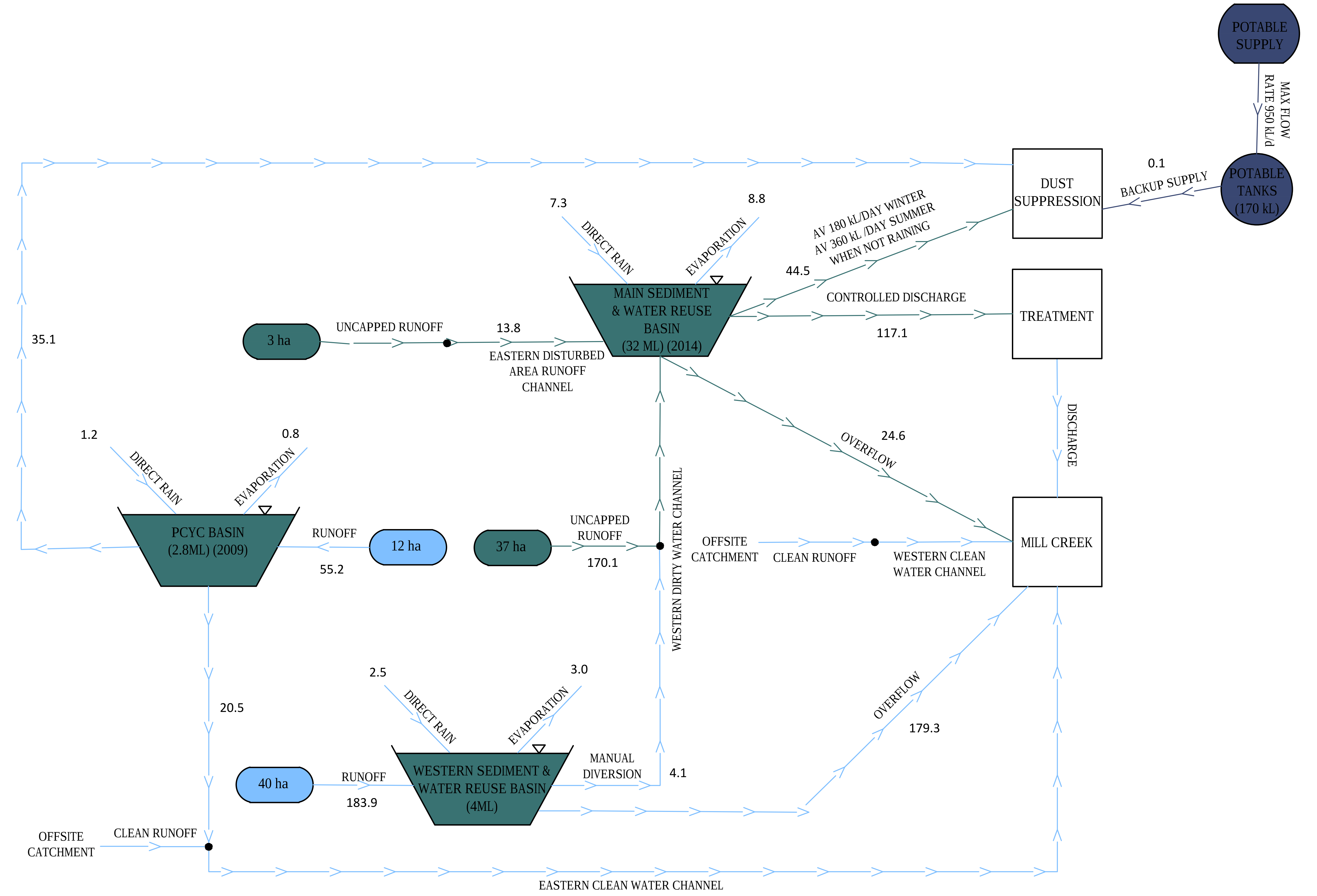
6.3.2 ARRT and GO facilities

Figure 6.3 shows the results of the water balance detailed in Section 4.3.2. The results indicate that the surface water management system could supply all of the water needed for composting purposes within the ARRT and GO facilities (5.2 ML/yr) for the range of potential rainfall conditions.

As discussed in Section 4.3.2 the minimum expected reuse demand rates were applied to conservatively assess the water cycle in terms of the system’s ability to capture water for water quality management. However, it is expected that site runoff will be of suitable quantity to supply demand even for a maximum demand scenario. This is illustrated that even during a dry year the water balance results (based on the minimum demand scenario) show an excess of 5.2 ML of water overflowing the sump and not being collected for reuse, which is equivalent to an additional 100% of the total demand rate.

It is not expected that this sourcing of water for the later stages of the composing process would have a significant impact on water supply and security of the main Sediment and Water Reuse Dam. This is due to the fact that total demand for the ARRT and GO facilities is less than 10% of the demand for dust suppression from the main dam, and the majority of the ARRT/GO demand could be sourced from the GO water containment system.

In reference to Figure 6.3, it should be noted that minimum and maximum annual flows do not necessarily “balance” for each node due to the fact that minimum or maximum rates may occur during different years for different transfers.



LEGEND

——>——	POTABLE WATER	——>——	LEACHATE
——>——	CLEAN WATER	——>——	WASTEWATER
——>——	SITE RUNOFF	XX	MEAN ANNUAL FLOW (ML/YEAR)

GHD

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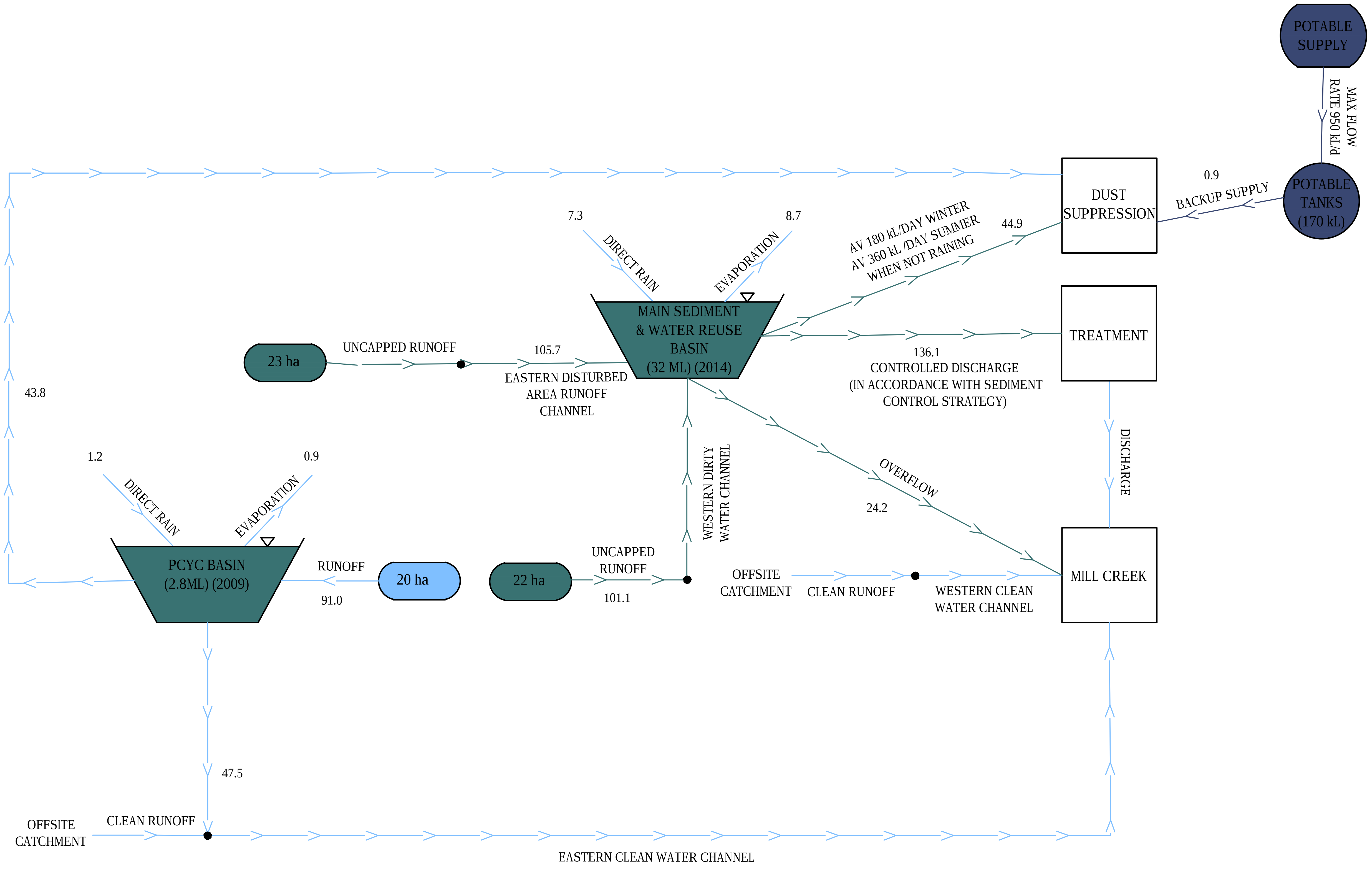
WATER CYCLE SCHEMATIC EXISTING SCENARIO

Job Number 21-23482
Revision B
Date JULY 2015

Figure 6.1

Level 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

Plot Date: 3 July 2015 - 2:13 PM Plotted by: Carol Ng Cad File No: G:\21\23482\Technical\Surface Water\Water Balance\Lucas Heights Water Cycle Scematics.dwg



LEGEND

—>—	POTABLE WATER	—>—	LEACHATE
—>—	CLEAN WATER	—>—	WASTEWATER
—>—	SITE RUNOFF	XX	MEAN ANNUAL FLOW (ML/YEAR)

SITA AUSTRALIA
LUCAS HEIGHTS RRP

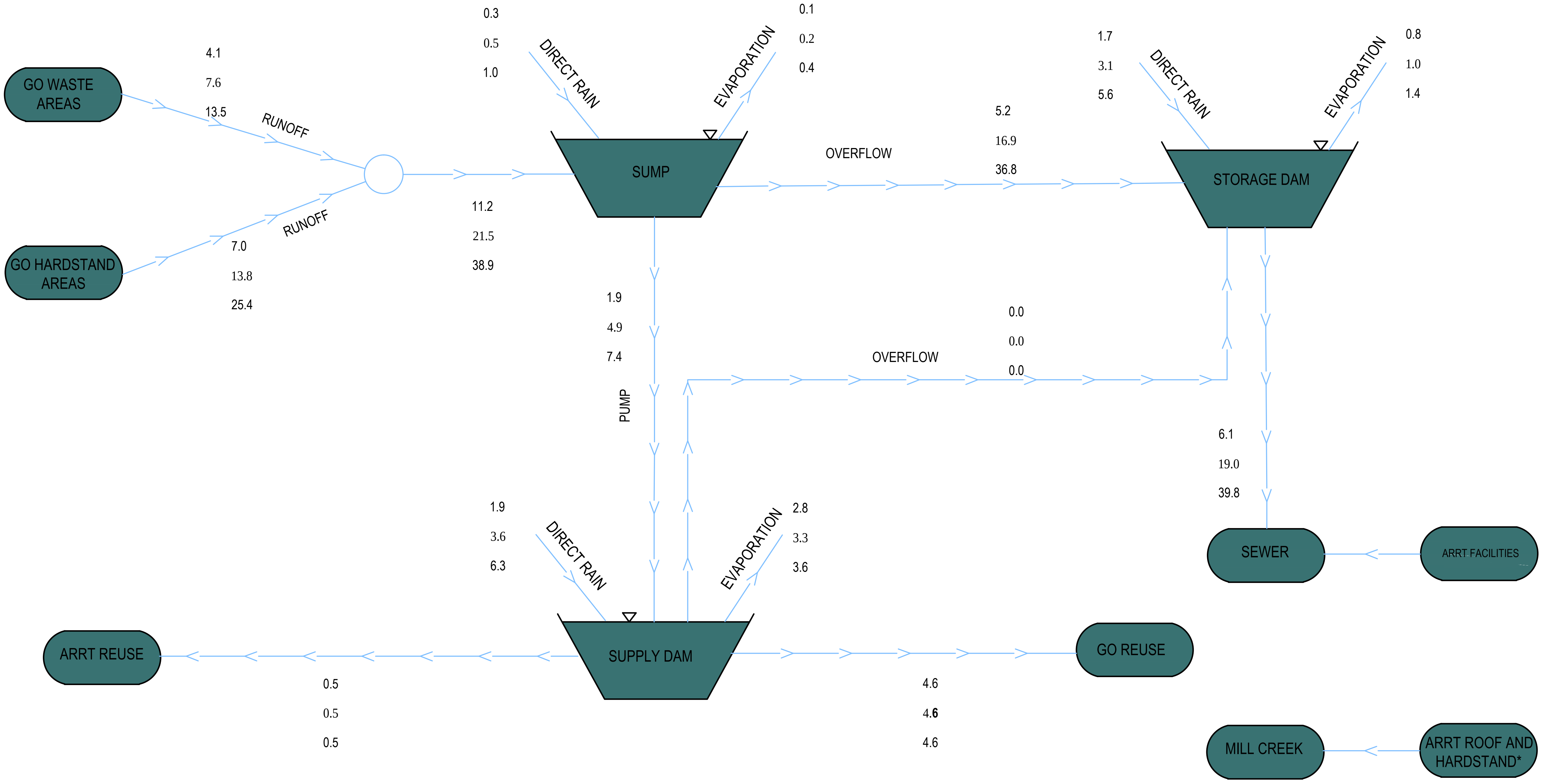
WATER CYCLE SCHEMATIC
PROPOSED SCENARIO (STG 5)

Job Number	21-23482
Revision	B
Date	JULY 2015

Figure 6.2

Level 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

Plot Date: 3 July 2015 - 2:13 PM Plotted by: Carol Ng Cad File No: G:\21\23482\Technical\Surface Water\Water Balance\Lucas Heights Water Cycle Scematics.dwg



* STORMWATER FROM THE ARRT HARDSTAND AREA
WHERE NO WASTE IS STORED

LEGEND

Minimum annual flow (ML / YEAR)

Mean annual flow (ML / YEAR)

Maximum annual flow (ML / YEAR)

GHD

SITA AUSTRALIA
LUCAS HEIGHTS RRP

WATER BALANCE RESULTS
ARRT / GO

Job Number 21-23482
Revision B
Date JULY 2015

Figure 6.3

Level 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

Plot Date: 3 July 2015 - 2:10 PM Plotted by: Carol Ng Cad File No: G:\21\23482\Technical\Surface Water\Water Balance\Lucas Heights Water Cycle ScematicsAARTGO.dwg

6.4 Flooding

6.4.1 Impact on downstream flow conditions

The results of the XP-RAFTS hydrologic model developed to estimate the peak design flow rate for flow leaving the site in Mill Creek are shown in Table 6.1. This model was developed as detailed in Section 4.4.1, providing comparison of the predicted peak runoff rate for both the approved final scenario and the proposed final scenario.

The results of the modelling show that the proposal would increase the peak flow rate discharged from the site by up to approximately 1%.

At this level of increase, downstream flooding would not change significantly.

Table 6.1 XP-RAFTS results – downstream peak flow rates

Scenario	Estimated Peak Flow Rate – 5-year ARI Event (m3/s)	Estimated Peak Flow Rate – 100-year ARI Event (m^3/s)
Approved final scenario	37.1	62.8
Proposed final scenario	37.5	63.2
% Increase	1.1 %	0.6 %

Although the ARRT and GO facilities involve additional impervious areas they are not expected to result in a significant impact downstream of the overall site in terms of peak flow rates. This is due to the fact that water management basins are proposed for the GO facility which would indirectly provide detention storage and the area of the facilities is small compared to the overall site and therefore forms a very small proportion of the overall catchment of any point external to the overall site.

6.4.2 Inundation of site features during flood events

The resultant 100-year ARI event flood conditions from the HECRAS hydraulic model developed as discussed in Section 4.4.2 are shown in Figure 6.4 and Figure 6.5.

Figure 6.4 shows the flooding conditions in the vicinity of the GO / ARRT facility area. These flood results were used to inform the design of the GO / ARRT facility area. On this basis, the proposed pad or building levels would be a minimum of 500 mm above the design 100-year flood level.

Figure 6.5 shows the flooding conditions in the vicinity of the leachate ponds. It can be seen that inundation of the leachate ponds is not expected during the 100-year ARI event, which is the commonly adopted flood planning level in NSW.

Therefore the proposal is not expected to result in unacceptable flood risk from water inundating the site features.

Furthermore, hydraulic calculations undertaken for the eastern and northern perimeter drainage, discussed in Section 4.4.2, showed that inundation of the existing excavated void from the east and the north is not expected for the 100-year ARI event.

6.4.3 Impacts on waterway morphology

The proposed Mill Creek realignment, which is adjacent to the proposed ARRT facility, has the potential to impact on downstream waterway morphology through modification of flow regimes in the creek. This potential impact was assessed in accordance with the procedure outlined in Section 4.4.3.

The results of the HECRAS modelling (as detailed in Section 4.4.2) indicate that the culvert immediately to the east of the Western Sediment and Water Reuse Basin forms a hydraulic control during large storm events. That is, the culvert restricts flows and water backs up behind it, controlling upstream flow conditions through the realigned section as well as downstream hydraulic behaviour.

Therefore modification of the flow regimes upstream of the culvert, through realignment of the creek, is not expected to have a significant impact on downstream flow conditions. As a result, significant impacts on downstream creek stability and morphology are not expected to arise. Furthermore, the creek is generally located in bedrock and is not susceptible to changes in morphology.

6.5 Surface water quality

As discussed in Section 2.5, the aquatic ecosystem assessment (refers Appendix C) allowed for assessment of 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.

This existing impact discussed above is not expected to increase as the proposal is expected to improve water quality through the following measures:

- Provision of final revegetated cap across the site, constructed as each area is completed. The cap would consist of a low permeability compacted clay layer (or an EPA approved alternative) which would reduce the generation of leachate through reduced rainfall infiltration and the ability to more effectively shed surface water off the site. As assessed in the Leachate Assessment Report (GHD 2015b), the proposed reprofiled landform and the proposed cap would allow less water through than the crushed sandstone cap which has been constructed on the site to date. These actions would also reduce the potential risk of leachate entering surface water and being discharged off-site
- The proposed staging for reprofiling the landfill which would progressively cap and revegetate areas which are currently not capped and revegetated. This would occur before disturbing areas that are already capped and revegetated
- 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
- Additional leachate control measures, including a dual gas/leachate management trench constructed near the perimeter of the re-profiling area, to control the risk of leachate escaping to surface water. The purpose designed trench would consist of a nominally 1.5 – 2 m deep trench within the existing waste mass backfilled with suitable drainage material and perforated pipe. Extraction risers would be located along the length of the trench, to allow leachate to be extracted and transferred to the existing leachate containment system.

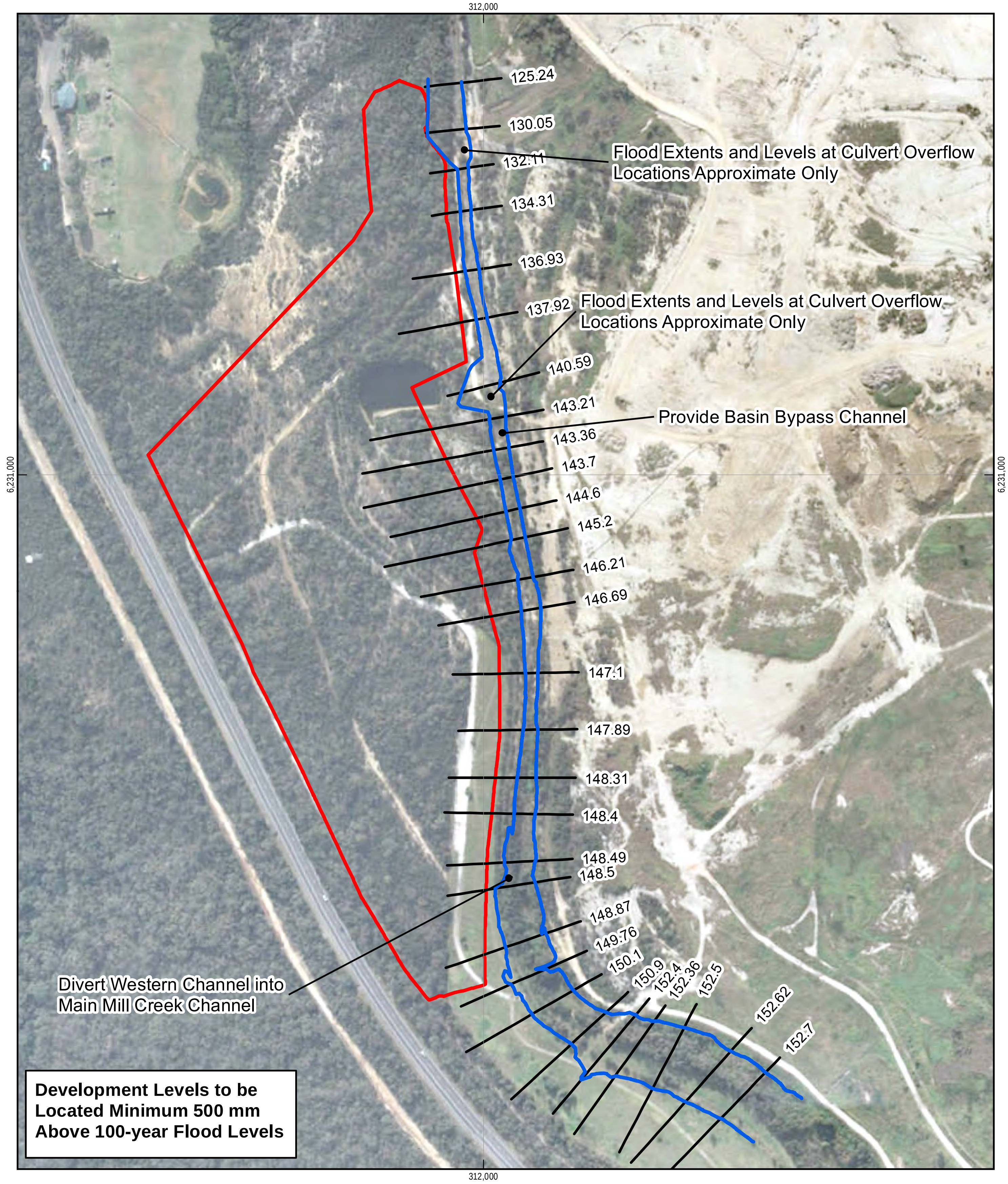
6.5.1 ARRT and GO facilities

There is the potential for leachate to be generated within the GO facility from runoff that has contacted the compost materials. As discussed in section 4.3.2 the water management system for the ARRT and GO facilities includes the following features:

- Supply Dam Volume: 4.8 ML

- Storage Dam Volume: 12 ML
- Surface water from the breathable covers over the concrete bunkers (7,020 m^2) in the GO facility area would be diverted to surface water as it would not have come into contact with compost.

The results of the water balance shown in Figure 6.3 indicated that for the above configuration no leachate discharges would be expected from the system over the modelled time series. Therefore it is not expected that there would be any leachate discharged to downstream waterways from the operation of the ARRT and GO facilities.



Flood Extents and Levels at Culvert Overflow Locations Approximate Only

Flood Extents and Levels at Culvert Overflow Locations Approximate Only

Provide Basin Bypass Channel

Divert Western Channel into Main Mill Creek Channel

Development Levels to be Located Minimum 500 mm Above 100-year Flood Levels

LEGEND

- 100yr ARI Event Flood Extents
- Hydraulic Model Cross Sections (Max 100-yr Water Level Labelled)
- 🟥 ARRT GO Facilities Preliminary Boundaries

Paper Size A4

0 12.525 50 75 100

Metres

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

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GHD

SITA Australia
Lucas Heights Resource Recovery Park

Job Number	21-23482
Revision	A
Date	12 May 2015

Flood Results – ARRT/GO Area

Figure 6-4

Level 15 133 Castlereagh St Sydney T 61 2 9239 7156 F 61 2 9239 7199 E sydmail@ghd.com W www.ghd.com

G:\21\23482\GIS\Maps\Deliverables\21_23482_Flooding_AART_GO_RevB.mxd

Data source: Imagery: SITA. Created by:rgtowner

LEGEND

100yr ARI Event Flood Extents

Hydraulic Model Cross Sections (Max 100-yr Water Level Labelled)

🟥 ARRT GO Facilities Preliminary Boundaries

Paper Size A4
0 5 10 20 30 40
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	06 Mar 2015

Flood Results – Leachate Ponds Area

Figure 6-5

Level 15 133 Castlereagh St Sydney **T** 61 2 9239 7156 **F** 61 2 9239 7199 **E** sydmail@ghd.com **W** www.ghd.com

G:\21\23482\GIS\Maps\Deliverables\21_23482_Flooding_LeachatePonds.mxd

Data source: Imagery: SITA. Created by:dolloyd

7. Mitigation measures

7.1 Overview

The following sections detail the proposed mitigation measures to manage the impacts identified in chapter 6, as well as assessing the residual risk after implementation of the mitigation measures. Comprehensive mitigation measures are proposed relating to both the design and the operations of the facilities. The mitigation measures are described below and would be employed throughout all stages of the proposal from establishment through to final closure.

7.2 Design mitigation measures

7.2.1 Erosion and sediment control

Erosion and sediment control measures for the proposal would be in accordance with the general principles of *Landcom 2005* and *Blue Book Volume 2b (DECC 2008)* including reprofiling the landfill in accordance with the staging plans (Appendix A) which have been developed to generally increase the areas of the site capped and revegetated thereby reducing the erosion potential of the site.

The management of erosion and sediment control at the site would also be undertaken in accordance with the EPA’s recommended requirements in Blue Book Volume 2b (DECC 2008) and the Environmental Protection Licence which stipulates discharge concentration limits for the site with allowance for higher discharge concentrations due to storm events when all practical measures have been taken to minimise discharge concentrations.

An erosion and sediment control plan or soil and water management plan would be developed for the proposed ARRT and GO facilities. These would cover both construction and operational phases.

The following sections provide further information on key elements of the proposed erosion and sediment control mitigation measures. With the implementation of the measures described above and in the following sections it is not expected that the proposal would result in a significant impact in terms of sediment discharge to downstream waterways.

Collection of disturbed area runoff and diversion of clean runoff

In accordance with *Landcom 2005* and *Blue Book Volume 2b (DECC 2008)* it is proposed that clean water run-on is diverted away from “disturbed areas” and sediment laden water is collected for appropriate management and treatment for rainfall events up to the 20-year ARI event. It is proposed that this is achieved through installation of surface water channels or utilisation of existing channels such as Mill Creek (for clean water). These channels would be designed including consideration of scour control. Rock protection, stepping, and energy dissipation would be employed where required.

A proposed preliminary sizing guide is shown in Table 7.1. This has been developed as detailed in section 4.2.1. This sizing guide would be applied to the proposed drainage channels throughout the proposal. Channels would be sized based on Table 7.1 considering the maximum catchment area they may collect at any point in time throughout the proposal. Further assessment would be performed as part of the OEMP (SITA, 2014a) to confirm sizing for specific channels during the detailed design stage of each phase of the reprofiling works and the GO/ARRT facilities.

Table 7.1 Channel preliminary sizing guide

Catchment Area (ha)	Design 20-year ARI Event Peak Flow Rate (m^3/s)	Required Flow Depth (m)	Required Channel Base Width (m)
1	0.53	0.25	1
2	1.08	0.35	1
5	2.63	0.5	1
10	5.27	0.75	1
20	10.49	1	1
35	17.95	1	2.5
50	26.21	1	5

It should be noted that Mill Creek in the vicinity of key infrastructure has the capacity to convey the 100-year ARI event peak flow rate and that inundation of the existing excavated void from the east and the north is not expected for the 100-year ARI event. Therefore enlargement of existing perimeter drainage is not proposed.

Removal of suspended sediments by utilising sediment basins

It is proposed that the main sediment dam located at the north-west corner of the basin be operated as a Type D sediment basin in accordance with the Blue Book (Landcom 2004 and DECC 2008). However the basin would also operate as a water reuse basin with its water reuse volume provided below the zone actively managed for erosion and sediment control.

Three zones would comprise the total storage of the basin (of total volume 32 ML):

- A sediment storage zone: This would be located at the invert of the basin and would be the volume of the basin that fills up with captured sediment over time. The volume of this zone would be 5 ML as calculated in section 4.2.2 with the predicted clean out frequency being in the order of once every 10 years. Existing sediment traps located further upstream within the site would be maintained and managed such that a large proportion of the mass of sediments is captured before entering the main basin. This would significantly reduces the cleanout frequency and sediment storage zone volume required.

- A water reuse zone: This would be located above the sediment storage zone and would provide water for reuse for dust suppression. Water levels would be allowed to fluctuate within this zone based on rainfall and water demand patterns. This would have an estimated volume of 17 ML which is calculated as the remaining volume of the basin once the sediment storage and sediment control “settling” zones are subtracted. This volume of water would be available for water reuse.

- A sediment control “settling” zone: This zone would allow for capture and treatment of the design erosion and sediment control event (as discussed in Section 4.2.2). The volume of this zone would be 10 ML as calculated in Section 4.2.2 and based upon the point in time during the proposal during which the largest catchment area would be directed to the basin (Phase 5). Once the water level in the basin is within this zone treatment and discharge through the stormwater treatment plant would be initiated and would continue until the water level is below the range of the zone. The stormwater treatment plant would treat waters such that the concentration of suspended solids in discharge water is less than 50 mg/L. When the water level exceeds the top of the “settling” zone an overflow from the basin would occur.

Runoff is collected in the excavated area of the site in its excavated void for a period of time over the life of the proposal. Depending on the quality of the water in the excavated void it is either pumped to the leachate treatment system or the main sediment basin. If water is pumped to the main sediment basin this would be done once the sediment control “settling” zone has been re-established and is still available and therefore the catchments draining to the depression do not affect the required volume of the “settling” zone.

With implementation of the above mitigation measures the requirements of the EPL in relation discharges of sediment laden waters are expected to be satisfied as follows:

- Controlled discharges through the stormwater treatment plant are monitored for quality prior to release and discharge requires concentrations of TSS less than 50 mg/L.
- Overflows would only occur when the design erosion and sediment control rainfall event is exceeded. Concentrations of TSS in these overflows may be greater than 50 mg/L, as permitted by the EPL, and in accordance with the requirements of *Landcom 2005* and *Blue Book Volume 2b (DECC 2008)* to avoid or minimise water impacts.

The spillway of the main sedimentation basin would include a trash rack to reduce the risk of litter being released from the site and this trash rack would be regularly inspected and cleared.

ARRT and GO facilities

During the construction phase the areas disturbed in the proposed ARRT and GO areas would be managed in accordance with the procedures outlined in *Blue Book Volume 1 (Landcom, 2004).* In particular, a soil and water management plan would be developed for the works, and would be incorporated into the contractor’s environmental management plans. General principles proposed in the plans would include minimisation of exposed areas at any one point in time, maximising ground cover, collecting sediment at the source and potentially provision of sediment basins utilising water management storages proposed for the operational phase.

7.2.2 Water sourcing and security

Measures are in place at the site to minimise demand for potable water. These would include reuse of water captured in site basins for dust suppression. These measures would continue throughout the proposal, and as discussed in section 6.3 the proposed landfilling activities and ARRT and GO activities are not likely to result in a significant increase in potable water demand.

The proposed ARRT facility would be designed and constructed such that there is not a significant increase in the demand for potable water.

The relocated GO facility would be constructed such that there is no increase in potable water demand in addition to current demands.

To confirm the assumptions adopted for the water balance, it is recommended that the water balance for the GO / ARRT facilities be calibrated 6 months after construction. The model should then be further calibrated 1 year after construction and subsequently once every 3 years.

With implementation of these mitigation measures there is not expected to be significant impacts from the proposal on water sourcing and security.

7.2.3 Flooding

As discussed in section 6.4 the proposal is not expected to result in significant impacts relating to flooding.

Detention storage would be provided at the proposed ARRT and GO facilities if required to maintain peak discharge rates at existing levels. The GO/ARRT facilities would be constructed outside the 100-year ARI flood levels such that inundation during the 100-year ARI event is not expected.

With implementation of these mitigation measures there is not expected to be significant impacts from the proposal on flood conditions.

7.2.4 Surface water quality

The proposal is expected to improve water quality through the following design features:

- Provision of final revegetated cap across the site, constructed as each area is completed
- Complete containment of leachate from the landfill, GO and ARRT facilities
- Additional leachate control measures, including a dual gas/leachate management trench constructed near the perimeter of the re-profiling area, to control the risk of leachate escaping to surface water. The purpose designed trench would consist of a nominally 1.5 – 2 m deep trench within the existing waste mass backfilled with suitable drainage material and perforated pipe. Extraction risers would be located along the length of the trench, to allow leachate to be extracted and transferred to the existing leachate containment system.

7.3 Operational mitigation measures

A comprehensive list of prevention, mitigation and rectification measures has been identified and they are detailed in the LHRRP Operations Environmental Management Plan (SITA Australia, 2014a), GO Facility Operations Environmental Management Plan (SITA Australia 2014b) and ARRT Facility Operations Environmental Management Plan (SITA Australia 2014c). 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.

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

7.3.1 LHRRP

- Where possible, minimising exposed areas over which sediment would be generated through maintenance of both natural and artificial ground cover such as grass or erosion control cover products
- Where sediment is generated, capturing the majority of sediments as close as possible to the point of generation through sediment traps
- Discharging of disturbed area drainage lines into a sediment basin designed in accordance with *Landcom 2005* and *Blue Book Volume 2b (DECC 2008)*
- Diversion of clean upstream runoff around the site to avoid mixing with runoff from disturbed areas
- Appropriate management of vehicle movements to minimise generation and transport of sediment
- Appropriate management of material stockpiles including locating them as far from drainage lines as possible
- General flood management practices would be employed on site including keeping drainage lines free of waste and debris and monitoring drainage lines during periods of heavy rainfall
- Surface water monitoring would continue to be undertaken as prescribed in EPL 5065.
- Further investigation of the habitat condition and macroinvertebrate populations to confirm the preliminary findings contained within Appendix C. It is recommended that this work be undertaken every three years commencing soon after reprofiling works commence in Area E.
- Progressively revegetated completed reprofiling areas

- Separate runoff from disturbed areas would be from undisturbed areas where possible
- Design and operate sediment dams and sediment traps to promote sedimentation
- Maintained erosion and sediment control measures until the site is stabilised
- Maintenance of drains to prevent weed build up
- Maximise use of collected water on site for dust suppression, irrigation, composting, maintenance of haul roads etc.
- Keep surface water drains free of litter

7.3.2 GO Facility

- Separate runoff from areas where compost and related materials would be placed from areas there is no compost and related materials, where possible
- Maintenance of bunds separating catchments in the GO facility
- Ongoing monitoring of leachate volumes generated, stored, re-used and disposed of for the GO facility
- Periodic review of the leachate water balance model

7.3.3 ARRT facility

- ARRT facility users are made aware of the requirement for loads to be delivered in covered or enclosed vehicles
- Sealed surfaces are sprayed using collected stormwater rather than potable water sources
- Ongoing monitoring of leachate volumes generated, stored, re-used and disposed of for the ARRT facility
- Periodic review of the leachate water balance model

8. Post-closure impact assessment

8.1 Post-closure management

After completion of site operations the site would be converted to a parkland area including significant vegetated and landscaped areas. The rehabilitation plans are included in Appendix E and include details of various surface water management structures such as weirs, Duck Pond, and Mill Pond.

This surface water assessment also included potential surface water impacts during this post-closure phase.

Water management dams

Details of the proposed post-closure surface water management system dams are listed below:

- The PCYC Dam and Western Sediment and Reuse Dam would have already been decommissioned by this stage in previous phases of the project.
- The main sediment and water reuse dam would remain, functioning as a water reuse dam, and would be again cleared of sediment at completion of operations in 2038 before the parkland's availability.
- Decommissioning of the ARRT and GO facilities, including the GO facility dams

Drainage channels

Drainage channels as shown in Appendix A would collect surface runoff. The channel locations have been proposed such that the area draining to the main sediment and reuse basin is approximately equal to the maximum catchment draining to the dam during the operational phase of the project.

This would provide the maximum volume of water available for re-use (if needed) over the parkland site, whilst not significantly decreasing environmental flows to Mill Creek compared to during the operational phase of the project. For example, if all of the site was directed to the basin, environmental flows in Mill Creek would be reduced, but if none of the site was directed to the basin, a minimal amount of water would be available for irrigation.

Indicative channel sizing

Detailed design of the drainage channels would be required prior to construction of the channels before the commencement of each landfill stage in consideration of potential for scour, including rock protection, energy dissipation or stepping where required. An indicative design has been undertaken and the design methodology, basis and results are contained in Appendix D. This indicative design takes into account the post-closure surface water drainage requirements.

The capacity of the perimeter drainage (Mill Creek and drainage around the east and north of the site) was also reviewed to determine if the peak 100-year ARI event could be conveyed in the drainage line and modelling was undertaken. Based on the dimensions obtained from the topographic survey, the outer perimeter drains would be able to convey a 100-year ARI event for Mill Creek.

The outer perimeter drains along the northern and eastern boundary and both perimeter drains are also expected to be able to convey water during the 100-year ARI event. As there are two perimeter drains along the northern and eastern boundaries and during a 100-year ARI event, both drains would be able to convey flows. The existing dimensions are therefore considered to be adequate. The existing perimeter drains are therefore proposed to be retained post-closure of the LHRRP.

Channel lining

The selection of lining type should consider the velocities likely to be experienced in the channels during a 20 year ARI design storm event in order to prevent excessive soil erosion. The 20 year ARI design storm event was selected in accordance with the Blue Book Volume 2b (DECC 2008) Table 6.1, for a duration of disturbance greater than 3 years.

Different lining types provide protection for flows within certain velocity range. Table 8.1 shows the critical indicative velocities for a range of lining materials.

Table 8.1 Critical velocity for different lining materials, adapted from the Blue Book Volume 1 (Landcom, 2005)

Material	Critical velocity (m / second) for inundation < 24 hours[2] Soil erodibility Low	Moderate	High
High performance bonded plastic fibres (vegetated)	5.0	5.0	5.0
Rock lined[3]	3.05	-	3.96
Plastic fibres with netting	3.6	3.6	3.6
Mesh reinforced pregrown turf	2.3	2.0	1.8
Kiku yu grass	1.9	1.7	1.4
Jute or coir mesh (close weave, bitumen sprayed)	1.7	1.5	1.3
Coconut / jute fibre mats	1.7	1.5	1.3
Couch, carpet grass, Rhodes grass	1.5	1.4	1.1
Bare soil	0.5	0.4	0.2

Expected channel velocities and potential channel lining treatments are shown on plan 21-23482-SK022 contained in Appendix D. The most suitable channel lining type would be determined during detail design with consideration of critical flows velocities and final drain locations.

8.2 Impact assessment

Table 8.2 presents the results of the impact assessment of the post closure site in terms of surface water. As can be seen from this table, the post-closure site uses would not result in any unacceptable impacts in terms of surface water.

Table 8.2 Post-closure impact assessment

Potential Impact	Assessment
Mobilisation of sediment from disturbed soils and discharge of sediment laden runoff	The post-closure site would be vegetated with minimal volumes of sediment able to be mobilised
Insufficient water available for parkland usage	Water balance modified to represent post closure scenario. Results of this show that the reuse dam only empties once during the modelled time series of 55 years for the following demand regime: * 0.4 ML is extracted per day when the storage volume on

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[2] Considered conservative as the channels are unlikely to be inundated for 24 hours

[3] From Fischenich (2001)

Potential Impact	Assessment
	that day is greater than 30% of capacity; and * 0.15 ML is extracted per day when the storage volume on that day is less than 30% of capacity. These demands may be adopted as withdrawal limits (subject to more detailed review at the completion of operational phase) and therefore shortages of water are expected to be infrequent.
Inundation of Leachate Dam from Water In Drainage Lines	Drainage line sizes adjacent to Leachate Pond to be maintained as existing, therefore inundation not expected during the 100-year event as discussed in Section 6.4.2.
Leachate entering surface water	The ARRT and GO facilities would be decommissioned and won't exist at the site, hence pose a nil risk of impacting on water quality. Entire site would be capped and revegetated reducing the risk of leachate being able to enter surface water.

8.3 Post-closure management

While Council would be responsible for maintaining the parkland, SITA would continue to have responsibility for the environmental performance of the disposed waste. The Voluntary Planning Agreement also describes SITA's commitments to maintaining assets at the LHRRP, including stormwater infrastructure.

A post-closure environmental management plan (SITA, 2014d) has been prepared which details the management requirements. 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.

Examples of key measures that are included in the post-closure environmental management plan are provided below:

- Removal of sediments from storage ponds after five years (and prior to handover) if required
- Activate the stormwater treatment plant if required
- Maintain vegetation in drains to ensure adequate flow
- Remove any built up litter from surface water drains
- Repair any erosion or scoured vegetation as required

9. Conclusions

9.1 Summary of key outcomes

Key outcomes of this assessment include:

- With the implementation of the measures proposed in this report it is not expected that the proposal would result in an unacceptable impact in terms of sediment discharge to downstream waterways
- It is not expected that the activities associated with the proposal would result in a major increase in potable water demand
- Stormwater discharged from the site is not expected to have any unacceptable impacts on flooding conditions downstream
- Re-profiling and re-capping of areas would reduce the potential risk of leachate entering the surface water system hence would not deteriorate receiving water quality
- The water balance suggests that the leachate proposed dams for the GO facility would have sufficient capacity and hence there would be no discharge of leachate to Mill Creek during modelled time series
- Overall weekly demand for process leachate from the operation of the ARRT facility composting process would exceed the volume of process leachate anticipated to be collected from the system. Hence no excess process leachate would be generated or able to be discharged to Mill Creek.

Therefore, the proposal is not expected to result in any unacceptable impacts relating to surface waters.

Mitigation measures are proposed to manage risks and achieve these outcomes, with key mitigation measures listed below:

- Separation of clean and sediment laden water with clean water diverted offsite and disturbed area runoff managed in the site surface water management system
- Minimisation of exposed areas at any point in time. In particular, the staging of the landfill would be developed such that the capped and revegetated area of the site would generally increase during the waste reprofiling works with the consequential reduction in the erosion potential of the LHRRP
- Utilisation of the main sediment basin as both a Type D sediment basin in accordance with *Managing Urban Stormwater: Soils and Construction Volumes 1 and 2b* as well as water reuse to limit reliance on potable water
- All surface water from the site would be treated in sediment basins before it is discharged off-site in accordance with the EPA's guidelines for sediment and erosion control for landfills (Blue Book Volume 2b (DECC 2008)
- Diversion of surface water in suitably sized stormwater diversion channels and berms
- Lined containment structures to suitably contain leachate from the GO and ARRT facilities
- Re-profiling and re-capping of areas to reduce the potential risk of leachate entering the surface water system.

9.2 Meets identified objectives

This report addresses the SEARs requirements (section 1.6) and concludes that the proposal would meet the following objectives as identified in section 1.2:

- Prevention of surface water contamination
- Minimising sediment generation and transport off the site
- Minimising soil erosion
- No significant impact to downstream flow conditions

10. References

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11. Limitations

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GHD otherwise disclaims responsibility to any person other than SITA Australia 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.

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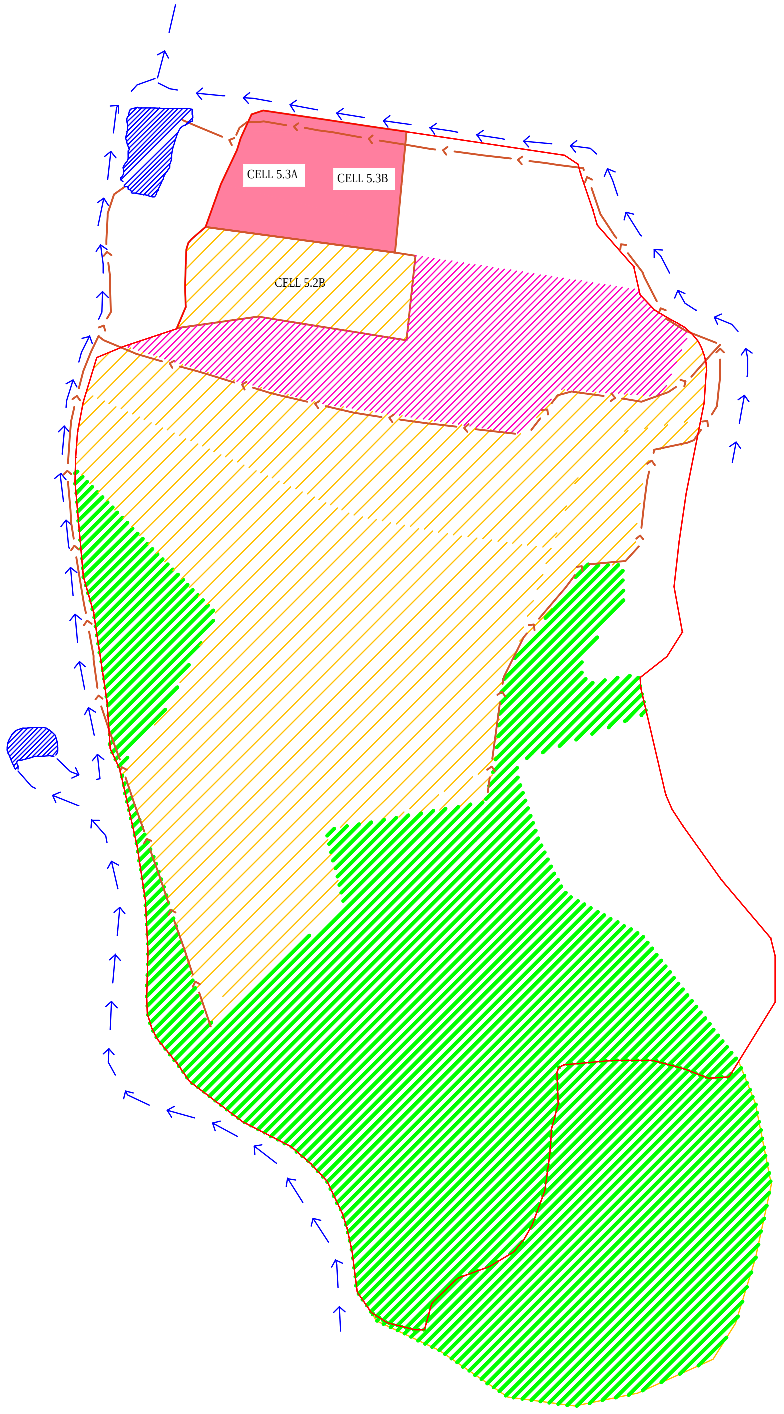
Appendices

Appendix A – Staging Drainage Plans



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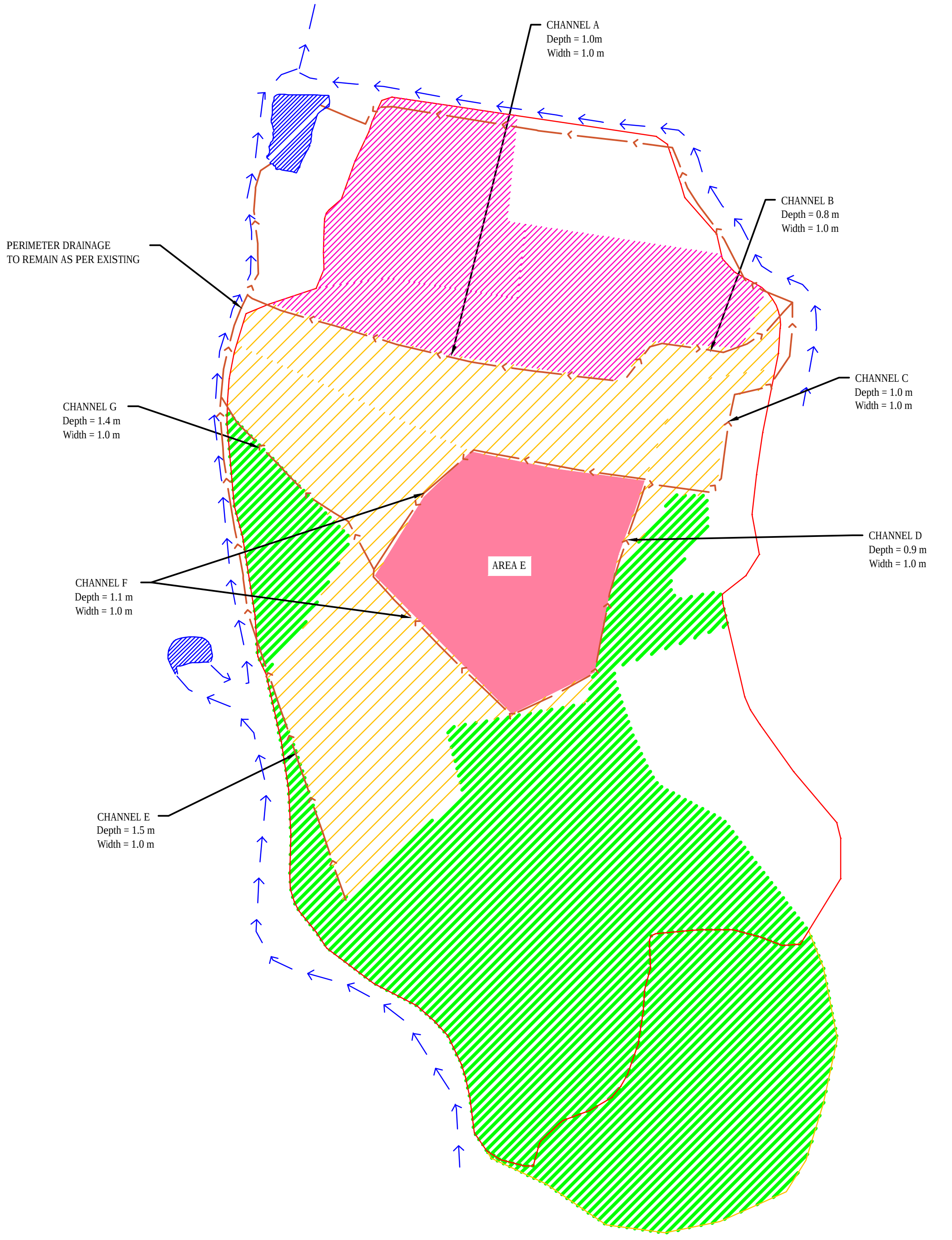
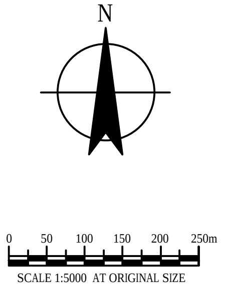


PHASE 1

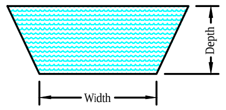
LEGEND:

- ― PROPOSED RE-PROFILING BOUNDARY
- ▭ ACTIVE CELL
- ▨ INTERMEDIATE COVER - PLATFORM
- ▨ INTERMEDIATE COVER - SLOPES
- ▨ EXISTING CAP
- 🟩 PROPOSED FINAL CAP - PLATFORM
- 🟩 PROPOSED FINAL CAP - SLOPES
- ▨ PROPOSED POST-CLOSURE CAP - PLATFORM
- ▨ PROPOSED POST-CLOSURE CAP - SLOPES
- → → — INDICATIVE SURFACE WATER DIVERSION DRAIN
- — › — INDICATIVE SURFACE WATER COLLECTION DRAIN



SCALE 1:5000 AT ORIGINAL SIZE

Notes:
All drainage channels are trapezoidal



PRELIMINARY

rev	description	app'd	date
C	REVISED		03.07.15
B	INITIAL ISSUE		05.03.15

SITA AUSTRALIA
LUCAS HEIGHTS RRP

PROPOSED REPROFILING DEVELOPMENT PLAN

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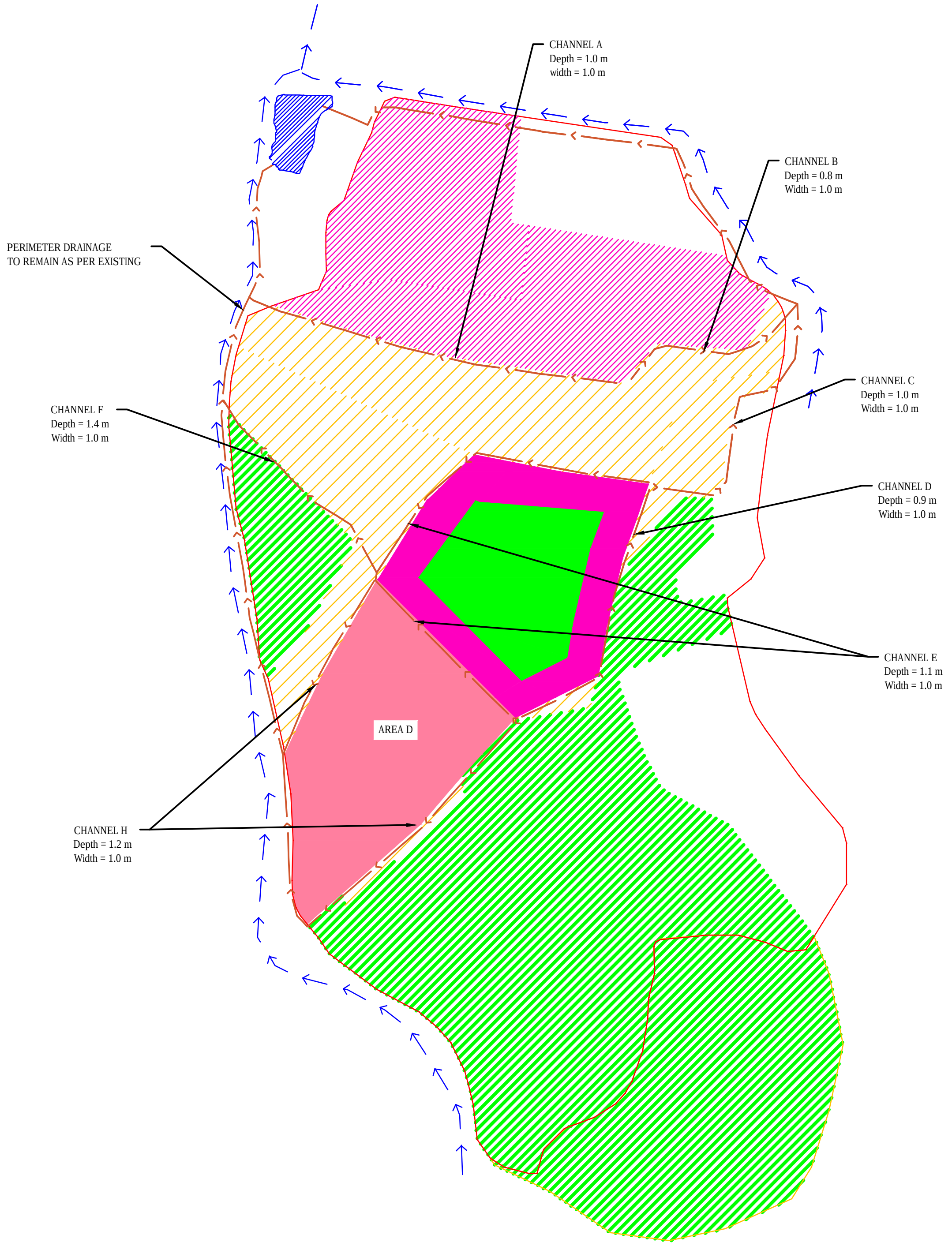
scale 1:5000 for A1
job no. 21-23482
date MAR 2015
rev no. B

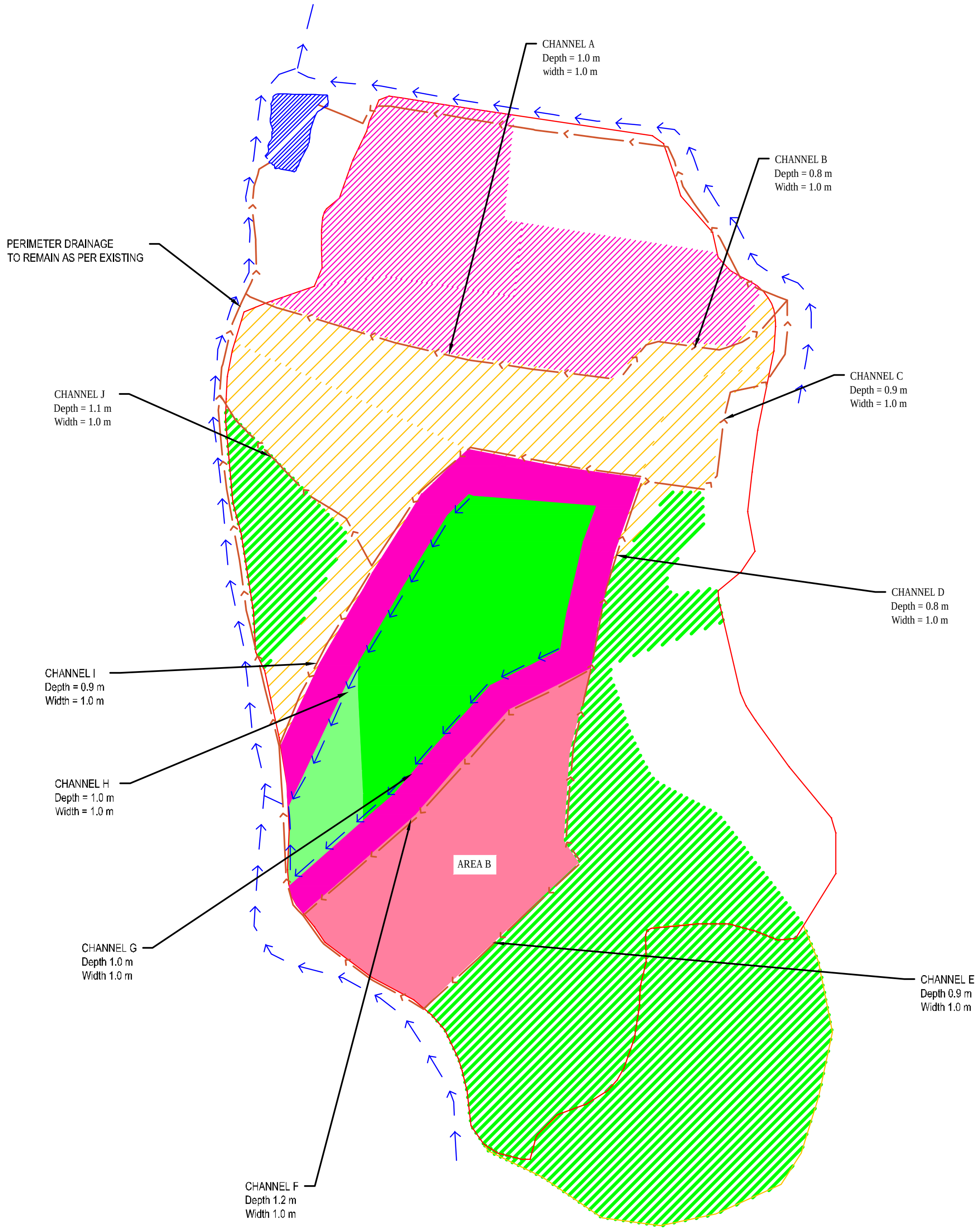
approved (PD) ....

SK011

Plot Date: 3 July 2015 - 2:30 PM
Plotted by: Carol Ng
Cad File No: G:\21\23482\CADD\Drawings\21-23396-SK011-SK016.dwg



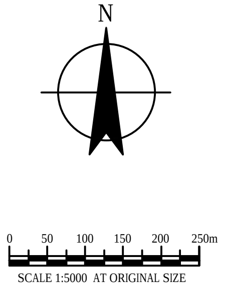
PHASE 2



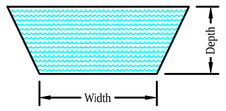
PHASE 3

LEGEND:

—	PROPOSED RE-PROFILING BOUNDARY
☐	ACTIVE CELL
▨	INTERMEDIATE COVER - PLATFORM
▨	INTERMEDIATE COVER - SLOPES
▨	EXISTING CAP
🟩	PROPOSED FINAL CAP - PLATFORM
🟩	PROPOSED FINAL CAP - SLOPES
▨	PROPOSED POST-CLOSURE CAP - PLATFORM
▨	PROPOSED POST-CLOSURE CAP - SLOPES
→ → —	INDICATIVE SURFACE WATER DIVERSION DRAIN
— > —	INDICATIVE SURFACE WATER COLLECTION DRAIN



Notes:
All drainage channels are trapezoidal



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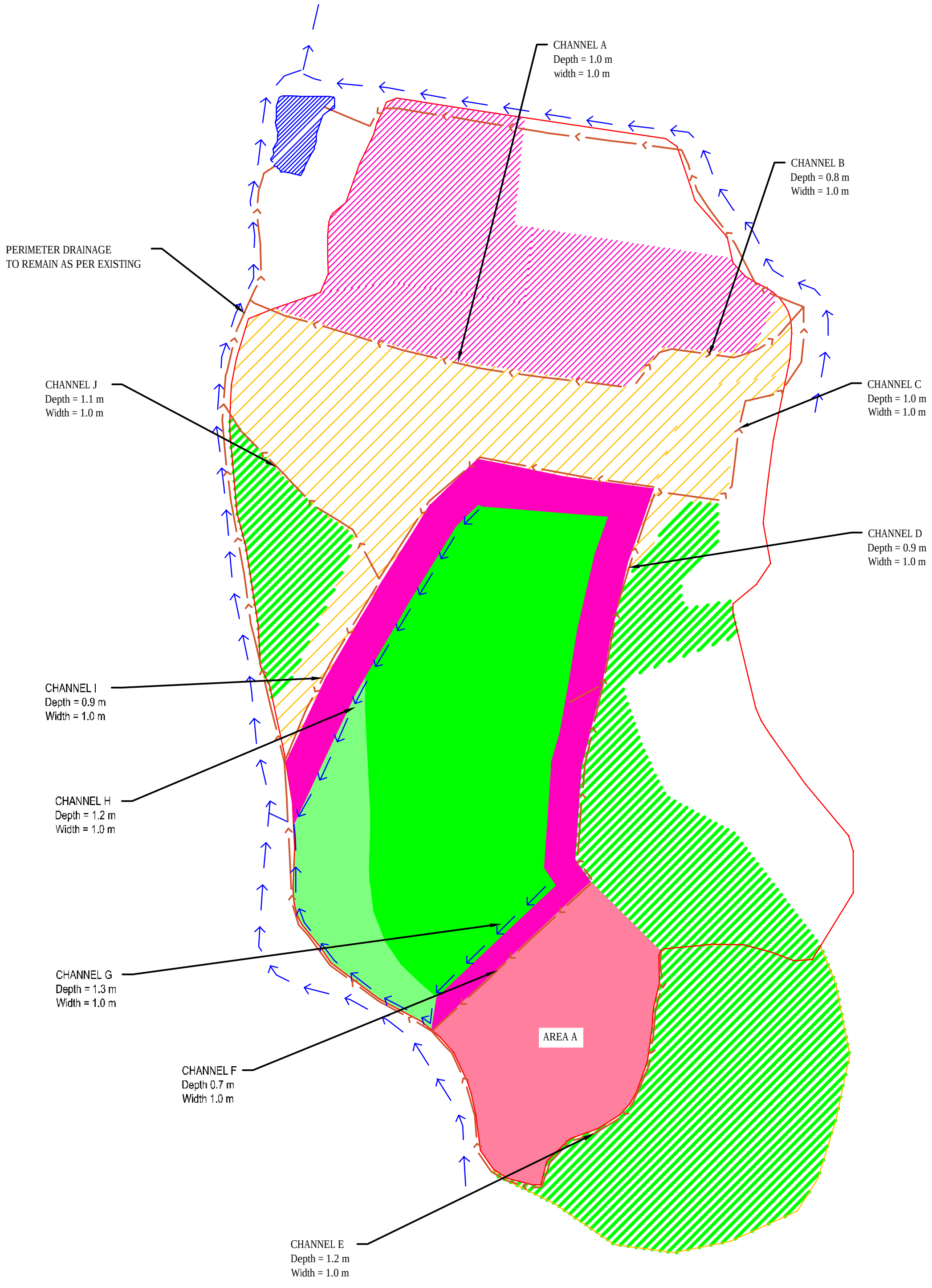

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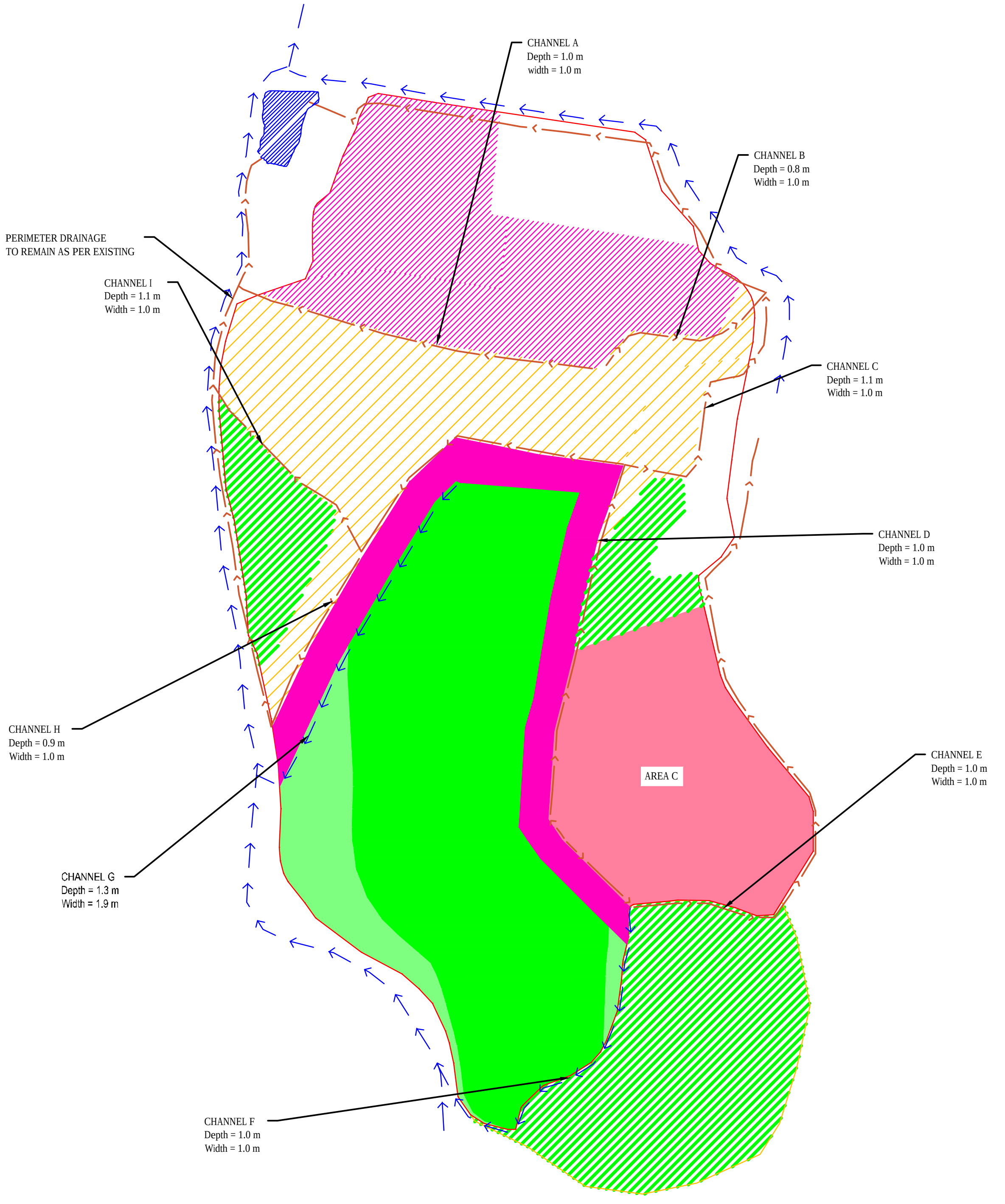

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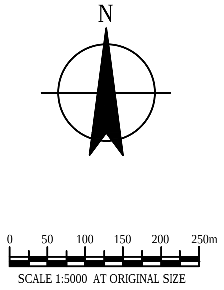

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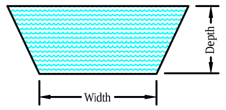

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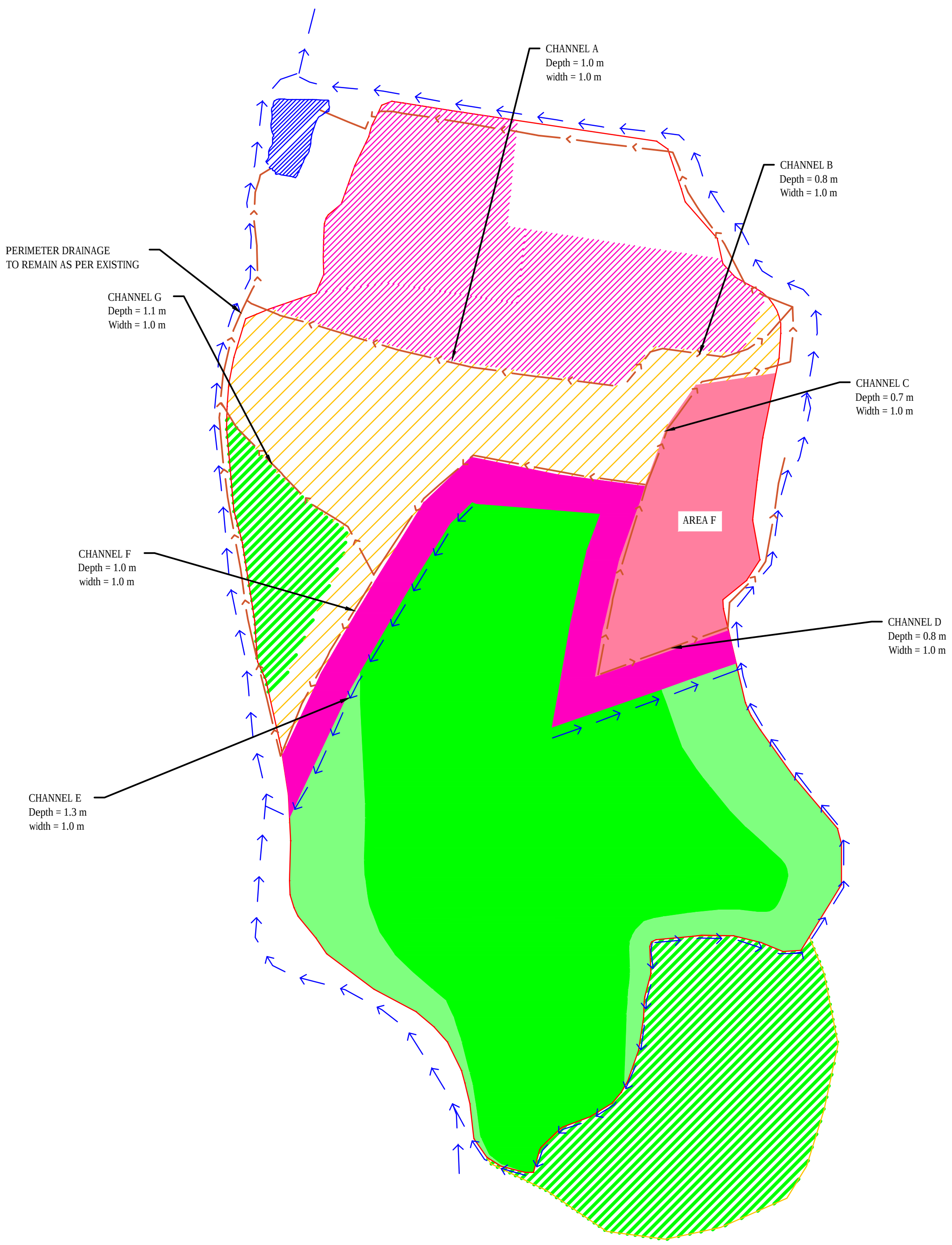

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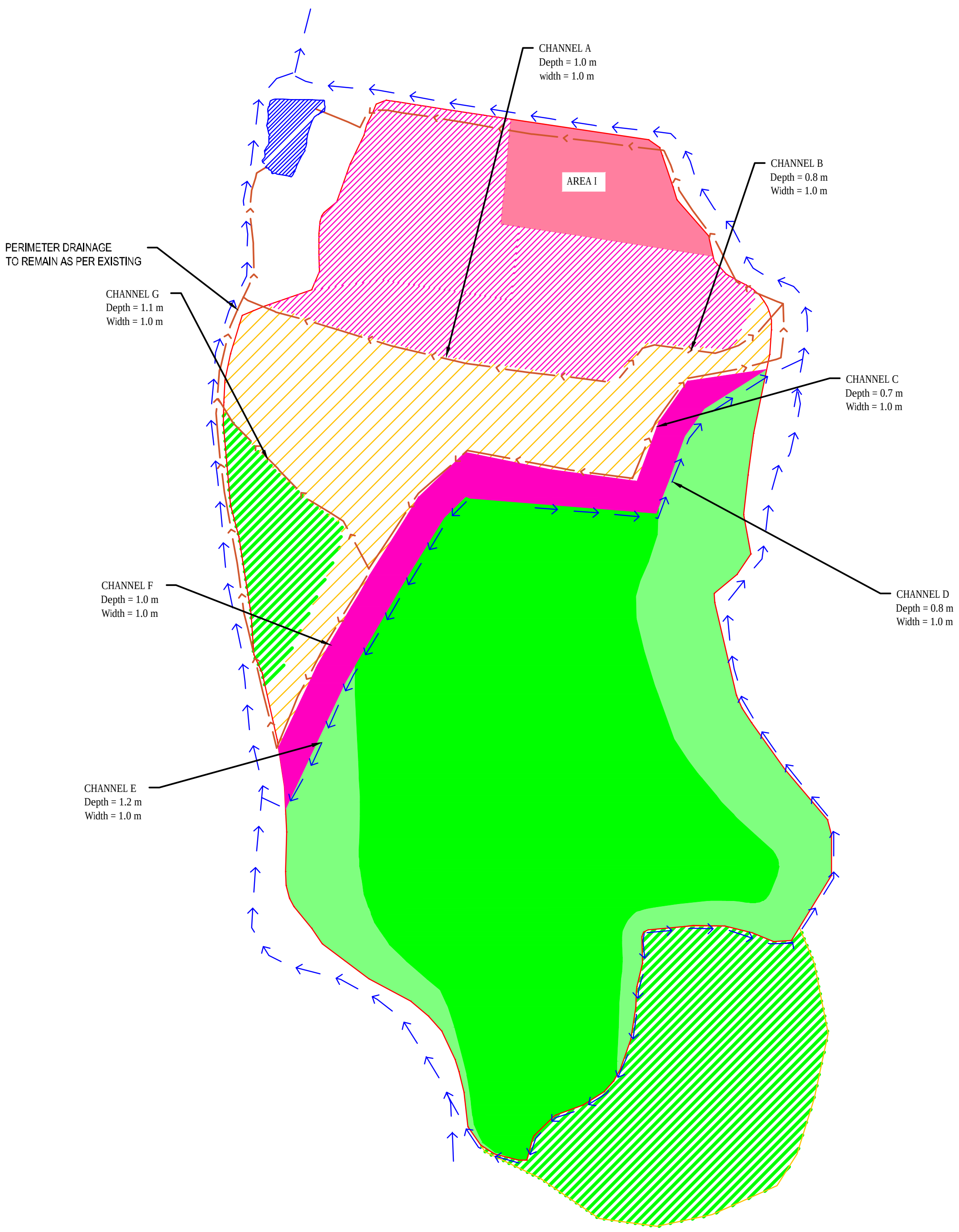

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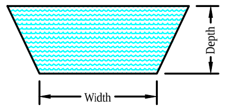

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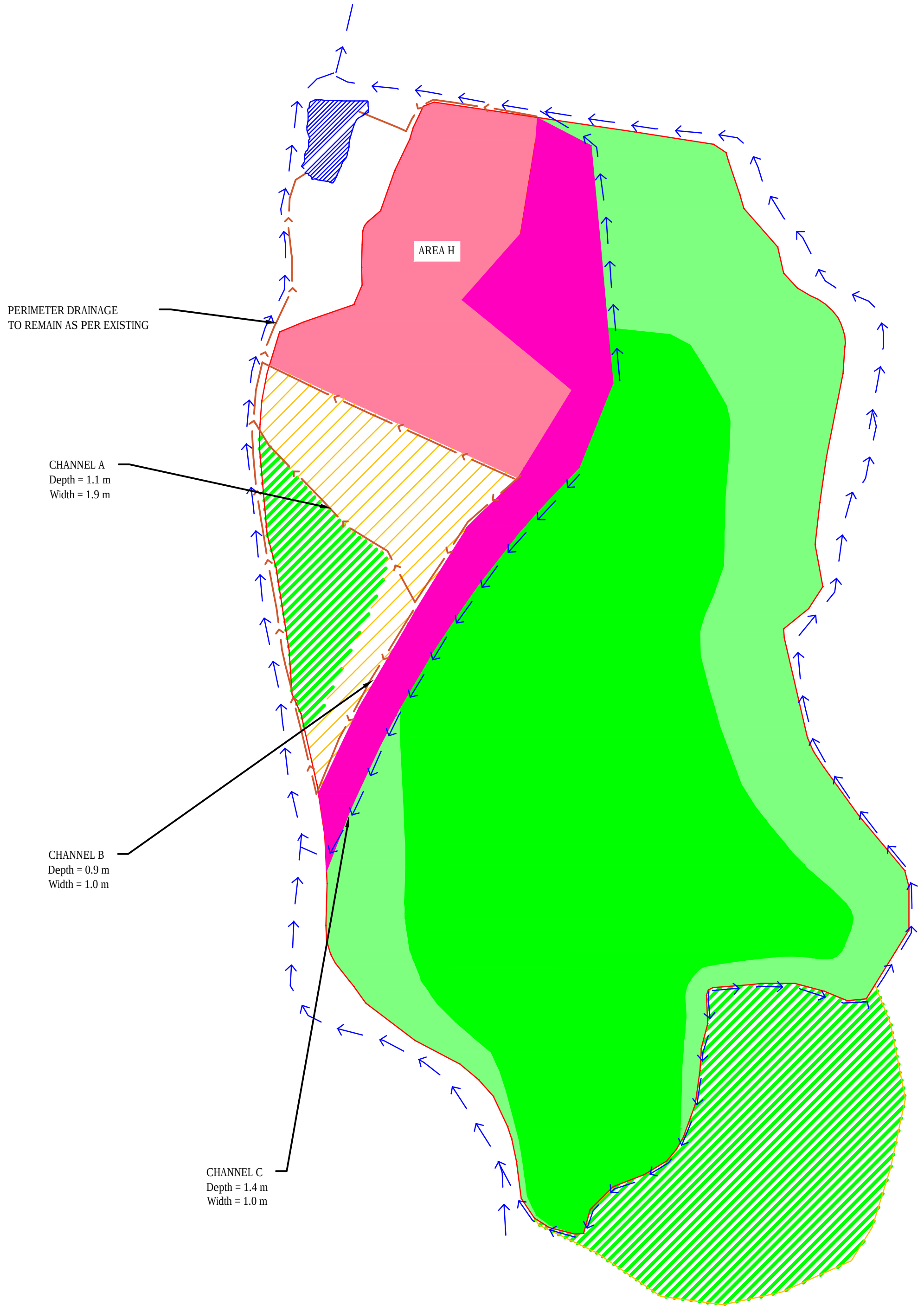

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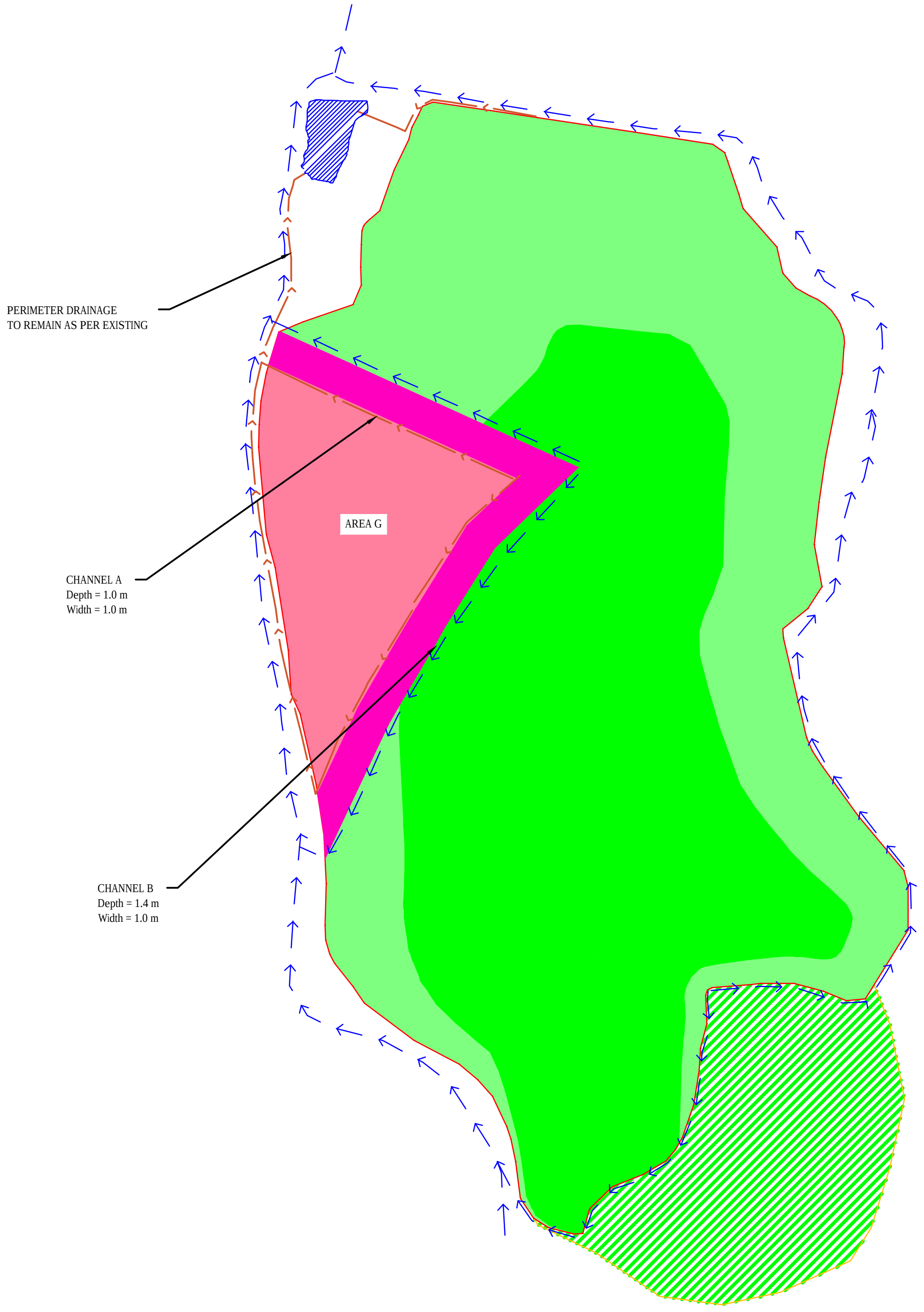

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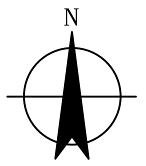

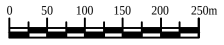

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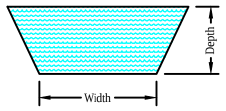

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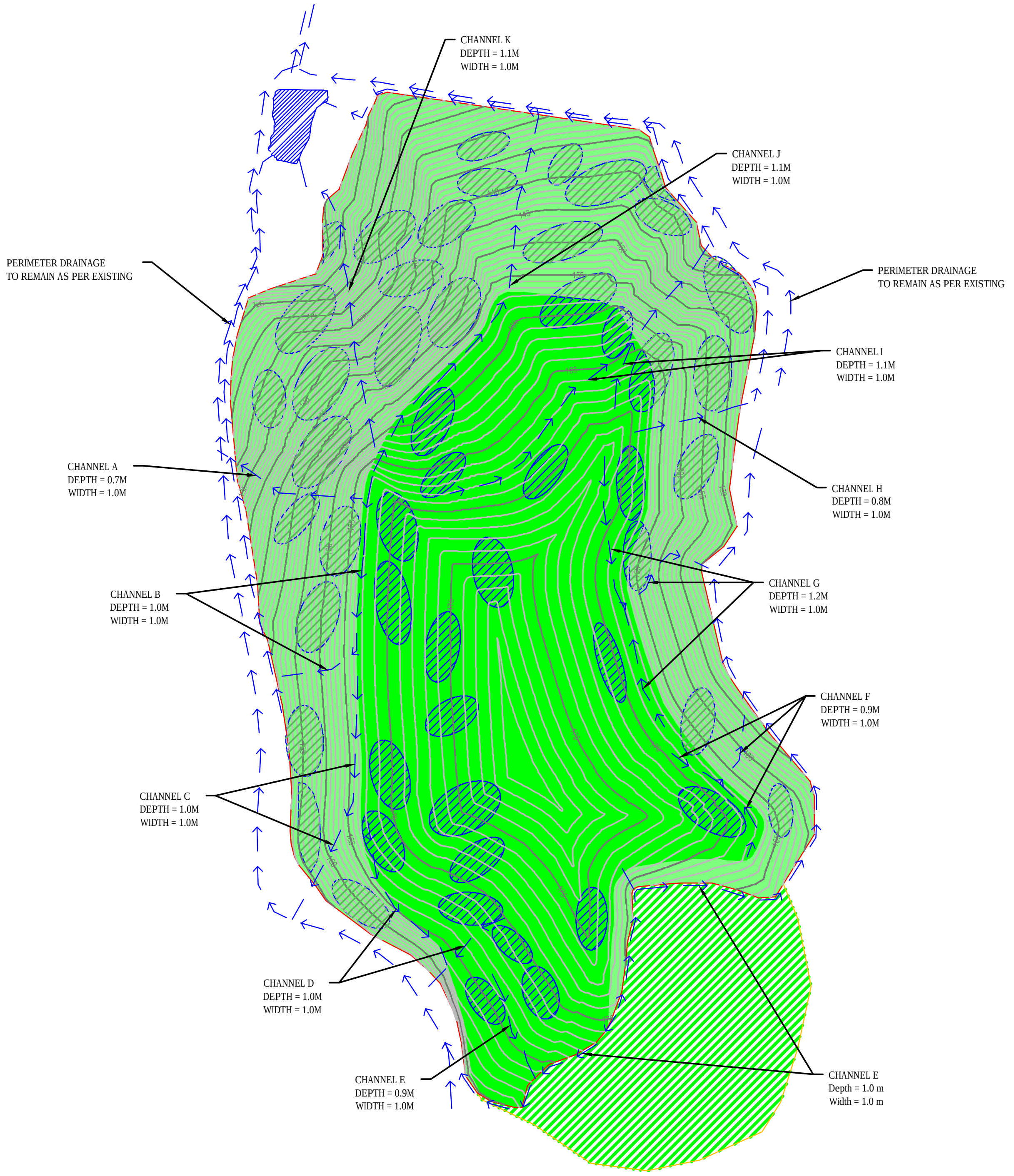

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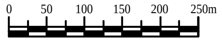

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NOTES:
1. REHABILITATION DESIGN TO INCLUDE GRADING AROUND MOUNDED AREAS AND INTO DRAINAGE LINES
2. CONCENTRATED FLOWS TO BE AVOIDED ADJACENT TO DRAINAGE LINES

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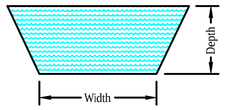

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Appendix B – Main Sediment and Water Reuse Basin Photos

Appendix C – 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

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[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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Appendices

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Appendix B - Macroinvertebrate Data

Appendix C - AUSRIVAS Macroinvertebrate Taxa Expected to occur but not Observed

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)

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[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)

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[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.
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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.

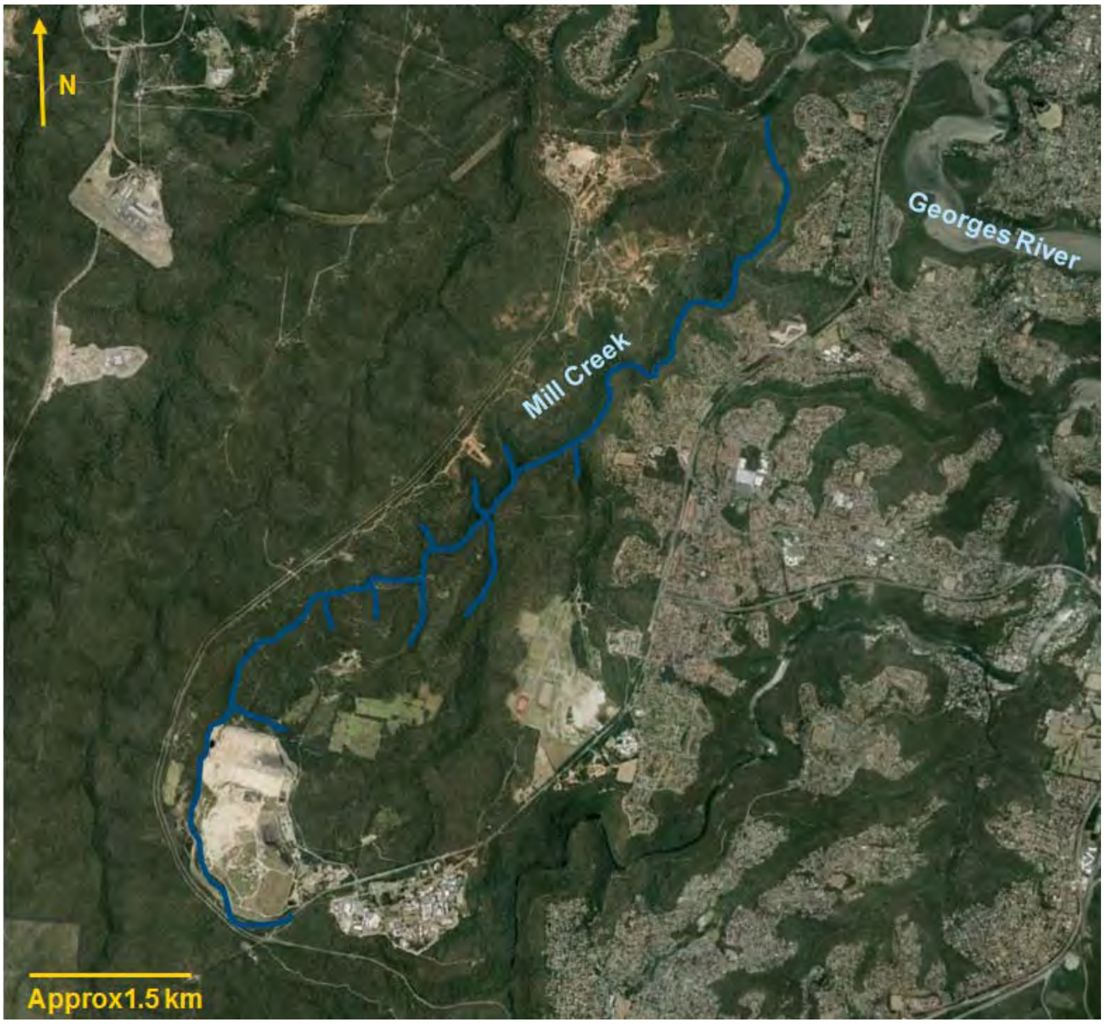


Figure 2.1 Locations of the LHRRP and Mill Creek

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.

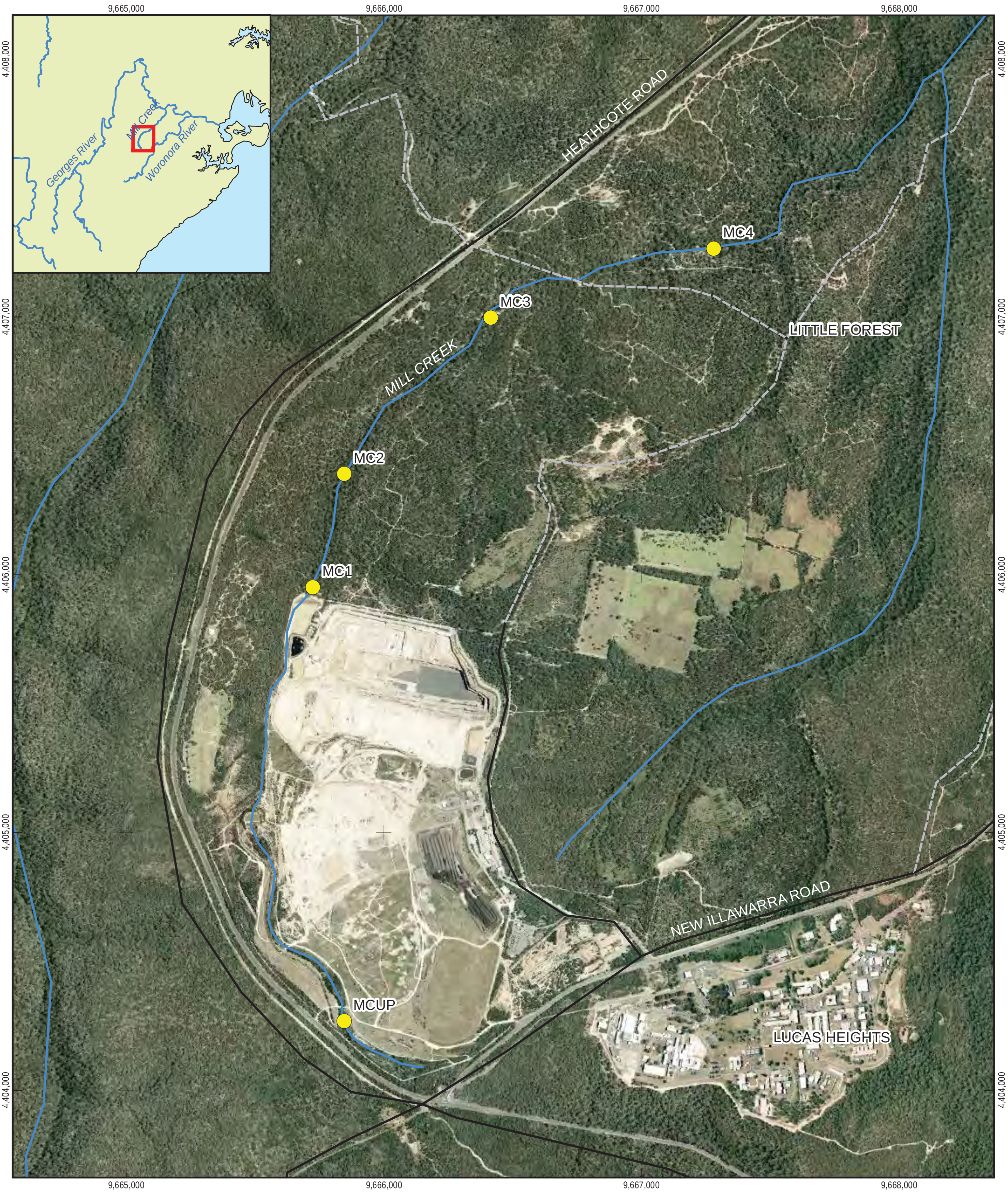
Table 3.1 Location details of environmental monitoring locations

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.

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[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

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[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).

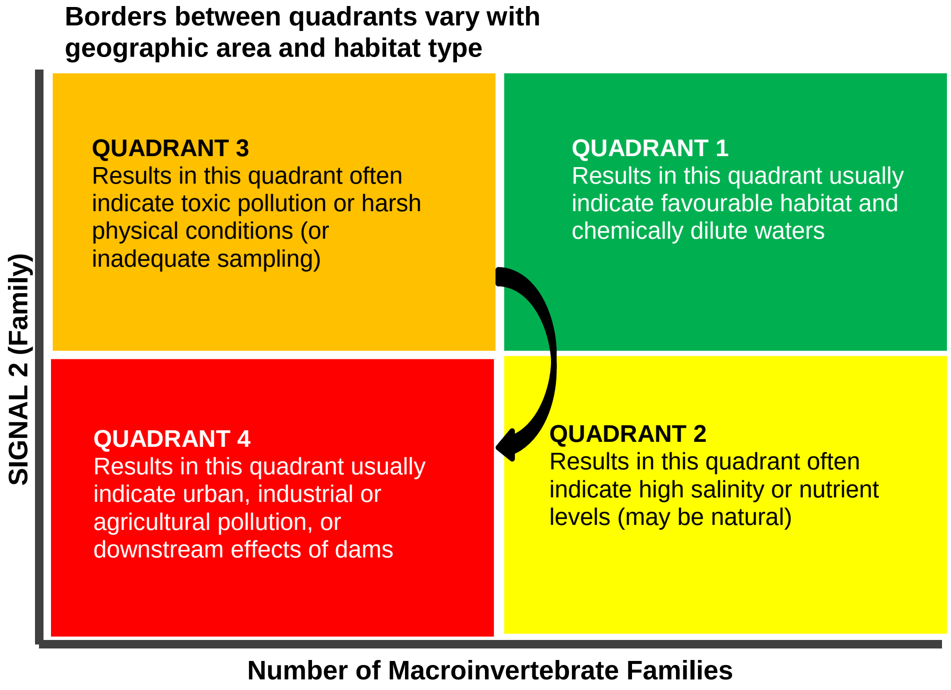

Figure 5.1 An example of the quadrant diagram for interpretation of the SIGNAL 2 and SIGNAL-SF biotic indices

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

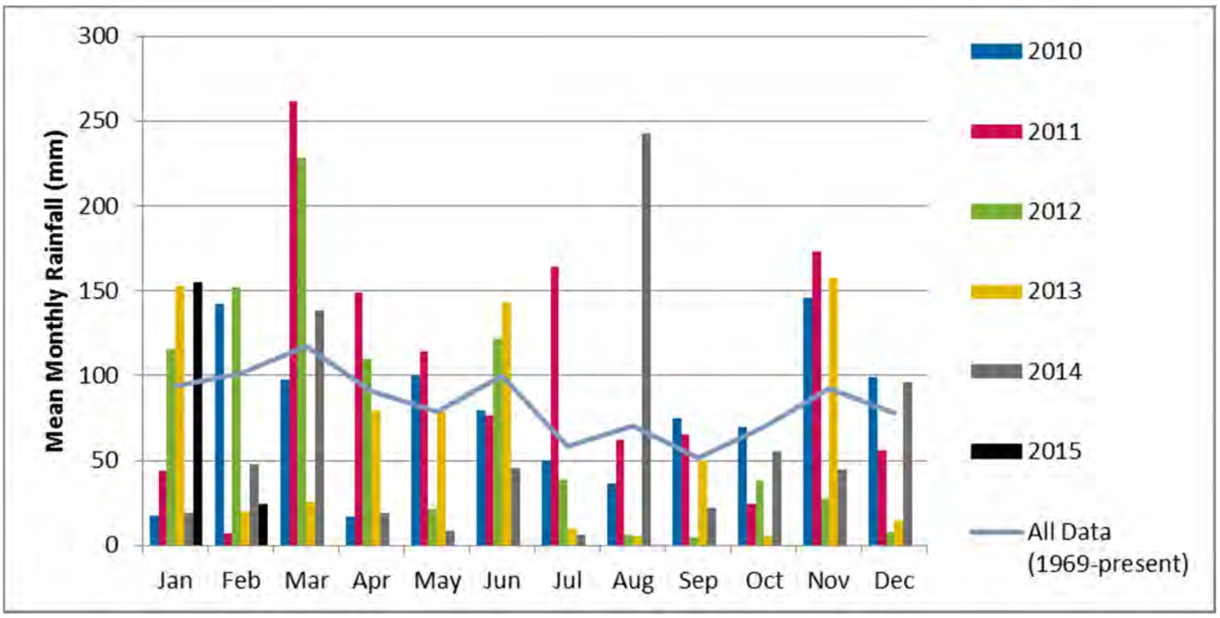

Figure 6.1 Mean monthly rainfall for years 2010 to 2015 and an average for all data available for Lucas Heights (ANSTO) Weather Station

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.

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[17] In this context, EPT stands for **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies).

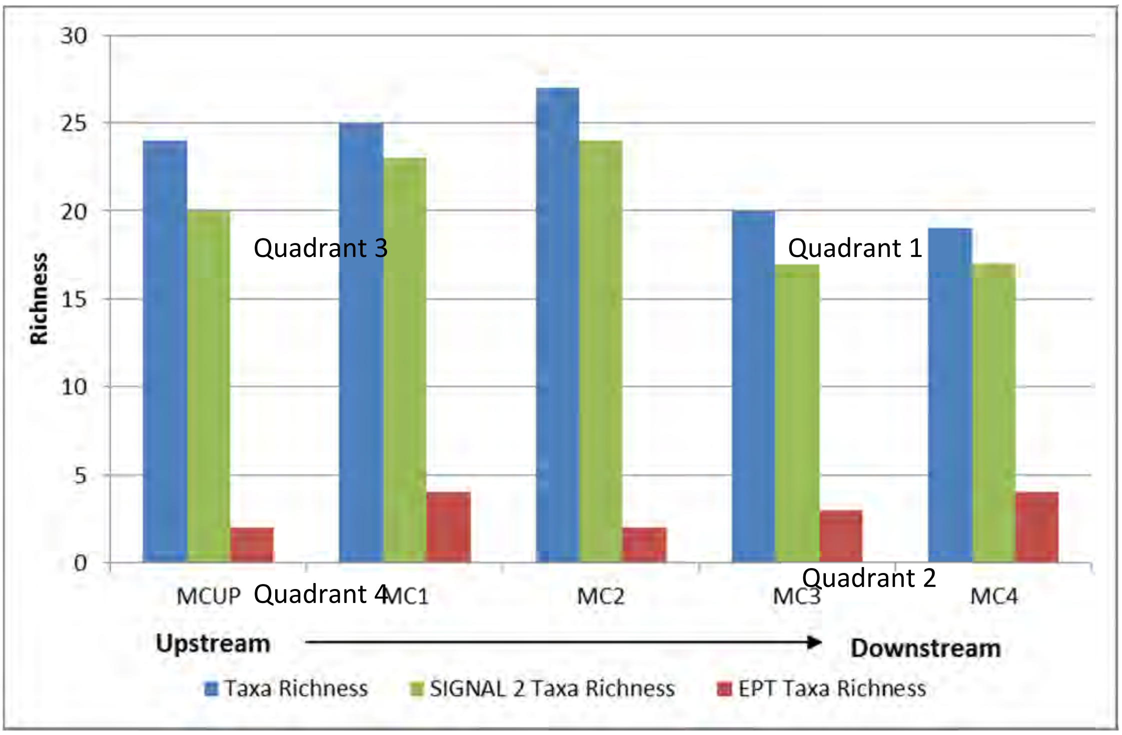


Figure 6.2 Macroinvertebrate richness scores for monitoring locations

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).

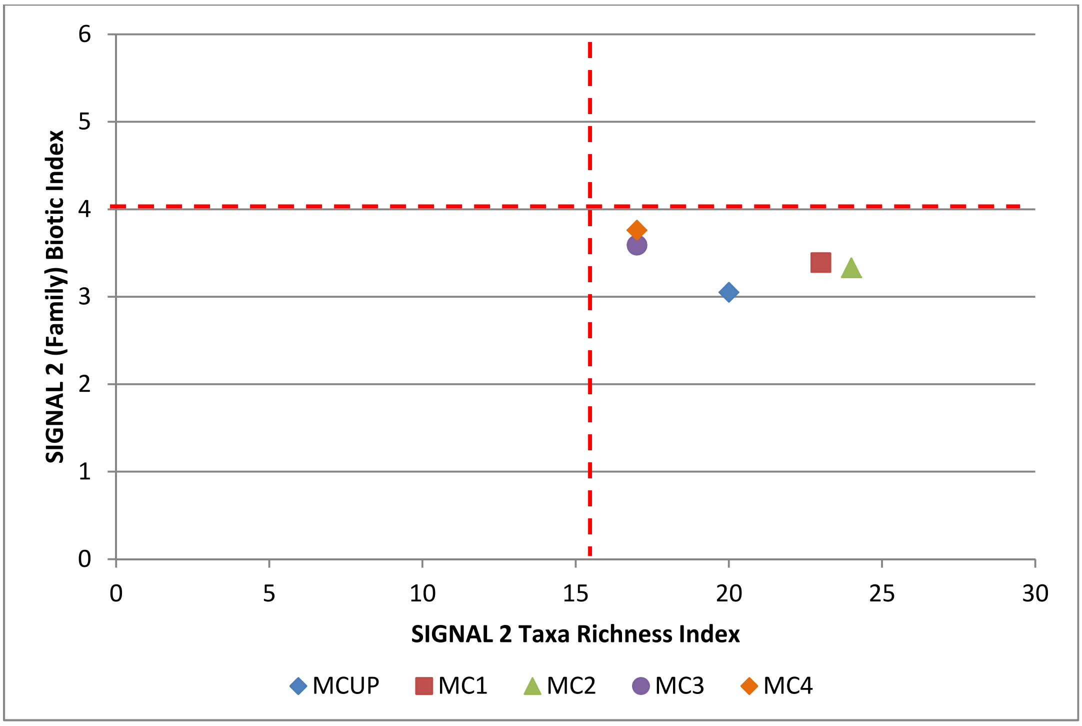


Figure 6.3 SIGNAL 2 biplot for monitoring locations displaying the quadrants according to the interim NSW boundaries

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.

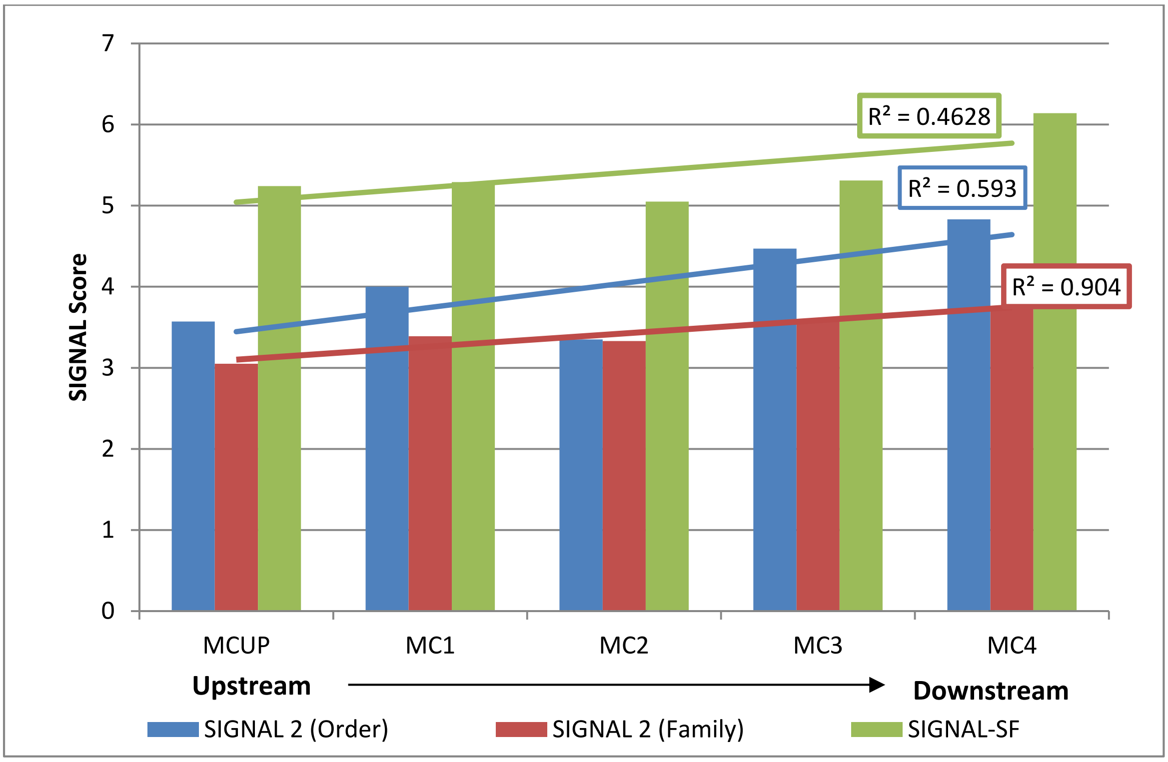


Figure 6.4 SIGNAL results displaying a linear trend line for each of the SIGNAL index scores

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.

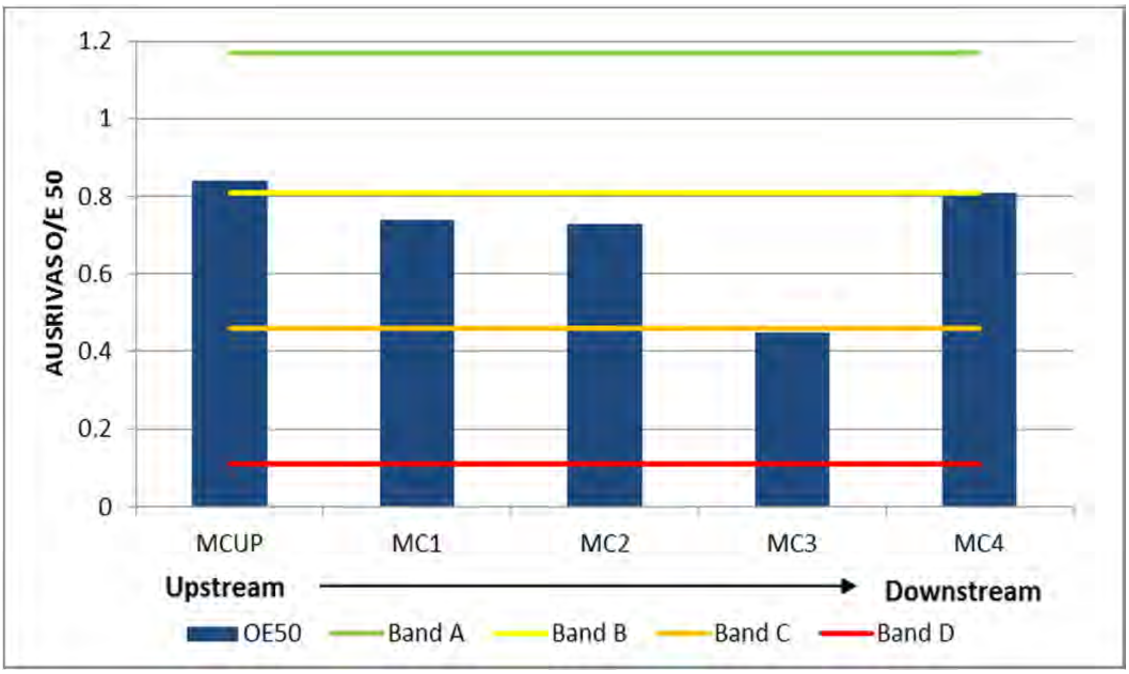


Figure 6.5 AUSRIVAS results displaying the upper Band limits and monitoring locations relative to the LHRRP

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

Water Sciences | Aquatic Ecosystem Site Assessment Report | SITA - SITA Support Services - Lucas Heights Landfill - Aquatic Ecosystem

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

Project Code	*Sampling Staff*		*Document Name*	*Date Printed*	*Pages*
2120508	*Adrian Dickson*	*Chantelle Dominiak*	*rpt_AquaticEcosystemReport*	*9/03/2015*	*Page 1 of 15*

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

Water Sciences **Aquatic Ecosystem Site Assessment Report** **SITA - SITA Support Services - Lucas Heights Landfill - Aquatic Ecosystem**

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	Substrate Composition	% Cover
Detritus (leaves/twigs)	20%	Bedrock	20%
Sticks (< 2 cm)	5%	Boulder (>200 mm)	0%
Branches (2-15 cm)	5%	Cobble (60-200 mm)	0%
Logs (> 15 cm)	0%	Pebble (20-60 mm)	0%
Algae	0%	Gravel (2-20 mm)	10%
Macrophytes	25%	Sand (0.02-2 mm)	30%
Overhanging Habitat	70%	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

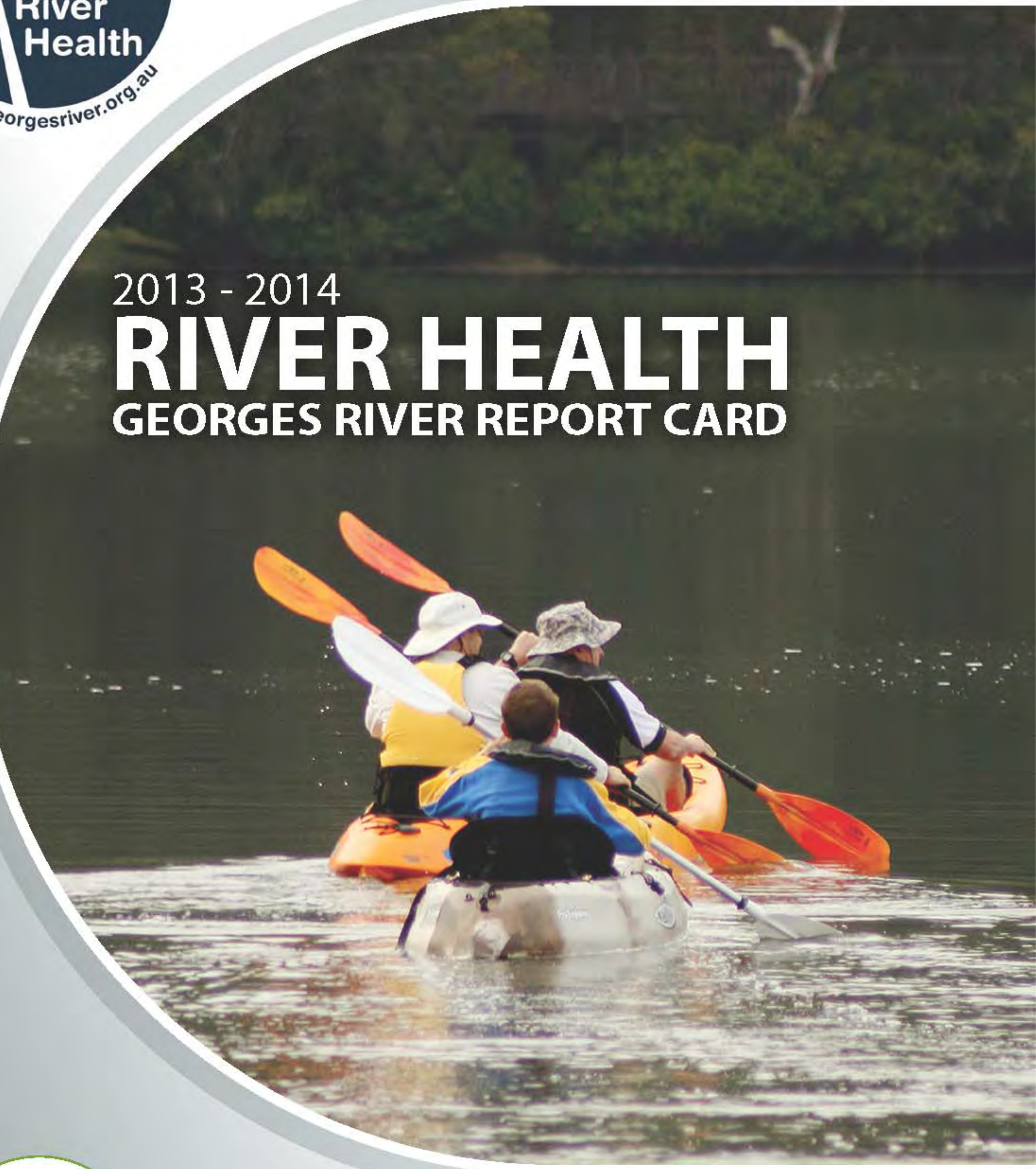
Appendix C - AUSRIVAS Macroinvertebrate Taxa Expected to occur but not Observed

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

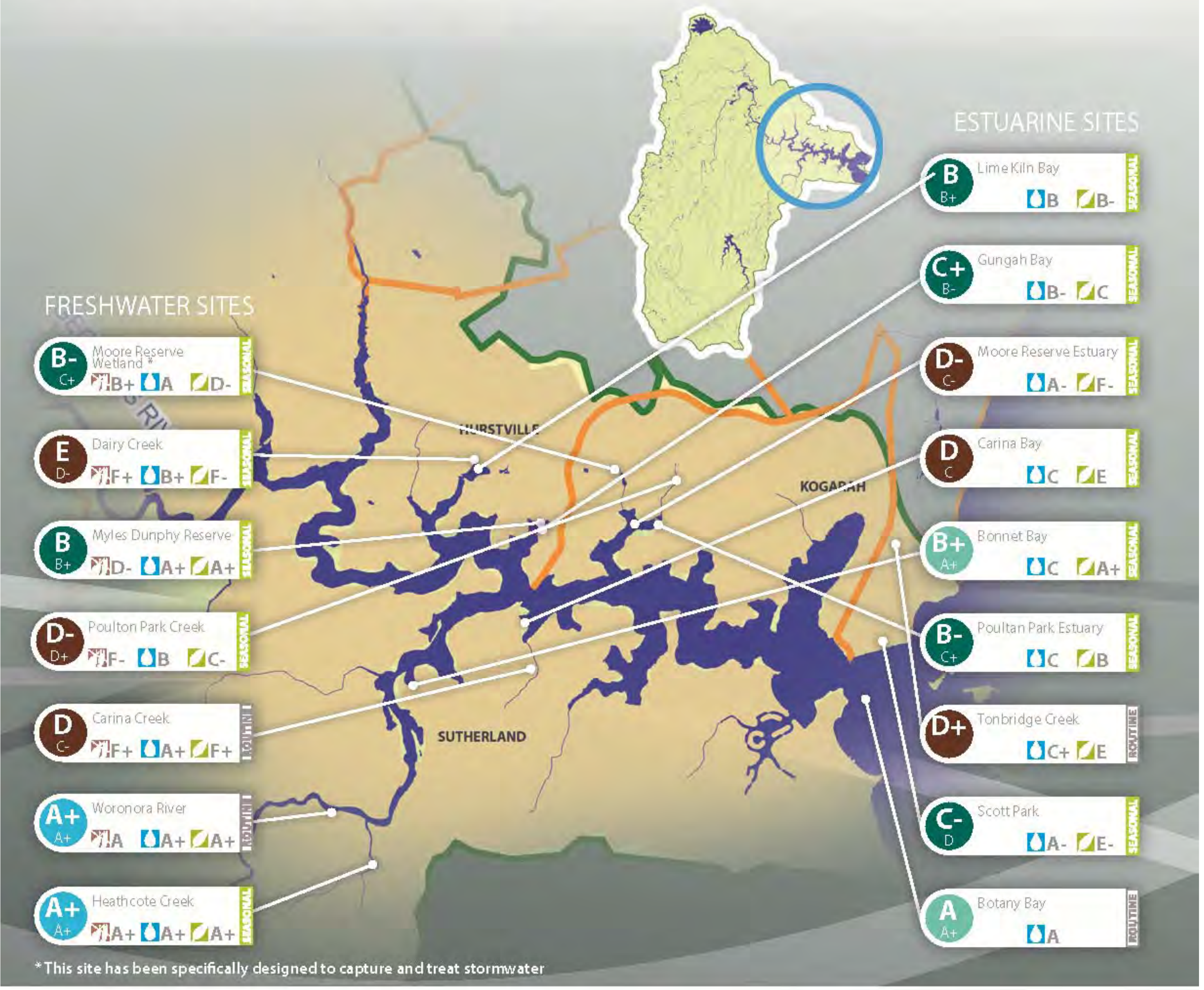
Results from 2013-14 River Health monitoring show the overall grade for the Georges River catchment marginally decreased when compared to the previous year, a result which is likely attributed to severe weather events negatively impacting water quality. However, this result does not indicate significant 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.



FRESHWATER SITES

B-	C+	Moore Reserve Wetland *	B+	A	D-	SEASONAL
E	D-	Dairy Creek	F+	B+	F-	SEASONAL
B	B+	Myles Dunphy Reserve	D-	A+	A+	SEASONAL
D-	D+	Poulton Park Creek	F-	B	C-	SEASONAL
D	C-	Carina Creek	F+	A+	F+	ROUTINE
A+	A+	Woronora River	A	A+	A+	ROUTINE
A+	A+	Heathcote Creek	A+	A+	A+	SEASONAL

*This site has been specifically designed to capture and treat stormwater

ESTUARINE SITES

B	B+	Lime Kiln Bay	B	B-	SEASONAL
C+	B-	Gungah Bay	B-	C	SEASONAL
D-	C-	Moore Reserve Estuary	A-	F-	SEASONAL
D	C	Carina Bay	C	E	SEASONAL
B+	A+	Bonnet Bay	C	A+	SEASONAL
B-	C+	Poultan Park Estuary	C	B	SEASONAL
D+		Tonbridge Creek	C+	E	ROUTINE
C-	D	Scott Park	A-	E-	SEASONAL
A	A+	Botany Bay	A		ROUTINE

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

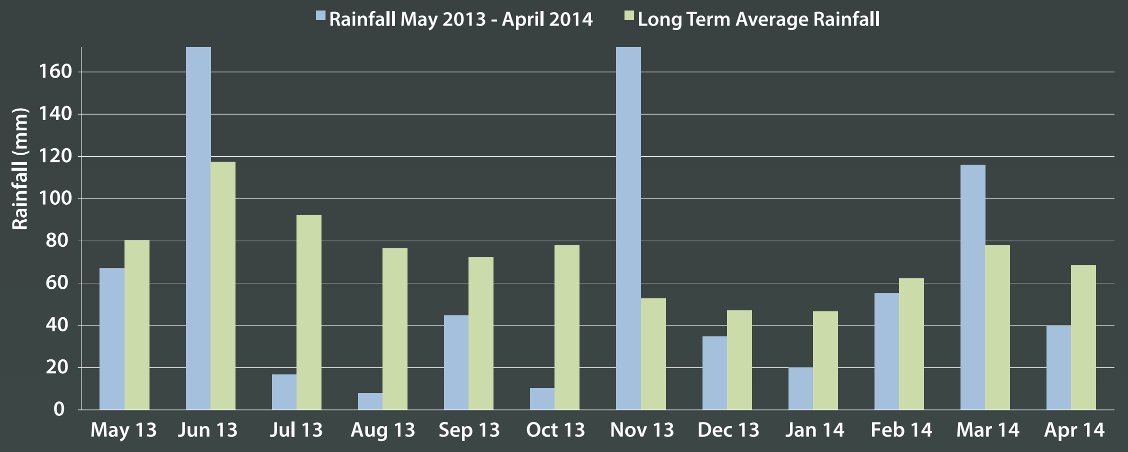
Healthy vegetation communities are important for maintaining a functioning ecosystem. Vegetation plays a major role in providing habitat, nutrient cycling, regulation of temperature and filtration of urban runoff. River Health assesses riparian (stream bank) and estuarine vegetation every three years. 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.

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.

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.

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.

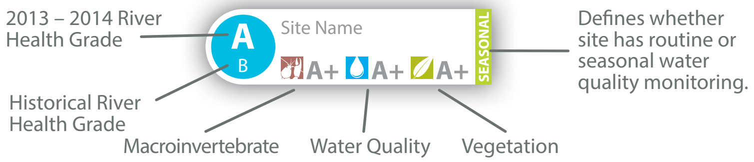
GRADING SYSTEM

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.

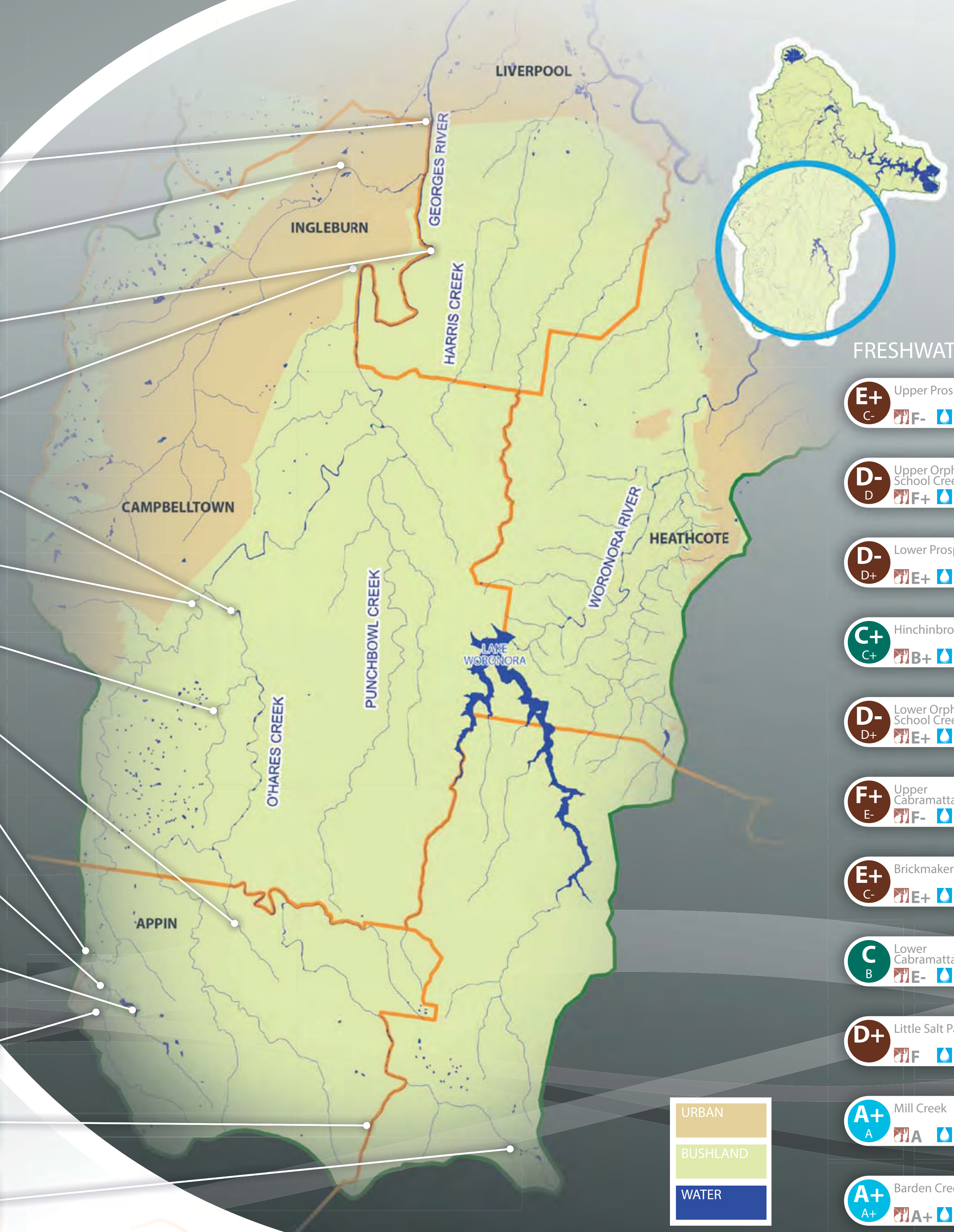
FIND US AT

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.

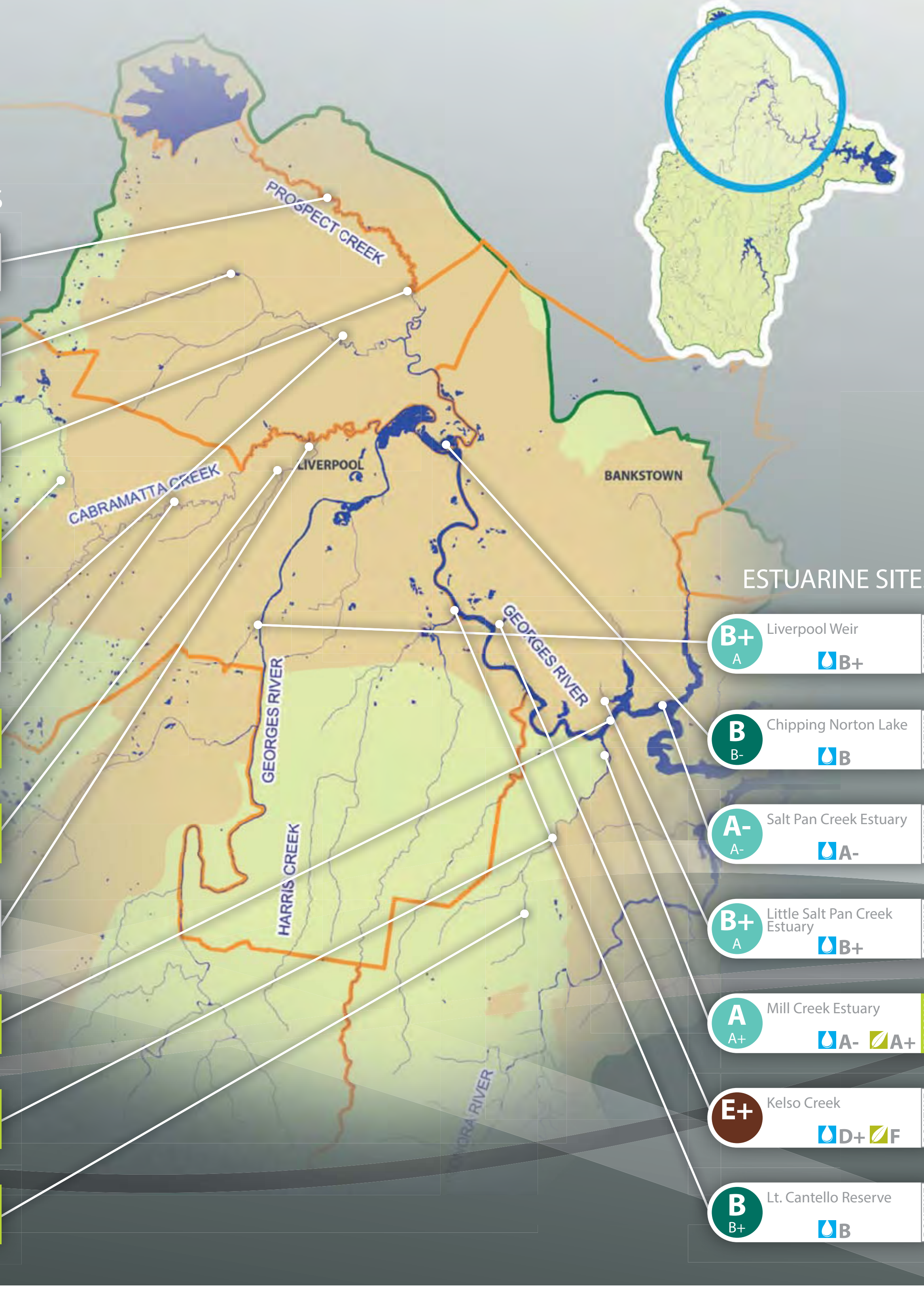
FRESHWATER SITES

A-	A-	Georges River at Cambridge Avenue	B	A+	B+	ROUTINE
B-	B-	Bunbury Curran Creek	C	A-	B	SEASONAL
A	A+	Georges River at Simmo's Beach	A-	A-	A+	ROUTINE
A+	A+	Georges River at Ingleburn Weir	A+	A	A+	SEASONAL
A	A	O'Hares Creek at the Woolwash	A-	A+	A+	SEASONAL
A+	B+	Georges River at the Woolwash	A-	A+	A+	ROUTINE
A+	A+	Stokes Creek	A+	A	A+	SEASONAL
A+	A	Cobbong Creek	A+	A	A+	SEASONAL
B-	B-	Georges River at Kennedy Grove	A	D+	B-	ROUTINE
B	B	Georges River Downstream Brennans Creek	B+	D-	A+	SEASONAL
B	B-	Brennans Creek	B	D+	A+	SEASONAL
A+	A	Upper Georges River	A+	A-	A+	ROUTINE
A+	A	Illuka Creek	A+	A-	A+	SEASONAL
A+	A+	Maddens Creek	A+	A+	A+	ROUTINE



FRESHWATER SITES

E+	C-	Upper Prospect Creek	F-	B	E-	ROUTINE
D-	D	Upper Orphan School Creek	F+	B	E-	ROUTINE
D-	D+	Lower Prospect Creek	E+	B	F-	ROUTINE
C+	C+	Hinchinbrook Creek	B+	B+	E-	SEASONAL
D-	D+	Lower Orphan School Creek	E+	B	F	ROUTINE
F+	E-	Upper Cabramatta Creek	F-	C	F-	SEASONAL
E+	C-	Brickmakers Creek	E+	B-	F-	SEASONAL
C	B	Lower Cabramatta Creek	E-	A-	B-	ROUTINE
D+		Little Salt Pan Creek	F	B+	C-	SEASONAL
A+	A	Mill Creek	A	A+	A+	SEASONAL
A+	A+	Barden Creek	A+	A+	A+	SEASONAL



ESTUARINE SITES

B+	A	Liverpool Weir	B+		ROUTINE
B	B-	Chipping Norton Lake	B		ROUTINE
A-	A-	Salt Pan Creek Estuary	A-		ROUTINE
B+	A	Little Salt Pan Creek Estuary	B+		ROUTINE
A	A+	Mill Creek Estuary	A-	A+	SEASONAL
E+		Kelso Creek	D+	F	ROUTINE
B	B+	Lt. Cantello Reserve	B		ROUTINE

UPPER GEORGES RIVER | 14 FRESHWATER SITES

MID GEORGES RIVER | 11 FRESHWATER SITES 7 ESTUARINE SITES

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	Adrian Dickson	A Dixon	a. Dixon	D Gamble	David Gamble	15.05.15
1	Adrian Dickson	A Dixon	a. Dixon	D Gamble	David Gamble	03.07.15
2	Adrian Dickson	A Dixon	a. Dixon	D Gamble	David Gamble	15.07.15

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Appendix D – Post-closure indicative drainage design

Memorandum

3 July 2015

To	Anthony Dixon		
Copy to	Rod Towner		
From	Carol Ng	Tel	02 9239 7651
Subject	Post-closure indicative drainage design	Job no.	21/23482

1 Methodology

The following sections detail the methodology used to provide indicative stormwater drainage details for the final post-closure landform.

1.1 Slope analysis

Slope analysis was undertaken using 3D modelling software (12D Model) on the proposed drainage channels on the final post-closure landform. This analysis allowed an approximate grade of sections of the stormwater channels to be determined. Slopes of the drainage channels ranged from 5% to 25%.

1.2 Channel Hydrology/Hydraulics

The 20 year ARI design storm event was selected for the channels in accordance with the Blue Book Volume 2b (DECC 2008) Table 6.1, for a duration of disturbance greater than 3 years. The channel dimensions were taken as per plan 21-23482-SK016 (attached), where the depth and base width of channel segments was denoted. The indicative dimensions in this plan were developed based upon the flow rates estimated by the XP-RAFTS model of the site and Manning's hydraulic calculations. These drainage channels where assumed to have a batter slope of 1(V):3(H) and maintain a freeboard of 500 mm. The velocities for the channels were then estimated based on the Manning's calculations and on the velocity when flowing full at 500 mm freeboard

As part of the surface water assessment, assessment of channel capacities was also undertaken for existing perimeter surface water channel such as Mill Creek and the eastern drainage channel. This involved a capacity check of these specific channels involving either a HECRAS one-dimensional hydraulic model or Manning's hydraulic calculations (refer to Surface Water Assessment Report GHD 2015). The dimensions of the existing channels were estimated based on available topographic survey data dated December 2014 provided by SITA and subject to the accuracies associated with the topographic survey. Indicative channel dimensions obtained from the topographic survey are provided in plan 21-23482-SK016. When undertaking detailed design, a detailed topographic survey should be prepared with these dimensions confirmed.

As noted in the Surface Water Assessment Report, the capacity of the perimeter drainage (Mill Creek and drainage around the east and north of the site) was checked to determine if the peak 100-year ARI event could be conveyed in the drainage line. It was noted based on the dimensions obtained from the topographic survey, modelling suggests that the outer perimeter drains would be able to convey a 100-year ARI event for Mill Creek. The outer perimeter drains along the northern and eastern boundary and both perimeter drains are also expected to be able to convey water during the 100-year ARI event. Considering there are two perimeter drains along the northern and eastern boundaries and during a 100-year ARI event, both drains would be able to convey flows, the existing dimensions are therefore considered to be adequate. The existing perimeter drains is therefore proposed to be retained post-closure of the LHRRP.

1.3 Liner material

Initially, each drainage segment was considered for 'softer' engineering options, such as rough soil, grass lands or turf reinforced mattress (TRM) considering the critical velocities described in Table 5.2 from *Managing Urban Stormwater: Soils and Construction Volumes 1* (Landcom, 2004). Where expected flow velocities exceed the critical flow velocity that is considered acceptable for the lining option, 'harder' engineering options such as reno mattress, riprap or rock were considered.

Generally, analysis of the slopes and drainage materials resulted in three categories of management:

0-5% slope	Grass lining (or similar)
5-15% slope	TRM lining (or similar)
15-25% slope	Rock lining (or similar)

Exceptions to these categories occurred for channels with a greater flow depth, which required higher order protection.

2 Results

Table 1 provides a summary of the analysis results. This is presented on plan SK022 which shows the set-out drainage channel segments and their indicative lining type.

Table 1 Indicative channel lining for different stormwater drain segments

Channel ID	Slope (%)	Estimated operational velocity (m/s)	Indicative lining type
A1	20.0%	3.5	TRM
A2	20.0%	3.5	TRM
B1	1.5%	1.6	Grass
B2	15.0%	5.0	Rock
C1	1.5%	1.6	Grass
C2	15.0%	5.0	Rock
D1	1.5%	1.6	Grass
D2	9.0%	3.8	Rock
E1	4.0%	2.3	TRM

Channel ID	Slope (%)	Estimated operational velocity (m/s)	Indicative lining type
E2	2.0%	1.6	Grass
E3	13.0%	4.1	Rock
E4	4.0%	2.3	TRM
E5	2.0%	1.6	Grass
F1	1.0%	1.1	Grass
F2	1.5%	1.4	Grass
F3	12.0%	3.9	Rock
G1	2.0%	2.2	TRM
G2	2.0%	2.2	TRM
G3	12.0%	5.4	Rock
H1	15.0%	3.7	Rock
I1	1.0%	1.4	Grass
I2	3.0%	2.5	TRM
I3	20.0%	6.4	Rock
J1	3.0%	2.5	TRM
J2	10.0%	4.5	Rock
J3	25.0%	7.1	Rock
K1	13.0%	5.1	Rock
K2	20.0%	6.4	Rock
K3	5.0%	3.2	TRM

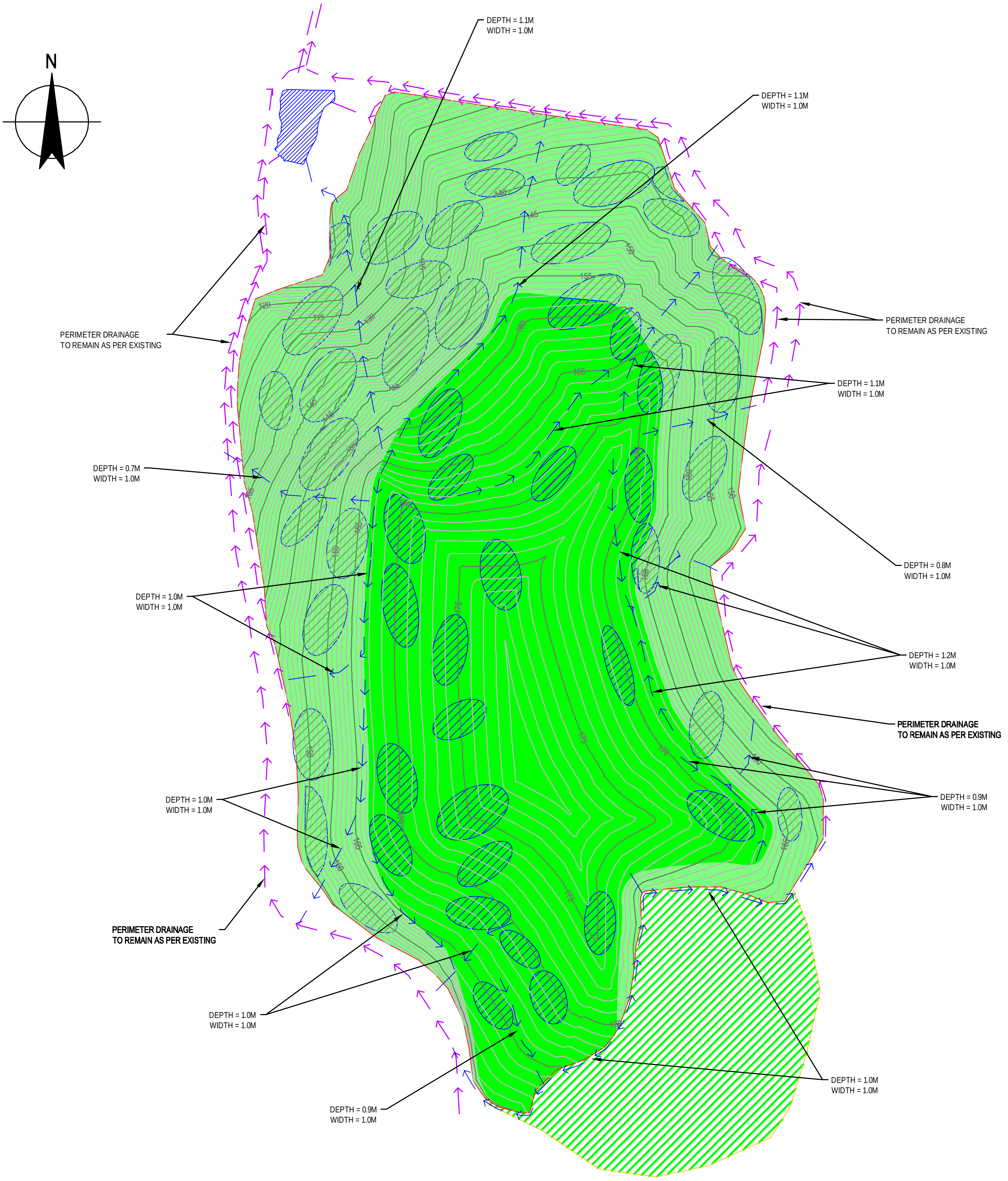
3 Timing and need for detailed design

Detailed design of the drainage channels is required prior to construction of the channels before the commencement of each landfill stage to determine the most suitable channel lining type with consideration of critical flows velocities and final drain locations. As part of this work the site’s drainage channels should have their dimensions surveyed.

It is expected that post 2025, no works would be undertaken on ANSTO land as the drainage infrastructures would already be in place and remain between 2025 and 2037, with maintenance if required. Prior to the establishment of the parkland and landscaping, the design of the drainage channels would be reviewed with consideration of potential for scour, including rock protection, energy dissipation or stepping where required and taking into account the conversion of the grassed areas into parkland (with these works to happen in 2038).

Attachment A: 21-23482-SK016-E

Attachment B: 21-23482-SK024-C



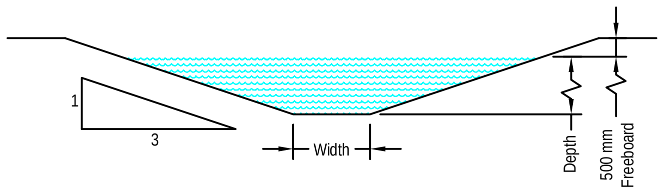
NOTES:
1. REHABILITATION DESIGN TO INCLUDE GRADING AROUND MOUNDED AREAS AND INTO DRAINAGE LINES
2. CONCENTRATED FLOWS TO BE AVOIDED ADJACENT TO DRAINAGE LINES
3. DETAILED DESIGN TO TAKE INTO ACCOUNT THE EXISTING AND FINAL CONTOURS OF LANDFILL LANDFORM
4. PERIMETER DRAINAGE CHANNELS TO REMAIN AS PER EXISTING
5. CHANNEL LINING AND LOCATIONS ARE INDICATIVE ONLY. TO BE CONFIRMED DURING DETAILED DESIGN WITH CONSIDERATION OF PEAK FLOW RATES AND EXPECTED FLOW VELOCITIES
6. INDICATIVE LINING MATERIALS SELECTED BASED ON "MANAGING URBAN STORMWATER: SOILS AND CONSTRUCTION" (LANDCOM 2004) TABLE 5.2: MAXIMUM DESIGN FLOW VELOCITIES IN WATERWAYS
7. ALL DRAINAGE CHANNELS LOCATED ON LANDFORM ARE TRAPEZOIDAL WITH 1V:3H SLOPES
8. DRAINAGE CHANNELS TO BE CONSTRUCTED PROGRESSIVELY WITH LANDFILLING AND CAPPING WORKS

NOT TO SCALE

LEGEND:

—	PROPOSED RE-PROFILING BOUNDARY
🟩	PROPOSED FINAL CAP - PLATFORM
🟩	PROPOSED FINAL CAP - SLOPES
▨	PROPOSED POST-CLOSURE CAP - PLATFORM (MOUNDED AREAS FOR TREES)
▨	PROPOSED POST-CLOSURE CAP - SLOPES (MOUNDED AREAS FOR TREES)
→ → –	PERIMETER DRAIN (TO REMAIN AS PER EXISTING)
→ → –	INDICATIVE SURFACE WATER DIVERSION DRAIN

NOTES:
ALL DRAINAGE CHANNELS ARE TRAPEZOIDAL



PRELIMINARY

E	REVISED	AD	19.08.15
D	REVISED	AD	20.07.15
rev	description	app'd	date

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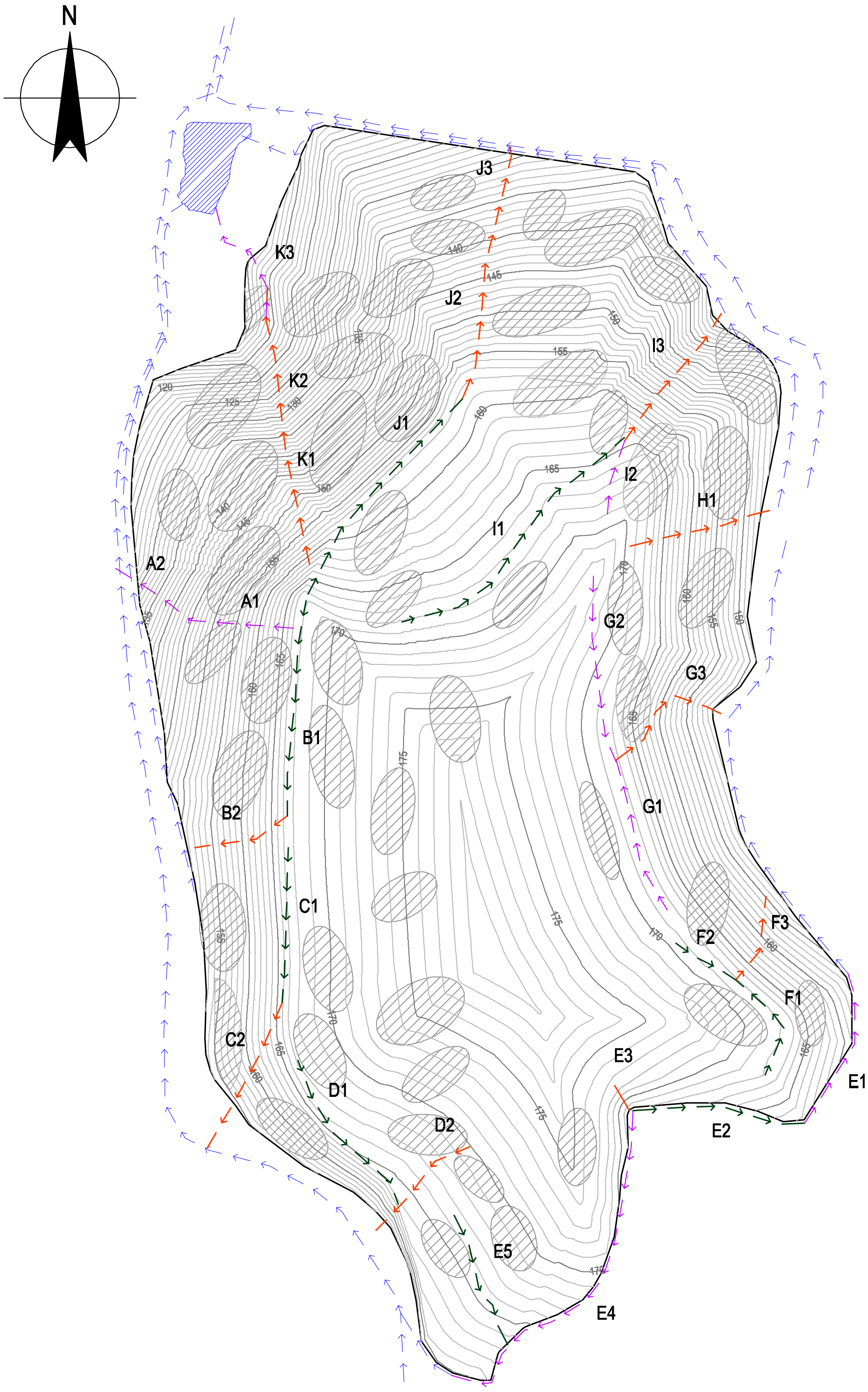
scale NTS for A3 job no. 21-23482
date JULY 2015 rev no. E

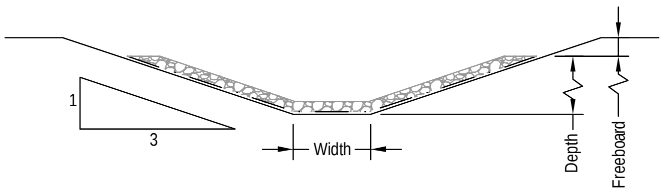
approved (PD) SK016

Plot Date: 25 August 2015 - 11:45 AM Plotted by: Alison Horlyck Cad File No: G:\21\23482\CADD\Drawings\209708 Attachment for ANSTO\21-23396-SK016.dwg

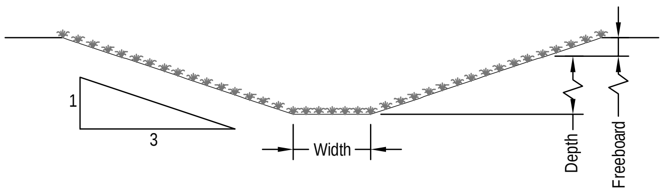


INDICATIVE DRAINAGE LINING MATERIALS

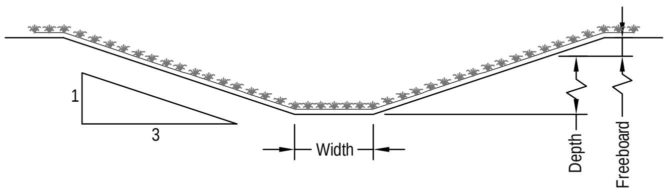
CHANNEL ID	APPROX. SLOPE (% FALL)	INDICATIVE LINING MATERIAL
A1	20.0%	ROCK
A2	20.0%	ROCK
B1	1.5%	GRASS
B2	15.0%	ROCK
C1	1.5%	GRASS
C2	15.0%	ROCK
D1	1.5%	GRASS
D2	9.0%	ROCK
E1	4.0%	TRM
E2	2.0%	GRASS
E3	13.0%	ROCK
E4	4.0%	TRM
E5	2.0%	GRASS
F1	1.0%	GRASS
F2	1.5%	GRASS
F3	12.0%	ROCK
G1	2.0%	TRM
G2	2.0%	TRM
G3	12.0%	ROCK
H1	15.0%	ROCK
I1	1.0%	GRASS
I2	3.0%	TRM
I3	20.0%	ROCK
J1	3.0%	TRM
J2	10.0%	ROCK
J3	25.0%	ROCK
K1	13.0%	ROCK
K2	20.0%	ROCK
K3	5.0%	TRM



ROCK LINING OF DRAINAGE CHANNEL



GRASS LINING OF DRAINAGE CHANNEL



TURF REINFORCED MATTRESS (TRM) LINING OF DRAINAGE CHANNEL

NOTES:

1. DETAILED DESIGN TO TAKE INTO ACCOUNT THE EXISTING AND FINAL CONTOURS OF LANDFILL LANDFORM
2. PERIMETER DRAINAGE CHANNELS TO REMAIN AS PER EXISTING
3. CONCENTRATED FLOWS TO BE AVOIDED ADJACENT TO DRAINAGE LINES
4. CHANNEL LINING AND LOCATIONS ARE INDICATIVE ONLY. TO BE CONFIRMED DURING DETAILED DESIGN WITH CONSIDERATION OF PEAK FLOW RATES AND EXPECTED FLOW VELOCITIES
5. INDICATIVE LINING MATERIALS SELECTED BASED ON "MANAGING URBAN STORMWATER: SOILS AND CONSTRUCTION" (LANDCOM 2004) TABLE 5.2: MAXIMUM DESIGN FLOW VELOCITIES IN WATERWAYS

NOT TO SCALE

LEGEND:

———	PROPOSED RE-PROFILING BOUNDARY
→ → → —	PERIMETER DRAINAGE
→ → → —	GRASS LINED STORMWATER DRAIN
→ → → —	TURF REINFORCEMENT MAT LINED STORMWATER DRAIN
→ → → —	ROCK LINED STORMWATER DRAIN
═══	FINAL POST SETTLED LANDFORM CONTOURS

PRELIMINARY

C	REVISED	AD	01.09.15
B	REVISED	AD	28.08.15
rev	description	app'd	date

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INDICATIVE DRAINAGE
FINAL LANDFORM

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