Appendix N – Aquatic ecology impact assessment

Centennial Newstan Pty Ltd

Newstan Mine Extension Project
Aquatic Ecology Impact Assessment

January 2020

Executive summary

Newstan Colliery is an existing underground coal mine located in the Lake Macquarie Local Government Area, approximately 25 km south west of Newcastle and 140 km north of Sydney, NSW. It is owned and operated by Centennial Newstan Pty Limited (Centennial Newstan).

GHD Pty Ltd (GHD) was commissioned by Centennial Newstan to prepare an Aquatic Ecology Impact Assessment for the Newstan Mine Extension Project (the project). This report provides an assessment of the potential impacts of the project on aquatic ecology in watercourses overlying and downstream of the Extension of Mining Area.

The project has the potential to cause impacts on aquatic ecology through changes to licensed discharges of water and through subsidence.

The following licensed discharge points (LDP) are potentially affected by the project:

- Awaba LDP009
- Newstan LDP017
- Newstan LDP001

Discharges via Awaba LDP009 to Stony Creek are predicted to increase as underground transfers of water from the Pollution Control Dam will cease. Elevated suspended solids concentrations could be observed in LDP009 discharges, which would have the potential to adversely affect macroinvertebrate communities. However, water quality monitoring of the Pollution Control Dam will occur prior to any controlled discharges to ensure water quality is within the concentration limits for the discharge, and the water will be treated to reduce suspended solids concentrations if required. This is predicted to effectively mitigate the risk of impacts to downstream aquatic communities.

The frequency of discharges to Stony Creek via LDP017 is likely to increase as a result of the project. As discharges through Newstan LDP017 are in response to heavy rainfall, any change to the water quality in the receiving environment of Stony Creek is predicted to be negligible and temporary, and unlikely to adversely affect freshwater aquatic communities. The influence of increased volumes of fresh water on benthic macroinvertebrates in the intertidal zone of Stony Creek is unlikely to be discernible from the response of the community to seasonal variation and long term climate variability.

Increased Newstan LDP001 discharges of up to 14.5 ML/day (which are already approved under the Northern Coal Logistics Project) are unlikely to affect macroinvertebrate community composition, as no substantial increase in LT Creek flow velocity is expected.

The following potential subsidence related impacts were identified:

- Reduced habitat availability and fragmentation of habitat
- Impacts on water and sediment quality
- Increases in flow velocity

Subsidence impacts may result in a reduced water availability within waterways which may result in reduced diversity of macroinvertebrate groups and potential loss of communities if there is complete loss of habitat in a waterway, or section of a waterway. The risk of such impacts was assessed as moderate for Stony Creek and Kilaben Creek due to the subsidence predicted within the catchments as a result of the project.

Surface deformations in the catchments overlying the proposed workings could impact water and sediment quality, resulting in low dissolved oxygen concentrations, potentially ecotoxic metal concentrations in the water and sediments, and smothering of the benthic substrate. These potential impacts can have adverse effects on aquatic communities, the risk of which was assessed as moderate for Lords Creek and Stockyard Creek, and high for Stony Creek and Kilaben Creek, based on the amount of subsidence expected within these catchments.

There is the potential for localised increases in flow velocities as a result of subsidence induced increases in gradient in relatively short watercourse reaches within the catchments of Stockyard Creek and Lords Creek. Increased flow velocities have the potential to affect macroinvertebrate community composition by making existing slow-flowing habitats unsuitable for taxa which prefer lentic water. Such impacts could result in a change in community condition in these creeks, however it was noted that macroinvertebrate communities at the downstream monitoring sites in Stockyard Creek and Lords Creek are not expected to be affected by the predicted changes to flow velocities in the upstream catchments.

Overall, the risk of subsidence related impacts to aquatic communities was assessed as moderate for Lords Creek, Stony Creek, Kilaben Creek and Stockyard Creek, and low for the unnamed tributary of Muddy Lake.

The Department of Primary Industries freshwater threatened species distribution maps indicated no threatened fish species within the study area. No impacts to fish passage in catchments overlying the proposed workings were predicted.

Mitigation, management and monitoring measures were recommended to allow for the identification of, and response to, the potential impacts to aquatic ecology identified by this report.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 1.2 and the assumptions and qualifications contained throughout the report.

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Abbreviations

ANZECC	Australian and New Zealand Environment Conservation Council
ANZG	Australian and New Zealand Governments
AUSRIVAS	Australian River Assessment System
cm	Centimetre
DGV	Default guideline value
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DPI	Department of Primary Industries
EC	Electrical conductivity
EPL	Environment Protection Licence
EPT	Ephemeroptera, Plecoptera, Trichoptera
kg	Kilogram
L	Litre
LDP	Licensed discharge point
LOR	Limit of reporting
m	Metre
mg	Milligram
ML	Megalitre
mm	Millimetre
N	Nitrogen
NATA	National Association of Testing Authorities
NTU	Nephelometric turbidity unit
RBA	Rapid bio-assessment
sat.	Saturation
SIGNAL-2	Stream Invertebrate Grade Number Average Level - Version 2
sp.	Species
TDS	Total dissolved solids
Temp	Temperature
TKN	Total Kjeldahl nitrogen
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
°C	Degree celsius
µm	Micrometre
µS	Microsiemens

Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate (CaCO3).
Analyte	A substance or chemical constituent that is undergoing analysis.
Anion	Negatively charged ion.
Bioavailability	The fraction of the total of a substance in the surrounding environment that is available to be taken up by living organisms.
Cation	Positively charged ion.
Community	An assemblage of organisms occupying a specified location and time, usually interacting with one another.
Community composition	All of the taxa present in a community.
Discharge	The quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Dissolved oxygen	A measure of the amount of oxygen that is dissolved in water.
Ecotoxicology	Scientific study of the effects of toxic substances on living organisms.
Electrical conductivity	A measure of the concentration of dissolved salts or ions in water.
Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa index	An index based on the number of taxa of the environmentally sensitive orders Ephemeroptera, Plecoptera and Trichoptera identified in a sample.
Estuarine	A partly enclosed coastal body of brackish water with one or more rivers flowing into it and with a free connection to the open sea.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report relates to the form and structure of waterways.
Guideline value	The concentration or load of physico-chemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur.
Hardness	The concentration of multivalent cations present in water. Generally, hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate ($CaCO_3$) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Ion	An electrically charged atom.
Index	Composite value that can give a quick ranking to an ecosystem feature (e.g. a water body), derived via a formula that combines measurements of important ecosystem characteristics; typically used to rank ‘health’ or naturalness.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the site Environmental Protection Licence.
Macroinvertebrate	An animal species that does not develop a vertebral column that is large enough to be seen without the use of a microscope. These animals generally include insects, crustaceans, molluscs, arachnids and annelids.
Macrophyte	A member of the macroscopic plant life of an area, especially of a large body of water.

Metalloid	A chemical element with properties that are a mixture of those of metals and non-metals.
Multivariate analysis	Statistical analysis concerned with data collected on multiple dimensions of the same subject.
Organic carbon	Generally, carbon which is chemically bonded to other carbon atoms, although methane (one carbon atom only) and its derivatives are considered organic.
Organic matter	Matter composed of organic compounds that have come from the remains of once-living organisms such as plants and animals and their waste products.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Rapid bioassessment	A form of biological assessment that uses standardised, cost-effective protocols to provide rapid sample processing, data analysis, reporting and management response. The results from such assessments are likely to be reliable to detect large impacts but not small or minor impacts.
Reach	A defined section of a stream with a uniform character and behaviour.
Richness	The number of species or taxa present (generally applied to a sample or community).
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Salinity	The dissolved salt content of a body of water or soil.
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Taxa	Any group of organisms considered to be sufficiently distinct from other groups to be treated as a separate unit (e.g. species, genera, families).
Taxonomic	An organism's location in the biological classification system used to identify and group organisms with similar physical, chemical and/or structural composition.
Total dissolved solids	A measure of the inorganic and organic substances dissolved in water.
Total Kjeldahl nitrogen	The sum of the concentrations of organic nitrogen, ammonia (NH_3) and ammonium (NH_4+) in water.
Total nitrogen	A measure of organic and inorganic nitrogen forms in water. The sum of concentrations of TKN and nitrite and nitrate as N.
Total phosphorus	A measure of organic and inorganic phosphorus in particulate and soluble forms.
Total suspended solids	A measure of the filterable matter suspended in water.
Tributary	A stream or river that flows into a main river or lake.
Turbidity (NTU)	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Univariate analysis	Statistical analysis concerned with data collected on one dimension of the same subject.

1. Introduction

GHD Pty Ltd (GHD) was commissioned by Centennial Newstan Pty Limited (Centennial Newstan) to prepare an aquatic ecology impact assessment for the Newstan Mine Extension Project (the project). This assessment forms part of an Environmental Impact Statement (EIS) to support a State significant development (SSD) application (SSD-10333) made under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Centennial Newstan is a subsidiary of Centennial Coal Company Limited (Centennial), a wholly owned subsidiary of Banpu Public Company Limited.

1.1 Background

Newstan Colliery is an existing underground coal mine located in the Lake Macquarie Local Government Area, approximately 25 km south west of Newcastle and 140 km north of Sydney, NSW. It is owned and operated by Centennial Newstan.

Mining operations at Newstan Colliery began in 1887 and upon the introduction of the NSW EP&A Act operated pursuant to continuing use rights in accordance with Part 4, Division 10 of the EP&A Act.

Newstan Colliery has at various times mined the upper coal seams (Great Northern and Fassifern seams) and lower coal seams (West Borehole, Borehole, Young Wallsend and Yard seams) and produced both semi-soft coking coal and thermal coal for the domestic and export markets. In the lower seams, workings to date have been concentrated to the west of the seam split, which is a defining geological feature of the mine. Mining has been undertaken using a combination of bord and pillar and longwall mining.

In August 2014, the underground operations at Newstan Colliery were placed into care and maintenance due to poor market conditions. In recent years, Centennial Newstan has commenced feasibility investigations into the recommencement of mining at Newstan Colliery. The most recent modification to DA 73-11-98 in January 2019 permits first workings mining within the West Borehole seam in the southern portion of the Newstan Colliery mining lease area. The first workings aim to improve Centennial Newstan's understanding of the geology within the West Borehole seam, including the presence, throw and strike of a major fault zone projected from the historical Newstan Colliery workings.

Centennial Newstan is now seeking approval for the continuation of mining within the West Borehole seam. The project proposes to extract up to 25.9 million tonnes (Mt) over a fifteen year period at a maximum production rate of 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal. Bord and pillar mining is proposed using continuous miner methods that will include areas of first workings, partial extraction and total extraction. A mix of metallurgical and thermal coal is proposed to be extracted. ROM coal will be delivered to the Newstan Colliery Surface Site via a series of existing underground conveyors. Once the coal reaches the Newstan Colliery Surface Site it will be handled in accordance with the approved operations for the Northern Coal Logistics Project (SSD-5145), managed by Centennial's Northern Coal Services business unit.

Other key features of the project include:

- Utilisation of the Newstan Colliery Surface Site to provide parking, bathhouse, administration and workshop facilities for the underground workforce. A small number of administrative, maintenance and monitoring personnel will also be located at Awaba Colliery Surface Site.
- Transportation of personnel and materials to and from the underground mining area via the existing men and materials drift at Newstan Colliery Surface Site.

- Continued operation of the two existing ventilation fans at Newstan Colliery Surface Site and the installation and operation of three new ventilation fans at the existing ventilation shaft at Awaba Colliery Surface Site.
- In-seam gas drainage, with gas transferred to a new gas flaring facility to be located within the existing disturbance footprint of Awaba Colliery Surface Site.
- Extraction of underground water via the existing Fassifern Pump Station at Newstan Colliery Surface Site and ongoing groundwater management in accordance with Centennial's *Northern Operations: Regional Water Management Plan*.

The project is aligned with the broader Centennial business strategy in that it facilitates the development of a new semi-soft coking coal product stream and a thermal coal product for both the domestic and export markets. The project will enable supply of export coal products while meeting contractual coal supplies to the domestic markets. Over time, the project can potentially replace the coal product currently supplied to the domestic market by other Centennial operations as these other resources become depleted. This will ensure ongoing security of supply for domestic electricity generation.

If approved, the project will allow for the optimisation of resource recovery from Newstan Colliery while providing ongoing direct and indirect employment opportunities. In addition, the project will provide a number of positive flow-on effects to the local, regional and state economies through additional wages and royalties.

1.2 Objectives and scope of work

The objective of the aquatic ecology impact assessment is to determine the potential impacts of the project on aquatic ecology in water courses overlying and downstream of the Extension of Mining Area (shown in Figure 3-1).

The scope of work for the aquatic ecology impact assessment included:

- Describing the project and Newstan Colliery water management.
- Identifying components of the project with potential to impact the aquatic ecology of the receiving environment.
- Characterise the existing condition (ecosystem value) of waterways that may be impacted by the project (based on outcomes of the field survey and desktop assessment).
- Undertaking biodiversity database searches relating to aquatic species and identifying threatened aquatic species relevant to the study area.
- Undertaking an assessment of the potential impacts of the project on aquatic biota.
- Develop measures to avoid, minimise and mitigate the potential aquatic ecology impacts of the project.

2. Legislation

2.1 Commonwealth legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Commonwealth Department of the Environment and Energy (DoEE) and provides a legal framework to protect and manage nationally important flora, fauna, ecological communities and heritage places defined as 'matters of national environmental significance' (MNES). An action that 'has, will have or is likely to have a significant impact on a matter of national environmental significance' is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Commonwealth Environment Minister. Approval under the EPBC Act is also required where actions are proposed on, or will affect, Commonwealth land and its environment.

The project was referred to the Commonwealth Department of the Environment and Energy due to the potential impacts on MNES, including water resources. The Project was declared to be a controlled action (EPBC 2019/8528), and requires assessment and approval under the EPBC Act. Additional assessment requirements under the EPBC Act are provided in the Surface Water Impact Assessment (SWIA).

2.2 State legislation

2.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act, administered by the NSW Department of Planning, Industry and Environment, is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

This Aquatic Ecology Impact Assessment forms part of an EIS to support development application SSD-10333 under Part 4 of the EP&A Act for the project. The Minister for Planning (or delegate) is the determining authority for the project.

2.2.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the NSW Environment Protection Authority (EPA), which is an independent statutory authority and the primary environmental regulator for NSW. The objectives of the POEO Act are to protect, restore and enhance the quality of the environment. Some of the mechanisms that can be applied under the POEO Act to achieve these objectives include programs to reduce pollution at the source and monitoring and reporting on environmental quality. The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal and for water, air, land and noise pollution.

Under the POEO Act, an environment protection licence (EPL) is required for premises at which a 'scheduled activity' is conducted. Schedule 1 of the POEO Act lists activities that are scheduled activities for the purpose of the Act. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity.

2.2.3 Water Management Act 2000

The aim of the *Water Management Act 2000* (WM Act) is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

Historically, the *Water Act 1912* was the main legislation for managing water resources in NSW; however, it is being progressively phased out and replaced by water sharing plans (WSPs) under the WM Act. Once a WSP commences, existing licences under the *Water Act 1912* are converted to water access licences (WALs), water supply works and use approvals (controlled activity approvals) under the WM Act. All new WALs and controlled activity approvals are also issued under the WM Act.

2.2.4 Fisheries Management Act 1994

The objectives of the *Fisheries Management Act 1994* (FM Act) are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. In particular, this includes:

- To conserve fish stocks and key fish habitats.
- To conserve threatened species, populations and ecological communities of fish and marine vegetation.
- To promote ecologically sustainable development, including the conservation of biological diversity.
- To promote viable commercial fishing and aquaculture industries.
- To promote quality recreational fishing opportunities.
- To appropriately share fisheries resources between the users of those resources.
- To provide social and economic benefits for the wider community of NSW.
- To recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.

Key fish habitats

One of the aims of the FM Act is to conserve key fish habitats. These are defined as aquatic habitats that are important to the sustainability of recreational and commercial fishing industries, the maintenance of fish populations generally and the survival and recovery of threatened aquatic species.

In freshwater systems, most permanent and semi-permanent rivers, creeks, lakes, lagoons, billabongs, weir impoundments and impoundments up to the top of the bank are considered key fish habitats. Small headwater creeks and gullies (known as first and second order streams) that flow for a short period after rain and farm dams on such systems are generally excluded, as are artificial waterbodies except for those that support populations of threatened fish or invertebrates.

Assessment of significance

The FM Act lists the factors to be addressed in the assessment of significance of impact on threatened species, populations and ecological communities of fish and marine vegetation.

2.2.5 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* (BC Act) provides legal status for biota of conservation significance in NSW. The BC Act aims to, amongst other things, 'maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development'. It provides for the listing of threatened species and communities, establishes a framework to avoid, minimise and offset the impacts of proposed development, and establishes a standard method for assessing the likely impacts on biodiversity values and calculating measures to offset those impacts.

This Act applies in relation to animals and plants and not in relation to fish and marine vegetation.

Part 7.2 (1) of the BC Act, states that development or an activity is "likely to significantly affect threatened species" if:

- It is likely to significantly affect threatened species or ecological communities, or their habitats, according to the test in section 7.3.
- The development exceeds the biodiversity offsets scheme threshold if the biodiversity offsets scheme applies to the impacts of development on biodiversity values.
- It is carried out in a declared area of outstanding biodiversity value.

An assessment of the project's impacts on biodiversity, including any offsetting requirements, has been completed separately to this aquatic ecology impact assessment in accordance with the requirements of the BC Act (RPS 2020).

2.3 Guidelines

2.3.1 IESC information guidelines

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) is a statutory body established under the EPBC Act in 2012. The IESC provides independent scientific advice to Australian government regulators on proposed coal seam gas or large coal mining developments that are likely to have a significant impact on water resources. Information guidelines (IESC 2018) outline the information requirements of the IESC to adequately assess a proposal and provide scientific advice on the potential water-related impacts.

The IESC has also published a series of explanatory notes to supplement the information guidelines to provide more detailed guidance on the preparation of environmental impact assessments. The explanatory note for deriving site-specific guideline values for physicochemical parameters and toxicants (IESC 2019) provides information on how the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) can be implemented for large coal mine developments.

2.3.2 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) provide guidance for assessing and managing ambient water quality in a wide range of water resource types and according to specified environmental values, such as aquatic ecosystems, primary industries, recreation and drinking water. The revised Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) were published in 2018 following scientific review of the ANZECC (2000) guidelines. The Water Quality Management Framework (ANZG 2018) provides the key requirements for determining appropriate guideline values or performance criteria to evaluate the results of water quality monitoring programs.

The ANZG (2018) guidelines adopt a risk-based approach to assessing ambient water quality by providing the framework to tailor water quality guidelines to local environmental conditions. Guideline values provided by ANZG (2018) can be modified into regional, local or site-specific guideline values (SSGVs) by taking into account factors such as the level of modification of the ecosystem, natural variability in water quality at reference sites, and water hardness. Guideline values are applied to the receiving environment at the edge of the mixing zone and do not apply to mine water at the point of discharge. For the purposes of the SWIA (GHD 2020b), the median (for physicochemical parameters and nutrients) and 95th percentile (for toxicants) results for the downstream sites were compared to the applicable default guideline values (DGVs), as recommended by ANZG (2018).

2.3.3 Managing Urban Stormwater

Managing Urban Stormwater: Soils and Construction Volume 1 (The 'Blue Book'; Landcom 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters. This document relates particularly to urban development sites; however, it is relevant to the project as it provides guidance on the configuration of erosion and sedimentation controls required during construction.

Additional guidelines on specific aspects of development and erosion and sediment control are also available. The relevant guideline relating to the Blue Book is *Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries* (DECC 2008), which provides guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of mines and quarries.

3. Methodology

3.1 Study area

The majority of the Project Application Area (shown in Figure 3-1) is located in undulating, unpopulated bushland and areas of rural residential land use. The study area for the Aquatic Ecology Impact Assessment is largely bound by the Project Application Area, though also includes a site downstream of the Project Application Area (CCSC1). Lake Macquarie and the surrounding residential suburbs of Toronto and Rathmines border the Project Application Area to the east. To the south lies Eraring Power Station and associated infrastructure including the Eraring Ash Dam. To the west of the Project Application Area lies the M1 Pacific Motorway with the Main Northern Railway line traversing the area in a north-south direction. Parts of the north-west of the Project Application Area are overlain by the Awaba State Forest.

The proposed Extension of Mining Area is overlain by a biodiversity offset area owned by Lake Macquarie City Council. The site, known as the Awaba Biodiversity Conservation Area, is managed for biodiversity conservation in accordance with the terms of an agreement established under the EPBC Act.

The proposed Extension of Mining Area is bordered by historical Newstan Colliery mine workings to the north and north-west while the western and northern area of the proposed Extension of Mining Area is partially overlain with mine workings from the Awaba Colliery in the Fassifern and Great Northern seams.

3.2 Desktop assessment

A desktop review was undertaken to help determine the conservation significance of Lords Creek, Stony Creek, Stockyard Creek, Kilaben Creek and the unnamed tributary of Muddy Lake, and to identify threatened species, populations and ecological communities listed under the BC Act and FM Act. A search for MNES listed under the EPBC Act that may occur in the area based on previous records, known distribution ranges, and habitats present was also undertaken.

The biodiversity databases and literature pertaining to the study area that were reviewed included:

- The Commonwealth DoEE Protected Matters Search Tool (PMST), for MNES (threatened and migratory biota) known or predicted to occur in the study area (DoEE 2019). The PMST was utilised with a 1 kilometre buffer around the surface water sampling locations at Lords Creek, Stony Creek, Stockyard Creek, Kilaben Creek, and the unnamed tributary of Muddy Lake.
- Office of Environment and Heritage (OEH) BioNet Atlas database for records of threatened species, populations and endangered ecological communities listed under the BC Act that have been recorded in the study area (OEH 2019). The BioNet Atlas database utilises a minimum search area of 10 square kilometres, which was centred on a point approximately half way between the Eraring Power Station and Fennell Bay.
- The key fish habitat map for the Lake Macquarie Local Government Area (DPI 2019a).
- Department of Primary Industries Freshwater threatened species distribution maps (DPI 2019b).
- Key threatening processes (KTPs) within the EPBC Act, the FM Act and the BC Act. A KTP is a process that may threaten the survival, abundance or evolutionary development of a native species or ecological community.

3.3 Field survey

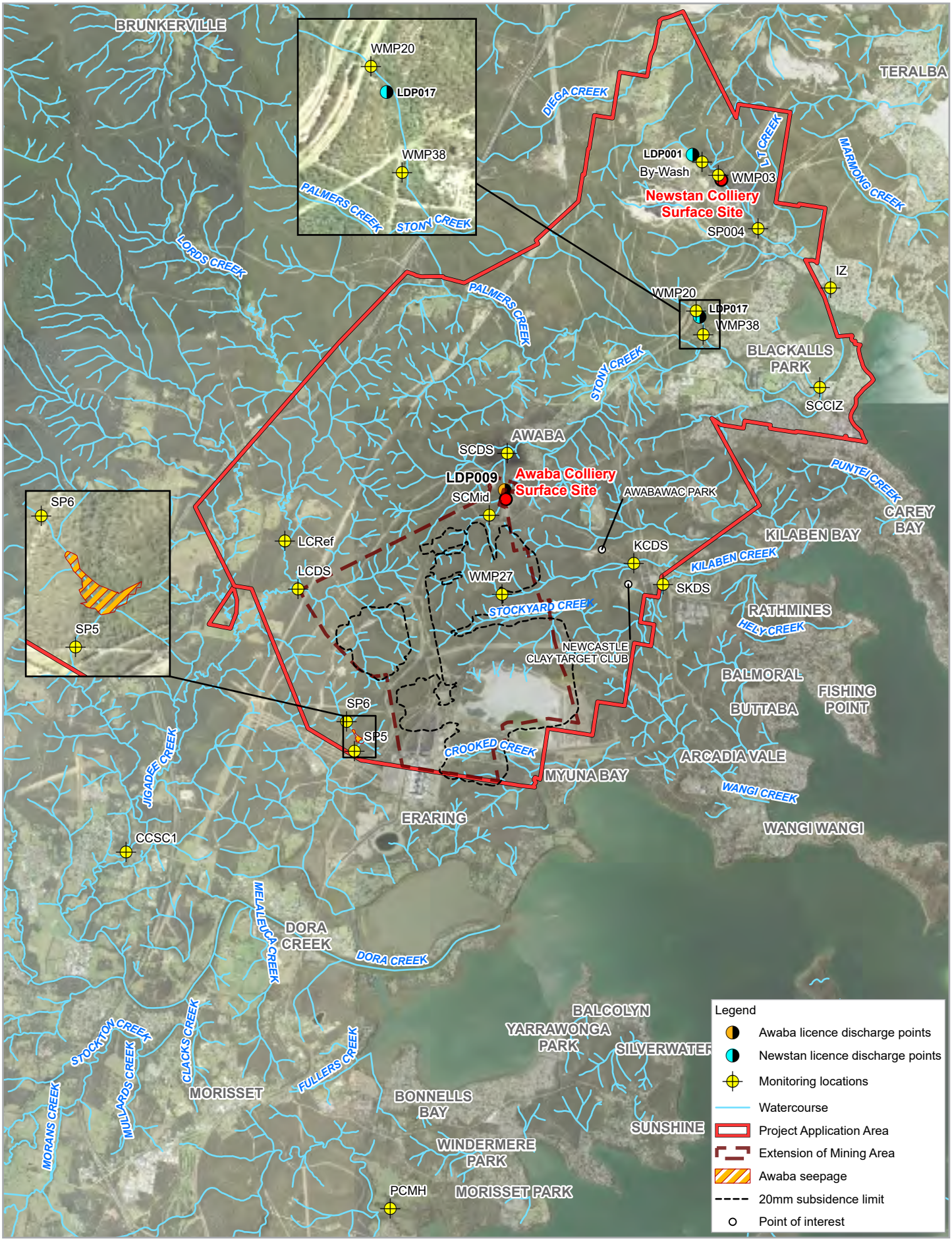
Fifteen freshwater sites and three estuarine sites were visited in autumn and spring 2019. These sites are outlined in Table 3-1 and locations are shown on Figure 3-1. The field survey program included sites sampled previously during routine aquatic ecology programs for Newstan and Awaba collieries, and new sites selected for the purpose of this project.

Freshwater sites LCDS, LCRef, KCDS, SKDS, SCMid and SCDS have been selected for this assessment due to their location on waterways upstream, downstream or within the Project Application Area and were sampled only in autumn and spring 2019. LCDS was dry in autumn 2019 and was therefore unable to be sampled, and contained insufficient water for the collection of macroinvertebrate samples during the spring 2019 sampling event.

Freshwater sites WMP27, WMP20, WMP38, By-Wash, WMP03, SP004, SP6 and SP5, and estuarine sites IZ, SCCIZ and PCMH have historically been sampled biannually for the Newstan and/or Awaba Colliery aquatic ecology monitoring programs. CCSC1 is a historical monitoring site that has been sampled previously by GHD for the Newstan Colliery aquatic ecology monitoring program, but had not been sampled since 2014 prior to the sampling being undertaken for this project. The history of aquatic ecology monitoring that has been undertaken at each of the sites in this assessment is summarised in Appendix A

Table 3-1 Sites sampled for the aquatic ecology impact assessment

Site Code	Catchment	Description	Dates Sampled	Site Type	Easting	Northing
Freshwater sites					Zone: 56 H	
CCSC1	Lords Creek	Jigadee Creek downstream monitoring site	24/05/19, 16/10/19	Potential impact	357193	6339718
LCDS	Lords Creek	Lords Creek downstream monitoring site	Dry in autumn, 17/10/19	Potential impact	359955	6343938
LCRef	Lords Creek	Lords Creek upstream of the Extension of Mining Area	22/05/19, 17/10/19	Reference	359744	6344712
WMP27	Kilaben Creek	Kilaben Creek within the Extension of Mining Area	14/05/19, 01/11/19	Potential impact	363231	6343857
KCDS	Kilaben Creek	Kilaben Creek downstream monitoring site	23/05/19, 18/10/19	Potential impact	365348	6344350
SKDS	Stockyard Creek	Stockyard Creek downstream monitoring site	23/05/19, 11/10/19	Potential impact	365815	6344020
SCMid	Stony Creek	Stony Creek monitoring site within the Extension of Mining Area	22/05/19, 17/10/19	Potential impact	363027	6345130
SCDS	Stony Creek	Stony Creek downstream monitoring site	23/05/19, 18/10/19	Potential impact	363314	6346122
WMP20	Stony Creek	Stony Creek upstream of LDP017	Dry in autumn, 14/10/19	Reference	366346	3648409
WMP38	Stony Creek	Stony Creek downstream of LDP017	Dry in autumn, 14/10/19	Potential impact	366459	6348025
SP6	Unnamed tributary of Muddy Lake	Unnamed tributary of Muddy Lake, upstream of Awaba seepage	15/05/19, 31/10/19	Potential impact	360859	6341343
SP5	Unnamed tributary of Muddy Lake	Unnamed tributary of Muddy Lake, Awaba seepage	13/05/19, 31/10/19	Potential impact	360735	6341816
By-Wash	LT Creek	By-Wash Dam, located downstream of Newstan LDP001	21/05/19, 14/10/19	Potential impact	366442	6350797
WMP03	LT Creek	LT Creek downstream of By-Wash Dam	21/05/19, 14/10/19	Potential impact	366705	6350585
SP004	LT Creek	LT Creek at the archery range	21/05/19, 14/10/19	Potential impact	367342	6349730
Estuarine sites						
PCMH	Pourmalong Creek	Pourmalong Creek at Silky Oak Drive, not impacted by current or proposed mining activities	20/05/19, 15/10/19	Estuarine reference	361435	6333996
IZ	LT Creek	LT Creek intertidal zone.	23/05/19, 16/10/19	Estuarine potential impact	368506	6348780
SCCIZ	Stony Creek	Stony Creek intertidal zone downstream of LDP017	20/05/19, 16/10/19	Estuarine potential impact	368334	6347176



Paper Size ISO A4

0 0.5 1 1.5 2 2.5

Kilometers

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

N

GHD

Centennial Newstan Pty Limited
Newstan Mine Extension Project
Aquatic Ecology Impact Assessment

Project No. **22-20188**
Revision No. **0**
Date **23/01/2020**

Locality Plan

FIGURE 3-1

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3.3.1 Habitat assessment

Field descriptions were recorded using modified NSW AUSRIVAS field sheets, based on visual estimates of characteristics such as stream bed composition (percentage of each substrate category e.g. sand and cobble), aquatic and riparian vegetation cover, amount of in-stream detritus, and other types of aquatic micro-habitats. The mean wetted width and mean water depth were also estimated.

The assessment included sketches of the longitudinal and cross-sectional profiles of the reach assessed, displaying the biological sampling site, locations where photos were taken and *in situ* water quality was measured, and the riparian zone width, type and height. The cross-section included the approximate bank height, stream width and depth, and the approximate height of riparian vegetation.

Field data were recorded by qualified and experienced aquatic ecologists.

3.3.2 Water quality sampling

In situ water quality

The following *in situ* physical and chemical parameters were measured at each sampling site using a YSI ProDSS multi-parameter water quality meter:

- Temperature (°C)
- pH (pH units)
- Electrical Conductivity (EC) (µS/cm)
- Dissolved Oxygen (DO) (mg/L and % saturation)

The meter was calibrated prior to use.

Chemical analysis – water

One water sample was collected at each site prior to the collection of sediment and macroinvertebrate samples. Samples requiring analysis of dissolved metals were field filtered using a single-use high volume 45 µm filter prior to collection in the sample bottle. Water samples were analysed for the parameters in Table 3-2 by a NATA accredited laboratory. Laboratory certificates of analysis (COAs) are provided in Appendix A.

Table 3-2 Analytical schedule - water samples

Suite	Analytes
Metals (dissolved and total)	Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, tin, titanium, vanadium, zinc
Major ions	Chloride, sulfate, alkalinity, calcium, magnesium, sodium, potassium
Nutrients	Total Nitrogen (TN), nitrate, nitrite, nitrate plus nitrite (NO_x), Total Kjeldahl Nitrogen (TKN), ammonia, Total Phosphorus (TP), Reactive Phosphorous (RP)
Other analytes	Total dissolved solids (TDS), total suspended solids (TSS), turbidity, dissolved organic carbon (DOC)

3.3.3 Sediment sampling

Sediment grab samples were collected following the sediment-water interface hand corer methods as outlined in the Sediment Quality Assessment (Simpson and Batley 2016) guide.

Two sediment samples were collected from each site and homogenised to produce one composite sediment sample. Sediment samples were collected using a 100 mm diameter, PVC hand corer that was pushed 200 mm into the substrate where the sediment was soft enough. Where sediment had a higher percentage of coarse particles that prevented sampling by corer, samples were collected using a plastic trowel. The sediment samples were analysed for the parameters presented in Table 3-3 by a NATA accredited laboratory. Laboratory COAs are provided in Appendix A.

Table 3-3 Analytical schedule - sediment samples

Suite	Analytes
Metals (totals and 1M HCl extractable where possible)	Antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, zinc
Nutrients	Ammonia, nitrite, nitrate, Total Kjeldahl Nitrogen (TKN), total nitrogen, total phosphorous
Other analytes	Total organic carbon (TOC)

3.3.4 Macroinvertebrate sampling

Freshwater

Field sampling following Rapid Bioassessment (RBA) protocols was undertaken in accordance with the NSW AUSRIVAS Sampling and Processing Manual (Turak *et al*. 2004). The AUSRIVAS program is a nationally recognised, industry standard sampling protocol for the assessment of river health, and was developed for Australia's National River Health Program.

Sampling was conducted using a standard ISO 7828 (1983) designed sweep-net with 250 µm mesh. Nets were washed thoroughly between sites and at the conclusion of all sampling to remove any invertebrates retained on net material. Samples were collected by sweeping the net along the edge of the bank in areas of little or no current. Collection of macroinvertebrates involved the sampling of all available microhabitats, including overhanging terrestrial vegetation, against snags, in backwaters, and through beds of macrophytes. Sampling was undertaken, working from downstream to upstream, over approximately 10 m of (discontinuous) edge habitat.

Two replicate edge samples were collected at sites selected for this program in both autumn and spring 2019. LCDS was dry during autumn 2019 and contained insufficient water for the collection of a macroinvertebrate sample in spring 2019.

Stony Creek sites sampled as part of the Newstan Colliery aquatic ecology monitoring program (WMP20 and WMP38) were dry in autumn 2019, and were consequently not sampled. Two replicate samples were collected from both sites in spring 2019. One macroinvertebrate sample was collected in both autumn and spring from sites assessed during the Awaba Colliery aquatic ecology monitoring program (WMP27, SP6 and SP5).

For each RBA sample, the collected material was placed into a sorting tray and macroinvertebrates picked for a minimum of 40 minutes by qualified and experienced aquatic ecologists using forceps and pipettes. If new taxa were found between 30 and 40 minutes, sorting continued for a further 10 minutes. The processing cycle was continued up to a total maximum sorting time of 1 hour.

Estuarine

Estuarine sites IZ, SCCIZ and PCMH were sampled for benthic invertebrates using a 100 mm diameter corer. The corer was pushed 200 mm deep into the sediment (where the substrate allowed). The samples were sieved through a 600 µm sieve to remove the fine silt, mud and clay. The remaining sample was preserved in methylated spirits and labelled for later identification. Three replicate samples were collected at each site.

3.3.5 Laboratory processing and macroinvertebrate identification

Freshwater samples

Macroinvertebrates were examined using Leica MZ 9.5 stereo-dissection microscopes with planachromat objectives and a zoom capability between 6.3-60x. Animals were identified using published taxonomic keys (Hawking 2000), unpublished working keys and an extensive specimen reference collection maintained by GHD. Macroinvertebrates were identified to the taxonomic resolution that followed the standard conventions of the NSW AUSRIVAS sampling and processing manual (Turak *et al*. 2004).

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. Raw macroinvertebrate data are provided in Appendix C.

Estuarine samples

Estuarine grab samples were 100 % sorted (i.e. all animals removed) and animals identified to family level where possible. Once identified, all animals were retained and stored in 100 % ethanol for long-term archiving. Raw infauna data are provided in Appendix C.

3.3.6 Scientific collection permit

GHD holds a NSW Department of Primary Industries (DPI) Scientific Collection Permit (SCP) P07/0412.5 (Exp. 31/10/2023) to conduct macroinvertebrate sampling in NSW rivers and streams. All sampling for the assessment was conducted in accordance with this SCP.

3.3.7 Quality assurance

Water and sediment

In accordance with GHD's Quality Assurance (QA) protocol, duplicate water and sediment samples were collected at the same time as the collection of the primary samples during both autumn and spring 2019. The collection of duplicate water and sediment samples allows for the assessment of the potential level of uncertainty associated with sampling method, preservation, transport or laboratory analysis. The results of the duplicate samples are presented in Appendix D for water quality and Appendix E for sediment quality.

Macroinvertebrates

One sample collected in both autumn and spring was examined by a second taxonomist to check the accuracy of identification. The macroinvertebrate QA results are provided in Appendix F.

3.3.8 Data analysis

Water quality and sediment quality

Water quality results were compared to Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000 and ANZG 2018). The following default guideline values (DGVs) were used to assess water quality:

- DGV ranges for physical and chemical stressors outlined in Table 3.3.2 of the ANZECC (2000) guidelines
- DGV ranges for conductivity (EC) and turbidity outlined in Table 3.3.3 of the ANZECC (2000) guidelines
- Toxicant DGVs for protection of 95 percent of freshwater species as outlined in the ANZG (2018) guidelines

Sediment quality results from both freshwater and estuarine sites were compared to the revised toxicant DGVs for sediment quality in ANZG (2018), which outlines the recommended sediment quality guidelines for metals, metalloids and organics. The sediment DGVs represent the thresholds above which biological effects are possible. GV-high values are also outlined, which are the thresholds above which there is a high probability of biological effects.

Freshwater macroinvertebrates

The following univariate indices were calculated to assess macroinvertebrate communities at each site:

- Taxonomic richness
- EPT richness
- SIGNAL-2

Taxonomic richness refers to the number of different taxa contained in a sample identified to family level, apart from certain taxa which were identified to order/class only or to sub-family (i.e. members of the family Chironomidae). Rare and common taxa are considered equally, as richness does not take into account abundance.

EPT richness is the number of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) families present in a sample. Macroinvertebrate families belonging to these orders are considered to be sensitive to changes in their environment, and therefore EPT taxa richness can be used to assess habitat and water quality.

SIGNAL-2 (Stream Invertebrate Grade Number – Average Level) (Chessman 2003) is a simple scoring system for macroinvertebrates of Australian rivers. SIGNAL-2 is a biotic index based on pollution sensitivity values (grade numbers) assigned to aquatic macroinvertebrates that have been derived from published and unpublished information on their tolerance to pollutants, such as sewage and nitrification (Chessman 1995).

Macroinvertebrates are assigned a grade between 1 (most tolerant) and 10 (most sensitive), and grades have been calculated for both the Order and Family taxonomic levels. Families in a sample that have not been assigned a grade are excluded from the analysis and the total number of families that have a SIGNAL-2 grade is the SIGNAL-2 richness. The overall SIGNAL-2 score for each sample is calculated by the sum total of the SIGNAL-2 grade for each taxon within a sample / SIGNAL-2 richness.

Classification or hierarchical agglomerative cluster analysis is a mathematical method of grouping entities according to the relative similarity of their attributes (community composition). Cluster analysis was used to help identify any differences (or similarities) in the macroinvertebrate communities between sites and waterways. The key to this technique is the Bray-Curtis similarity matrix, which is constructed from the individual similarities between all possible pairs of sites (Bray and Curtis 1957; Clifford and Stephenson 1975). From this matrix, a classification using Hierarchical Agglomerative Clustering is obtained and represented visually as a dendrogram (tree diagram). Samples which are similar in macroinvertebrate assemblage are grouped together on the dendrogram. Multivariate analyses were performed using PRIMER 7 (Clarke and Gorley 2015) statistical analysis software.

Estuarine benthic infauna

The following univariate indices were calculated for benthic infauna at estuarine sites:

- Taxonomic richness
- Abundance

Taxonomic richness refers to the number of different taxa collected in a sample.

Abundance refers to the number of individuals of each taxon recorded a site.

Given that the sample collection method is standardised, the data collected from estuarine sites can be considered quantitative.

3.4 Ecotoxicological monitoring

For the Newstan LDP001 discharge, EPL 395 requires an ongoing (annual) ecotoxicological monitoring program and associated reporting (Conditions E1.3 and E1.4). Condition L5.1 requires direct toxicity assessment (DTA) with the freshwater cladoceran *Ceriodaphnia dubia* (survival and reproductive impairment). DTA involves exposing laboratory test species to a range of concentrations of sampled water for a specified exposure period. At the end of the exposure period, specific endpoints are assessed, such as species survival, reproduction or growth. Statistical analysis of the results provides the Effect Concentration of the discharge where 10 percent (EC_{10}) and 50 percent (EC_{50}) of test organisms exhibited an inhibition effect and the No Observable Effect Concentration (NOEC) of the discharge, which represents the highest tested concentration that has no effect on the test organisms (when compared to the results of the control sample). EPL 395 limit condition L5.1 specifies that the toxic effect of the water released from LDP001 must not exceed an EC_{50} of 50 percent. In this case an exceedance would be a result lower than 50.

The most recent report on the results of the ecotoxicological monitoring was prepared in 2019 (GHD 2019b).

4. Existing conditions

4.1 Environmental conditions

Sampling in autumn 2019 was carried out between 20 and 24 May, and sampling in spring 2019 was carried out between 14 and 18 October. The sampling of Awaba Colliery sites considered in this assessment was conducted between 13 and 15 May 2019, and on 31 October and 1 November 2019.

Table 4-1 displays the temperature and rainfall data for the days where sampling was undertaken in 2019, as recorded by the Centennial Newstan Weather station. The temperature ranged from a minimum of 6.9°C to a maximum of 30.7°C. There was very little rainfall during the sampling periods, with only 0.2 mm recorded on 17 October 2019.

Rainfall at Newstan Colliery between January and December 2019 is displayed in Figure 4-1. In the 30 day period prior to the autumn monitoring event there was 26.4 mm of rain recorded, whereas 89.8 mm of rain was recorded in the 30 days prior to the spring monitoring event. 61.8 mm was recorded between 17 and 19 September 2019. In the seven days prior to the autumn and spring monitoring events 0.6 and 20.4 mm of rain were recorded respectively. These conditions were considered suitable for macroinvertebrate sampling using the methods described in Section 3.3.4.

Table 4-1 Daily weather observations during the autumn and spring 2019 monitoring events

Date	Minimum temperature (° C)	Maximum temperature (° C)	Rainfall (mm)
Autumn 2019			
13/05/19	7.8	23.0	0
14/05/19	9.8	24.8	0
15/05/19	8.6	22.4	0
20/05/19	8.4	23.8	0
21/05/19	9.2	27.1	0
22/05/19	9.7	25.8	0
23/05/19	11.6	23.3	0
24/05/19	8.9	25.1	0
Spring 2019			
14/10/19	6.9	24.6	0
15/10/19	9.8	27.1	0
16/10/19	11.4	24.5	0
17/10/19	14.3	30.7	0.2
18/10/19	7.6	23.5	0
31/10/19	12.4	29.5	0
01/11/19	10.9	29.9	0

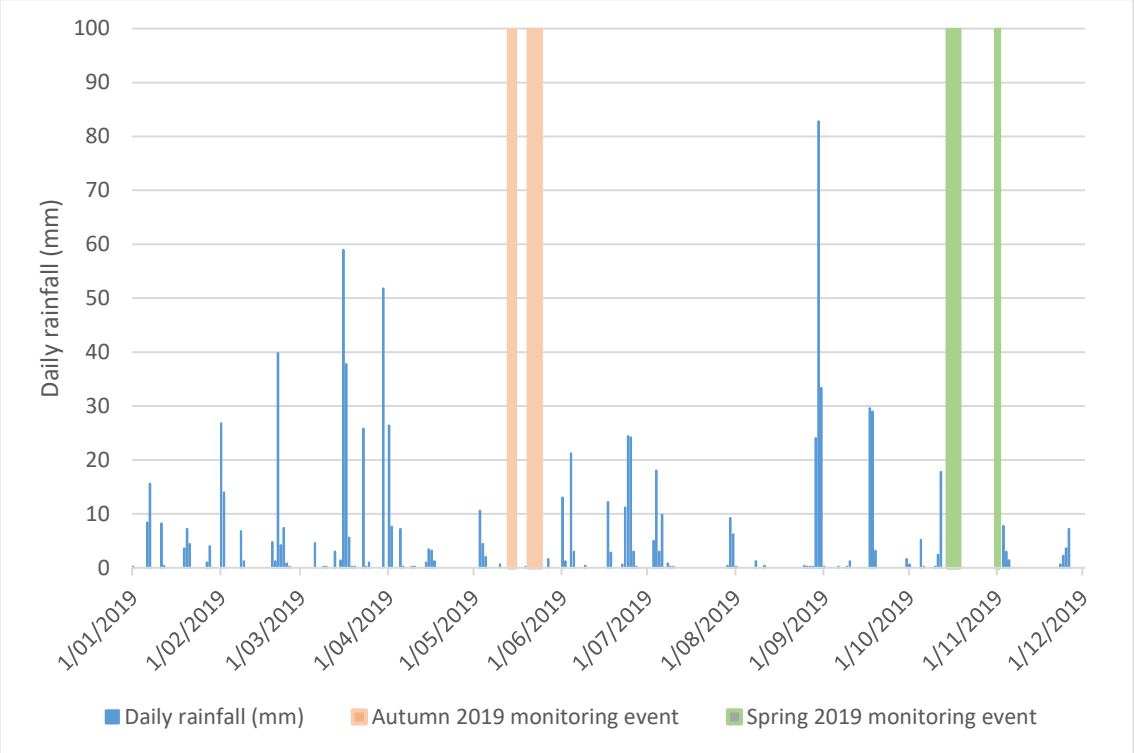


Figure 4-1 Daily rainfall at Newstan Colliery

4.2 Conservation significance

4.2.1 Matters of national conservation significance

The DoEE Protected Matters Search Tool (DoEE 2019) was used to produce an EPBC Act Protected Matters Report for Lords Creek, Stony Creek, Stockyard Creek, Kilaben Creek and the unnamed tributary of Muddy Lake, including the surface water sampling points relevant to the Extension of Mining Area. The report is provided in Appendix G. A summary of the Protected Matters Search results and the potential impacts of the project is provided in Table 4-2.

Table 4-2 EPBC Act protected matters search results relevant to aquatic environments

Protected matter	Matter located within search radius	Comments	Potential impacts
Wetlands of international significance (Ramsar sites)	None	No Wetland of international significance within the search radius	None
Listed threatened aquatic species	• Black Rockcod, Black Cod, Saddled Rockcod (*Epinephelus daemelii*)	Has not been observed in Lake Macquarie by Lake Macquarie City Council (LMCC) (2019). Does not inhabit freshwater though can inhabit estuaries.	None, as *Epinephelus d.* does not inhabit freshwater, and the potential impacts to water quality and habitat condition in Lake Macquarie are considered negligible.

Protected matter	Matter located within search radius	Comments	Potential impacts
Listed aquatic migratory species	• Loggerhead Turtle (*Caretta caretta*) • Green Turtle (*Chelonia mydas*) • Leatherback Turtle, leathery Turtle, Luth (*Dermochhelys coriacea*) • Hawksbill Turtle (Eretmochelys imbricate) • Flatback Turtle (*Natator depressus*)	• *C. caretta* has been observed in Lake Macquarie by LMCC (2019) • *C. mydas* has been observed in Lake Macquarie by LMCC (2019) All of these species are marine turtles.	None, as these marine turtles do not inhabit freshwater, and the potential impacts to water quality and habitat condition in Lake Macquarie are considered negligible (GHD 2020b).

4.2.2 Matters of state conservation significance

The search of the OEH BioNet Wildlife Atlas database (OEH 2019) for records of threatened species listed under the BC Act, did not identify any records of threatened aquatic species in the waterways in the study area. The fish present in these waterways have not been surveyed.

The Key Fish Habitat map for Lake Macquarie Local Government Area (DPI 2019a) indicates that Lords Creek, Stony Creek, Stockyard Creek, Kilaben Creek and the unmapped tributary of Muddy Lake are Key Fish Habitat. This map is provided as Appendix H. Despite the mapping of Key Fish Habitat, fish are likely to be scarce within the study area, given the ephemeral nature of the waterways.

The Department of Primary Industries (DPI 2019b) Freshwater threatened species distribution maps indicated no threatened fish species within the study area.

4.2.3 Key threatening processes

Of the 21 KTPs listed under the EPBC Act, none are relevant to the project.

There are currently eight KTPs listed under Schedule 6 of the FM Act, of which the following KTP is potentially relevant to the project:

- Installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams.

There are 38 KTPs listed under Schedule 3 of the BC Act. Of these, the following is potentially relevant to the project:

- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.

A summary of these KTPs and their relevance to the project is provided in Table 4-3.

Table 4-3 Key threatening processes relevant to the project

Act	Key threatening process	Relevance to the project	Likelihood/further consideration required
FM Act	Installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams.	The project is predicted to result in subsidence in the catchments of Lords Creek, Stony Creek, Kilaben Creek and Stockyard Creek (MSEC 2019), which has the potential to alter the natural flow regimes. Discharges via Awaba LDP009, Newstan LDP001 and LDP017 have the potential to alter natural flow regimes in Stony Creek and LT Creek.	High Refer to Section 5.1 for impact assessment relating to discharges and Section 5.2 for impact assessment relating to subsidence.
BC Act	Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands.	The project is predicted to result in subsidence in the catchments of Lords Creek, Stony Creek, Kilaben Creek and Stockyard Creek, which has the potential to alter the natural flow regimes. Discharges via Awaba LDP009, Newstan LDP001 and LDP017 have the potential to alter natural flow regimes in Stony Creek and LT Creek.	High Refer to Section 5.1 for impact assessment relating to discharges and Section 5.2 for impact assessment relating to subsidence.

4.3 Current licensed discharges

4.3.1 Newstan Colliery Surface Site

Newstan Colliery is currently licensed under EPL 395 to discharge water from the following licensed discharge points (LDPs):

- LDP001 – discharges into the Main By-Wash Dam and then LT Creek
- LDP002 – Final Pollution Dam Overflow
- LDP017 – Stony Creek Pipeline Outlet
- LDP021 – Graunchs Dam overflow weir

Of these LDPs, the project has the potential to impact discharges from LDP001 and LDP017, the locations of which are shown in Figure 3-1.

Water quality concentration limits for LDP001 and LDP017, specified by EPL 395, are provided in Table 4-4. Monitoring of water quality is undertaken daily during discharge. Discharge from LDP001 is limited to 11 ML per day. No volumetric limits apply to LDP017. As part of the Northern Coal Logistics Project, a volumetric limit for Newstan LDP001 of 14.5 ML/day was approved (SLR 2014). Further information regarding Newstan LDP017 and LDP001 is provided below.

Table 4-4 Water quality concentration limits for licensed discharge points

Parameter	Unit	LDP001	LDP017
Aluminium	mg/L	0.15	0.22
Antimony	mg/L	-	0.009
Arsenic	mg/L	-	0.042
Barium	mg/L	0.25	0.25
Beryllium	mg/L	-	0.004
Bicarbonate alkalinity	mg/L	711	711
Boron	mg/L	1.3	0.37
Cadmium	mg/L	0.0008	0.0004
Calcium	mg/L	-	38
Chloride	mg/L	-	516
Chromium (dissolved)	mg/L	-	0.006
Cobalt (dissolved)	mg/L	-	0.003
Copper (dissolved)	mg/L	0.005	0.007
Electrical conductivity	µS/cm	3250	3250
Iron (dissolved)	mg/L	-	230
Lead (dissolved)	mg/L	0.038	0.023
Lithium (dissolved)	mg/L	0.4	0.164
Magnesium	mg/L	-	16
Manganese (dissolved)	mg/L	-	12
Mercury (dissolved)	mg/L	0.0006	0.0006
Molybdenum (dissolved)	mg/L	0.04	0.045
Nickel (dissolved)	mg/L	0.0425	0.024
Nitrogen (total)	mg/L	2.7	2.7
Oil and grease	mg/L	6	6
pH	pH unit	6.5-8.5	6.5-8.5
Phosphorus (total)	mg/L	0.41	0.41
Potassium	mg/L	-	6
Selenium (total)	mg/L	0.011	0.011
Silica (dissolved)	mg/L	-	24.8
Silver (dissolved)	mg/L	-	0.001
Sodium	mg/L	-	635
Sulfate	mg/L	-	232
Tin	mg/L	-	0.003
Titanium	mg/L	-	10
TKN	mg/L	2.6	2.6
TSS	mg/L	50	50
Vanadium (dissolved)	mg/L	-	0.01
Zinc (dissolved)	mg/L	0.04	0.04

Newstan LDP017

The Fassifern Underground Storage at Newstan Colliery is connected to Stony Creek by the Stony Creek pipeline, which has the potential to discharge via Newstan LDP017. Water discharges from this LDP to Stony Creek via a concrete weir with a gabion wall, located approximately 30 m downstream of reference site WMP20. Discharges through LDP017 occurred following the high intensity rainfall event between 21 and 23 April 2015. These discharges occurred between 11 May 2015 and 17 June 2015. There has been no further discharge from LDP017 since June 2015. No water quality data for Newstan LDP017 were available as there were no discharges during the monitoring period assessed for the SWIA (GHD 2020b). As discharges through Newstan LDP017 have only occurred in response to heavy rainfall, the impacts to water quality and flows, and thereby aquatic communities in the receiving environment of Stony Creek, were likely to have been minor and temporary.

Newstan LDP001

Surface water management at Newstan Colliery, including operation of the licensed discharge point (LDP) from the water treatment plant to LT Creek (LDP001), form part of the Northern Coal Logistics Project (SSD-5415). A volumetric discharge limit of 11 ML/day is specified by EPL 395 for Newstan LDP001, with no other volumetric limits specified for any other LDP. As part of the Northern Coal Logistics Project, the volumetric limit for Newstan LDP001 was approved to increase to 14.5 ML/day, subject to a number of conditions being addressed (SLR 2014).

Daily discharge volumes through Newstan LDP001 are presented in Figure 4-2 between January 2013 and August 2019. The average discharge rate over this time was 6.71 ML/day, with a maximum discharge of 12.4 ML/day recorded in March 2013. Discharges have occasionally reduced to low levels as a result of maintenance activities or changes within the underground mine environment.

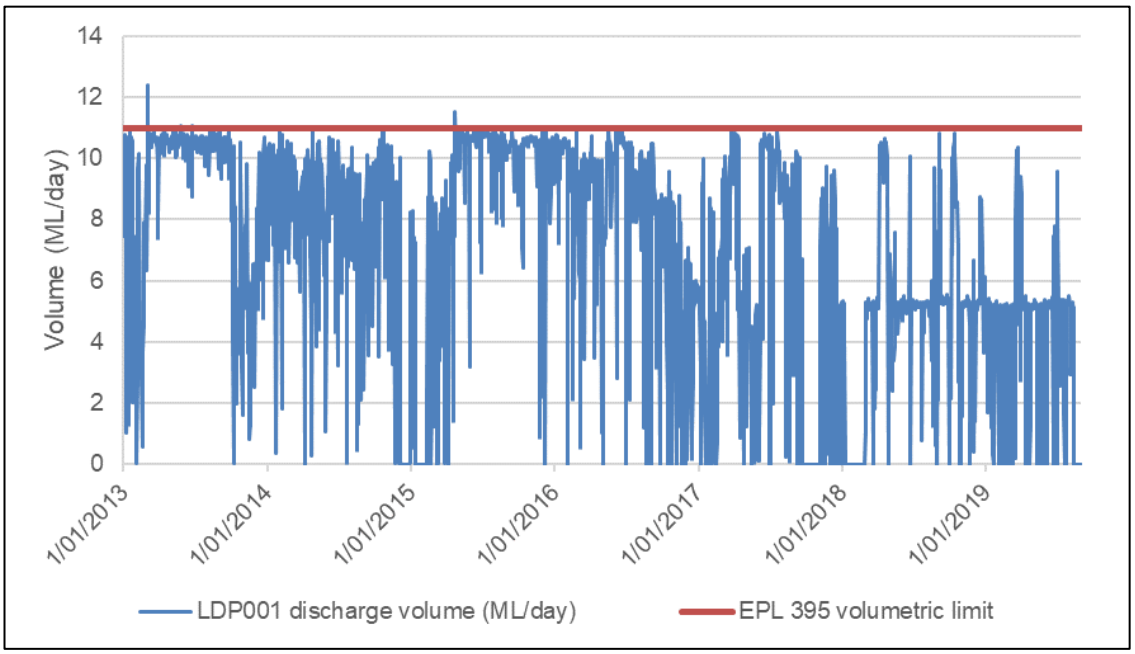


Figure 4-2 Historical Newstan LDP001 discharge volume

4.3.2 Awaba Colliery Surface Site

Centennial Newstan also currently holds EPL 443 for the Awaba Colliery Surface Site, with water licensed to be discharged from the site through the following LDPs:

- Awaba LDP001 – Borehole located on the eastern side of the Main North Railway.
- Awaba LDP002 – Borehole located along Hawk Mount Road.
- Awaba LDP003 – Borehole located on the western side of the Main North Railway.
- Awaba LDP004 – Borehole located along Hawk Mount Road.
- Awaba LDP005 – Borehole located on the eastern side of the private coal haul road at Barnes Dam.
- Awaba LDP006 – Borehole located in private gravel quarry.
- Awaba LDP007 – Borehole located on the south side of Gravel Road from Freemans Drive.
- Awaba LDP008 – Irrigation area from the wastewater maturation pond.
- Awaba LDP009 – Outlet from the Pollution Control Dam (PCD) to Stony Creek.

Awaba LDP001, LDP002, LDP003, LDP004, LDP005, LDP006 and LDP007 are no longer in use or have been decommissioned. LDP008 is not currently used, as there are no staff permanently based at Awaba Colliery Surface Site. Of these LDPs, the project has the potential to impact discharges from LDP009 only. The location of Awaba LDP009 is shown in Figure 3-1. The volumetric discharge limit for Awaba LDP009 as specified by EPL 443 is 8 ML/year. EPL 443 includes exceptions to the volumetric discharge limits, however these are no longer relevant as the dewatering and discharge infrastructure are no longer in use or have been decommissioned.

Water quality concentration limits specified by EPL 443 for all LDPs at Awaba Colliery are provided in Table 4-5. Further information regarding Awaba LDP009 is provided below.

Table 4-5 Environment Protection Licence 443 water quality concentration limits for Awaba Colliery Surface Site

Parameter	Units	100th percentile concentration limits
Oil and grease	mg/L	10
pH	pH units	6.5–8.5
TSS	mg/L	50

Awaba LDP009

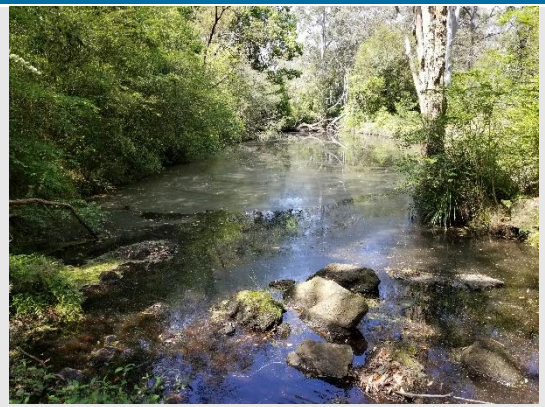
The PCD is the final structure for the management of runoff from the Awaba Colliery Surface Site prior to discharge from LDP009 to Stony Creek. LDP009 discharges to Stony Creek downstream of monitoring site SCMid and upstream of monitoring sites SCDS and SCCIZ. Monitoring sites WMP20 and WMP38 are on a tributary of Stony Creek and are not potentially affected by discharges from LDP009.

Following cessation of mining at Awaba Colliery, an automated system was established to pump water from the PCD to the Awaba underground void to reduce the management requirement for discharges through Awaba LDP009. As such, no discharges via LDP009 have occurred during the monitoring period January 2016 to April 2019 (for which water quality data were assessed in the SWIA (GHD 2020b).

4.4 Key aquatic habitat attributes

Waterways within the study area are generally characterised by narrow channels, with most sites consisting of isolated pools with low flow. Descriptions of the instream habitats and photographs of each of the sites sampled in autumn and spring 2019 are presented in Table 4-6.

Table 4-6 Site photos taken in autumn and spring 2019

CCSC1		Site description
 Facing upstream, 16/10/19	 Facing downstream, 16/10/19	CCSC1 is located on Jigadee Creek in the Lords Creek catchment downstream of the Extension of Mining Area. A concrete weir crosses the site with macroinvertebrate samples collected from the downstream pool. A road bridge crosses Jigadee Creek in the upstream pool. The site is situated near a rural residential area. The stream at this site is 10 to 20 metres wide. The riparian zone contains mostly native vegetation with some exotic species. A film covered the surface of the water during both sampling events and duckweed was observed in spring 2019. Instream habitats included submerged woody habitat, overhanging grasses and coarse detritus. The substrate was mostly rocky, with some deposition of silt along the left bank.
LCDS		**Site description**
 Facing upstream, 17/10/19	 Facing downstream, 17/10/19	LCDS is located on a tributary of Lords Creek within the Extension of Mining Area. The site is located in a native bushland area, with the riparian zone containing *Eucalypts sp., Casuarina sp., Gahnia sp., Phragmites sp.* and *Melaleuca sp.* The site is highly ephemeral, containing sufficient water for the collection of water and sediment samples only in spring, and contained no water in autumn 2019.

LCRef		Site description
 Facing upstream, 22/05/19	 Facing downstream, 22/05/19	LCRef is located on Lords Creek upstream of the Extension of Mining Area, within dense native bushland. The creek at this site was a maximum of six metres wide, and was much deeper in spring than autumn 2019. The riparian vegetation at LCRef consisted mostly of *Eucalyptus sp.*, *Melaleuca sp.* and *Gahnia sp.* Instream habitats at the site included submerged woody habitat, trailing and submerged *Gahnia sp.,* and detritus. The substrate was consolidated mud.
WMP27		**Site description**
 Facing upstream, 01/11/19	 Facing downstream, 14/05/19	WMP27 is located on Kilaben Creek within the Extension of Mining Area. The site is a deep, narrow channel with isolated pools. This site is located within a patch of remnant closed canopy forest with ferns and grasses dominant in the understorey. There has been some disturbance from vehicle access tracks and some eroded areas were observed during sampling. Otherwise there has been little disturbance to the site. Instream habitats consisted of sticks, undercut banks, overhanging *Gahnia sp.* and coarse detritus. The substrate is mostly sandy with some silt.

KCDS		Site description
 Facing upstream, 23/05/19	 Facing downstream, 23/05/19	KCDS is located on Kilaben Creek downstream of the Extension of Mining Area. It is located near Wilton Road within a native bushland area. The stream width at the site was up to 5.0 meters in autumn and up to 2.2 meters in spring 2019. The riparian vegetation at KCDS contained eucalyptus forest with a *Gahnia sp.* understory. Instream habitats at KCDS included overhanging vegetation, *Chara sp.*, submerged woody habitat and leaf litter. The substrate mostly sandy with some silt.
SKDS		Site description
 Facing upstream, 16/10/19	 Facing downstream, 16/10/19	SKDS is located on Stockyard Creek downstream of the Extension of Mining Area, and is next to Wangi Road, an Ausgrid substation and Toronto Golf Course. The site contains isolated pools up to 10 metres wide, with deep sections up to approximately 1.5 metres deep. The riparian vegetation at the site consisted of dense native bush comprising primarily of *Eucalyptus sp.* and *Gahnia sp.* Instream habitats at KCDS included macrophytes including *Phragmites sp.* and other emergent macrophytes, a small amount of submerged woody habitat and detritus. The substrate consisted of consolidated silt and sand.

SCMid		Site description
		SCMid is located on Stony Creek within the Extension of Mining Area, directly upstream of the Awaba Colliery Surface Site and the Newstan-Eraring Haul Road. The stream width at the site is a maximum of two metres, with a depth of 0.5 metres. The riparian vegetation at the site consisted of mostly native vegetation including *Eucalyptus sp., Gahnia sp., Glochidion ferdinandi,* ferns and grasses. Instream habitats at SCMid included overhanging *Gahnia sp.,* leaf packs, mud banks and submerged woody habitat. The substrate consisted of a mix of gravel, sand and silt.
Facing upstream, 17/10/19	Facing downstream, 17/10/19	

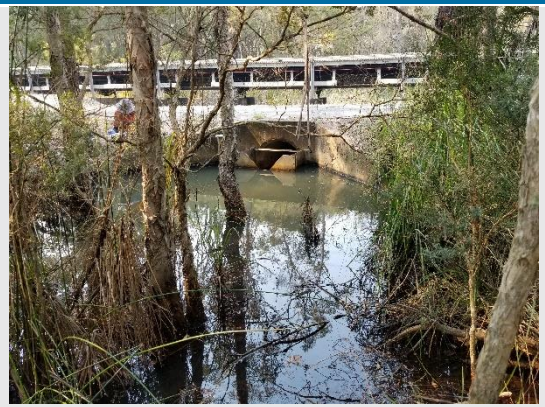
SCDS		Site description
		SCDS is located on Stony Creek downstream of the Extension of Mining Area. The stream consisted of isolated pools up to six metres wide, with deep water sections of at least 1.8 metres. The riparian vegetation at the site consisted of submerged woody habitat and overhanging vegetation. The substrate consisted of loose silt.
Facing upstream, 18/10/19	Facing downstream, 23/05/19	

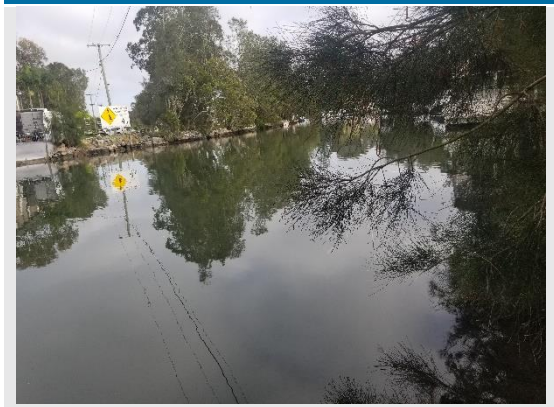
WMP20		Site description
		WMP20 is located on a tributary of Stony Creek outside of the Extension of Mining Areaand upstream of LDP017. This site consists of a shallow isolated pool with a maximum width of three metres. The creek flows through an area of mostly native vegetation, including *Eucalyptus sp., Melaleuca sp.* and *Gahnia sp.,* as well as the introduced shrub *Lantana camara.* Instream habitats at the site included submerged woody habitat, trailing *Gahnia sp.* and detritus. The substrate at the site was most silt with a small amount of sand.
Facing upstream, 14/10/19	Facing downstream, 15/10/19	
WMP38		**Site description**
		WMP38 is located on a tributary of Stony Creek outside of the Extension of Mining Areaand downstream of LDP017. This site consists of an isolated pool with a maximum width of five metres. The creek flows through an area of mostly native vegetation, including *Eucalyptus sp., Melaleuca sp.* and *Gahnia sp.,* as well as the introduced shrub *Lantana camara.* Instream habitats at the site included submerged woody habitat, trailing *Gahnia sp.* and detritus. The substrate at the site was entirely silt.
Facing upstream, 14/10/19	Facing downstream, 14/10/19	

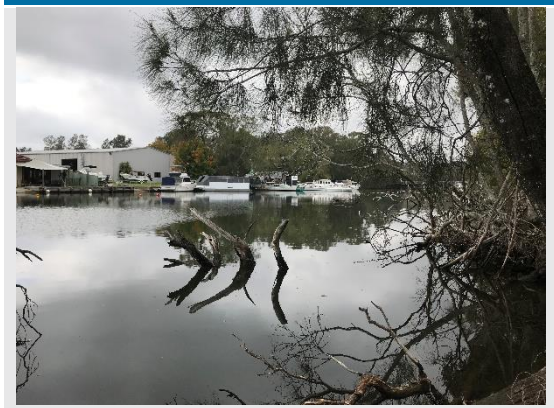
By-Wash		Site description
 Facing upstream, 14/10/19	 Facing downstream, 14/10/19	By-Wash is an impoundment located on LT Creek downstream of Newstan LDP001, with a width of around 50 metres. The right bank of the impoundment is sampled. The riparian vegetation at the site is dense native forest of *Eucalyptus sp.* and *Melaleuca sp.* on the left bank, and a narrow strip of smaller native trees and shrubs on the right bank. Instream habitats at By-Wash include macrophytes *Typha sp.* and *Carex sp.*, submerged woody habitat, detritus and algae. The substrate was entirely soft silt.
WMP03		Site description
 Facing upstream, 14/10/19	 Facing downstream, 14/10/19	WMP03 is located on LT Creek downstream of Newstan LDP001 and By-Wash dam. The Newstan Colliery Surface Site is on the right bank. The riparian vegetation at the site is dominated by native and introduced shrubs, vines and grasses on the right banks, and *Eucalyptus sp., Melaleuca sp., Gahnia sp.* and *Lantana camara* on the left bank. Instream habitats at WMP03 include trailing vegetation, *Carex sp.*, floating and submerged macrophyte and sticks. The substrate is a mix of silt, sand and solidified material, which presumably precipitated from licensed discharges prior to the commissioning of the Clean Water Plant (CWP) at Newstan Colliery Surface Site.

SP004		Site description
		SP004 is located on LT Creek downstream of Newstan LDP001 on Miller Road, in a narrow, deep, fast flowing section of the channel. The riparian vegetation at the site is native forest of *Eucalyptus sp.* and *Melaleuca sp.*, with weeds and introduced plant species including *Lantana camara* closer to the road. Instream habitats at include large amounts of *Typha sp.* and leaf litter. The substrate was mostly silt.
Facing upstream, 14/10/19	Facing downstream, 14/10/19	

SP6		Site description
		SP6 is located on the unnamed tributary of Muddy Lake upstream of the Awaba seepage, outside the Extension of Mining area. The riparian vegetation at the site is dense native forest of *Eucalyptus sp., Melaleuca sp.* and *Gahnia sp.* Instream habitats at SP6 include large amounts of trailing vegetation, *Typha sp., Carex sp.*, submerged woody habitat and leaf litter. The substrate was sand and consolidated silt with a thick coverage of detritus.
Facing upstream, 31/10/19	Facing downstream, 31/10/19	

SP5		Site description
 Facing upstream, 31/10/19	 Facing downstream, 31/10/19	SP5 is located on the unnamed tributary of Muddy Lake outside of the project area. SP5 is downstream of the Awaba seepage area and is located directly upstream of the coal conveyer at the Cooranbong Entry Site. The riparian vegetation at the site is mostly native, consisting of *Melaleuca sp., Gahnia sp.* and native and introduced shrubs and grasses. The substrate was mostly consolidated mud with complete coverage by a thick blanket of detritus. Instream habitats include sedges, trailing *Gahnia sp.*, sticks and detritus.
PCMH		Site description
 Facing upstream, 15/10/19	 Facing downstream, 15/10/19	PCMH is a reference estuarine site located on Pourmalong Creek outside of the Extension of Mining Area. The creek at this point is between 20-30 metres wide. Mangroves line the river on the right bank. Mature *Casuarina sp.* and *Melaleuca sp.* were present in the riparian zone behind the mangroves. Upstream, land use is largely native vegetation and state forest, which includes a recreational walking track. There has been some clearing in the immediate vicinity of the sampling location. Nearby, there is an access road and bridge for the Morisset Hospital. The substrate is mostly soft silt.

IZ		Site description
		IZ is an estuarine site located on LT Creek downstream of site SP004 and the Newstan Colliery Surface Site, outside the Extension of Mining Area. The creek at this site is about 20 metres wide with waterfront residential properties on both banks. Very little riparian vegetation remains. The substrate is mostly soft silt.
Facing upstream, 16/10/19	Facing downstream, 16/10/19	

SCCIZ		Site description
		SCCIZ is an estuarine site located on Stony Creek downstream of the Extension of Mining Area. The creek at this site is about 30 metres wide. The left bank at the site is a residential area, while the right bank contains industrial buildings. Riparian vegetation is minimal, with sparse *Casuarinas* and recently planted grasses along the left bank. The substrate contains soft silt and shell grit.
Facing upstream, 16/10/19	Facing downstream, 16/10/19	

4.5 Water quality

The water quality within each of the catchments potentially impacted by the project was assessed in the SWIA (GHD 2020b). In this section, water quality monitoring results for the autumn and spring 2019 aquatic ecology monitoring events are discussed.

4.5.1 *In situ* water quality

Table 4-7 presents the results of in situ water quality monitoring at freshwater sites in autumn and spring 2019.

Lords Creek

pH at Lords Creek sites is generally circumneutral, and within the DGV range, with the one exception of site LCRef in spring, when a slightly more acidic pH was observed. This was likely associated with the decomposition of organic matter and the formation of humic and fulvic acids.

EC was lowest at the upstream reference site LCRef, and stable at site CCSC1. The highest EC was observed at site LCDS, which was likely indicative of evaporative concentration, noting that the sample was collected from a remnant pool when little water was observed in the creek.

DO was consistently low in the Lords Creek catchment, with the highest saturation recorded being 21.6 percent at site LCDS in spring. The low DO saturations were indicative of DO consumption associated with organic matter decomposition, and the low turbulence of the water bodies, which limits re-aeration.

Kilaben Creek

pH at the Kilaben Creek sites was generally slightly acidic, with an exceedance observed at each site likely associated with organic matter decomposition. EC was lower at upstream site WMP27, with the higher results observed at site KCDS likely indicative of other land uses within the upstream catchment, including Awabawac Park (an off-road motorsports complex) and Wilton Road, which could contribute dissolved solids to Kilaben Creek through runoff. DO was low at both sites, likely as a result of organic matter decomposition and the lack of flow in the watercourse during both sampling events.

Stockyard Creek

Stockyard Creek site SKDS was an isolated pool during both sampling events. More rainfall was received in the month prior to the spring sampling event, the effect of which is indicated by the lower EC observed in spring. Low pH values and low DO saturations were observed at the site, which were likely reflective of organic matter decomposition.

Stony Creek

Slightly acidic conditions were observed at the Stony Creek sites, with some pH values below the DGV range. EC ranged between 144 and 491 µS/cm, with the highest value observed at reference site WMP20, where it was likely reflective of evaporative concentration of salts. Low DO saturations were observed at all Stony Creek sites, with near-anoxia observed at sites SCMid, WMP20 and WMP38.

LT Creek

The elevated bicarbonate alkalinity of the Newstan LDP001 discharge is evidenced by the pH at all LT Creek sites being above 8. Photosynthesis removes carbon dioxide from water column and increases pH, in LT Creek this can result in pH values higher than that of the licensed discharge (which EPL 395 limits to 8.5), as observed at sites By-Wash and WMP03.

Elevated EC was observed at all LT Creek sites, which is also reflective of the salinity of the licensed discharge. DO in LT Creek was generally high, indicating the aeration provided by the consistent flows in the creek, and the effect of submerged photosynthesis.

Unnamed tributary of Muddy Lake

At reference site SP6, pH was neutral to slightly alkaline, and moderate salinity was observed, which reflect the alkalinity of the outcropping Teralba conglomerate in the area. In contrast, higher pH values are observed at site SP5, and EC is much higher, exceeding the DGV. This is attributable to the Awaba seepage, which has alkalinity and salinity reflective of the water in the Awaba underground void.

DO at both sites SP6 and SP5 was low, though it was lower at site SP6, where the effects of organic matter decomposition are exacerbated by the intermittent nature of the creek. In contrast, at site SP5 the Awaba seepage provides consistent flow, and DO is observed to rise in the unnamed tributary of Muddy Lake with increasing distance from the Awaba seepage.

Estuarine sites

Table 4-8 presents the results of in situ water quality monitoring at estuarine sites in autumn and spring 2019. pH at estuarine sites ranged between 7.42 and 8.00, which is within the expected range for carbonate buffered marine waters. EC was high at all sites, exceeding 45,000 µS/cm, which indicates the dominance of marine water at each site. DO was low at all sites, with no temporal or spatial pattern indicated.

Table 4-7 *In situ* water quality results at freshwater sites, autumn and spring 2019

Site code	Site type	Habitat	Date sampled	Time (24hr)	Temp (°C)	pH (pH units)	EC (µS/cm)	DO (% sat)	DO (mg/L)
DGVs for lowland rivers in South-East Australia (ANZECC 2000)					NA	6.5-8.5	2200	85-110	NA
CCSC1	Potential impact	Edge	24/05/19	09:30	12.3	6.97	247	**14.6**	1.57
			16/10/19	12:02	15.0	6.77	249	**1.4**	0.19
LCDS	Potential impact	Edge	17/10/19	09:00	15.6	6.62	282	**21.6**	2.15
LCRef	Reference	Edge	22/05/19	09:50	11.8	7.22	189	**7.1**	0.77
			17/10/19	10:15	15.8	**6.46**	153	**16.2**	1.60
WMP27	Potential impact	Edge	14/05/19	09:50	14.9	**6.42**	148	**13.5**	1.35
			01/11/19	13:45	16.0	6.73	161	**17.4**	1.72
KCDS	Potential impact	Edge	23/05/19	11:00	14.9	6.59	379	**5.3**	0.53
			18/10/19	11:40	14.6	**6.20**	301	**11.3**	1.14
SKDS	Potential impact	Edge	23/05/19	13:10	15.1	**6.44**	504	**5.0**	0.50
			16/10/19	14:35	14.6	**5.92**	280	**9.7**	0.95
SCMid	Potential impact	Edge	22/05/19	12:20	14.5	6.57	204	**0.8**	0.09
			17/10/19	12:37	16.5	**5.65**	144	**5.7**	0.55
SCDS	Potential impact	Edge	23/05/19	08:40	13.5	6.98	219	**11.6**	1.22
			18/10/19	09:00	14.2	6.64	377	**40.0**	4.10
WMP20	Reference	Edge	14/10/19	15:10	15.0	**5.83**	491	**6.4**	0.64
WMP38	Potential impact	Edge	14/10/19	15:35	13.1	**6.40**	180	**5.6**	0.57
By-Wash	Potential impact	Edge	21/05/19	08:00	15.8	**8.71**	**2832**	**73.7**	7.21
			14/10/19	09:00	18.5	8.42	2163	**84.5**	7.85
WMP03	Potential impact	Edge	21/05/19	11:30	16.5	8.40	**2643**	91.4	8.84
			14/10/19	11:05	18.4	**8.52**	**2251**	90.7	8.36
SP004	Potential impact	Edge	21/05/19	10:10	16.4	8.24	**2611**	**79.4**	7.71
			14/10/19	13:35	18.2	8.46	**2260**	85.0	7.94
SP6	Potential impact	Edge	15/05/19	10:30	11.9	7.58	1150	**12.4**	1.31
			31/10/19	14:30	16.1	6.97	1076	**5.4**	0.52
SP5	Potential impact	Edge	13/05/19	12:30	12.5	7.95	**3833**	**54.8**	5.69
			31/10/19	09:05	16.2	7.58	**3746**	**48.6**	4.69

Notes:

Results in orange bold are outside the relevant DGV.

NA – No GV applies

Table 4-8 *In situ* water quality results at estuarine sites, autumn and spring 2019

Site code	Site type	Habitat	Date sampled	Time (24hr)	Stage of tide	Temp (°C)	pH (pH units)	EC (µS/cm)	DO (% sat)	DO (mg/L)
ANZECC (2000) GVs for estuaries in South-East Australia.						NA	7.0-8.5	NA	80-110	NA
PCMH	Estuarine reference	Estuarine	20/05/19	11:20	Incoming	17.2	7.85	54,693	**48.1**	3.72
			15/10/19	14:27	High	23.9	7.92	49,379	**71.8**	5.03
IZ	Estuarine potential impact	Estuarine	24/05/19	12:00	Incoming	18.8	7.42	50,491	**48.1**	3.67
			16/10/19	08:15	Low	22.5	7.86	47,989	**43.8**	3.17
SCCIZ	Estuarine potential impact	Estuarine	20/05/19	09:30	Incoming	17.5	8.00	52,263	**70.3**	5.45
			16/10/19	09:27	Incoming	21.0	7.61	45,292	**42.4**	3.18

Notes:

Results in **orange bold** are outside the relevant DGV.

NA – No GV applies.

4.5.2 Laboratory water quality

The results of laboratory water quality analyses in autumn and spring 2019 are presented in Table 4-9, Table 4-10, Table 4-11, Table 4-12, Table 4-13, and Table 4-14 below. For sites that have been monitored prior to 2019, long term summary statistics are provided in Appendix I.

Lords Creek

Table 4-9 presents the results of laboratory water quality analyses for sites in the Lords Creek catchment.

Results for TSS and turbidity differed, with the highest turbidity observed at site LCDS, when the TSS concentration was below the LOR. This was likely due to the colour of the water influencing the turbidity (as it is an optical measurement), as it was noted that the pool at site LCDS had the colour of dissolved organics, as evidenced by the high DOC concentration.

Sodium was the dominant cation at all of the Lords Creek sites, and chloride and bicarbonate were the dominant anions at all sites except site LCDS, where sulfate was the dominant anion.

Elevated aluminium concentrations were observed at all sites. All of these observations exceeded the DGV except for site LCRef in spring, when the observed pH was below 6.5, making the available DGV for aluminium inapplicable. These aluminium concentrations are most likely reflective of the influence of local lithology. Elevated dissolved iron concentrations were observed at all sites, which also reflects the influence of local lithology.

Elevated concentrations of chromium, copper and zinc, which exceeded the relevant DGVs, were observed at site LCDS. These concentrations were not indicative of any form of contamination, but rather of evapoconcentration of these metals in the remnant pool that was sampled. An elevated copper concentration was also observed at site LCRef in spring. Land uses within the Lords Creek catchment, such as agriculture and the Pacific Motorway, may have influenced this result.

Elevated TN and TP concentrations, which exceeded the relevant DGVs, were observed at each of the Lords Creek sites, indicating that nutrient enrichment is an existing condition within the catchment.

DOC concentrations ranged from 24 to 57 mg/L, which is indicative of dry conditions and the decomposition of organic matter.

Kilaben Creek and Stockyard Creek

Results of laboratory analysis for the Kilaben Creek and Stockyard Creek sites are presented in Table 4-10.

Moderate turbidity was observed at each site, though no exceedances of the DGV were observed. The highest turbidity and TSS results were observed at site WMP27. TSS concentrations were below the LOR at site KCDS, though similar turbidity values to those observed at site WMP27 indicated that water colour was influencing the turbidity.

Sodium was the dominant cation in Kilaben Creek and Stockyard Creek, and chloride was the dominant anion at sites WMP27 and SKDS. In contrast, mixed anionic dominance was observed at site KCDS, indicating either a change in the outcropping geology or impacts from surrounding landuses between sites WMP27 and KCDS.

Elevated aluminium concentrations were observed at sites WMP27 and SKDS, though only the concentration observed at site WMP27 in spring 2019 exceeded the DGV due to the other observations being associated with pH values below 6.5. The dissolved copper concentration at site WMP27 in autumn 2019 may have been influenced by the local lithology, noting the lack of landuses apart from native vegetation within the catchment at this site. The elevated cadmium and zinc concentrations observed at site KCDS in autumn and at site SKDS in spring may have been influenced by land uses upstream of these sites, such as Awabawac Park (an off-road motorsports complex), and the Clay Target Club (a shooting range), respectively. The locations of Awabawac Park and the Clay Target Club are shown in Figure 3-1.

Nutrient enrichment was observed at sites WMP27 and SKDS, with elevated TN concentrations at both sites and elevated TP concentrations at site SKDS. At site KCDS the only exceedance of the nutrient DGVs was for TP in spring.

Stony Creek

Results of laboratory analysis for Stony Creek freshwater sites are presented in Table 4-11. Elevated turbidity values, which exceeded the DGV, were observed at site SCMid in autumn, and at sites WMP20 and WMP38 in spring. Each of these exceedances was associated with a TSS concentration of between 24 and 25 mg/L.

Sodium was the dominant cation at each of the Stony Creek catchment sites. At sites SCMid and SCDS there was mixed anion dominance, whereas at site WMP20 the dominant anion was sulfate and at WMP38 the dominant anion was bicarbonate.

Elevated aluminium concentrations were observed at all sites, with exceedances of the DGV observed at sites SCMid and SCDS. The aluminium concentrations observed at sites WMP20 and WMP38 did not exceed the DGV due to the pH being below 6.5 at these sites.

Elevated copper concentrations, which exceeded the DGV, were observed at sites SCDS, WMP20 and WMP38 in spring. These concentrations may have reflected the influence of local lithology on runoff, noting that about 20 mm of rain was received in the area during the week prior to the sampling event. This may also explain the elevated zinc concentrations observed at all of the Stony Creek sites, and the elevated nickel concentration observed at site WMP20 in spring 2019.

Nutrient enrichment was observed at all sites, with all TN observations exceeding the DGV. The DGV for TP was exceeded at site SCMid in autumn, site WMP38 in spring, and at site SCDS in autumn and spring 2019.

LT Creek

Table 4-12 presents the results of laboratory analysis for the LT Creek freshwater sites. These results show that the discharges from the CWP at Newstan Colliery Surface Site result in relatively consistent water quality in LT Creek. The licensed discharge is of low turbidity, and in terms of major ions, is dominated by sodium and bicarbonate. Dissolved metal concentrations are low, with no exceedances of the DGVs observed, with the exception of the nickel concentration at the By-Wash site in autumn. It is noted that this concentration did not exceed the EPL limit for LDP001, which is based on the ameliorative effect on nickel toxicity that the hardness of the discharge provides.

NOx concentrations exceeded the DGV at sites By-Wash and SP004 in autumn, and at site WMP03 in spring. The TN concentration at site By-Wash in autumn exceeded the DGV. Ammonia, TP, RP and DOC concentrations in LT Creek have remained low.

Unnamed tributary of Muddy Lake

Results of laboratory analysis for the unnamed tributary of Muddy Lake sites are presented in Table 4-13. Sites SP6 and SP5 showed similarly low results for TSS and turbidity. Site SP5 was substantially more saline due to the Awaba seepage, which is of mixed cation dominance and dominated by the sulfate anion. In contrast, site SP6 is ionically dominated by sodium and chloride.

The only exceedances of the DGVs for metals were for aluminium at site SP6 in autumn and spring, which were likely indicative of the local lithology. Higher concentrations of the metals boron, lithium, manganese and nickel were observed at site SP5.

Elevated concentrations of TN, which exceeded the DGV, were observed at site SP6 in autumn and spring. The TP concentration at site SP5 in spring exceeded the DGV. Concentrations of DOC were substantially higher at site SP6 in both autumn and spring, which was likely due to decomposition of organic matter in the isolated pool at the site.

Estuarine sites

Table 4-14 presents the results of laboratory analysis for the estuarine monitoring sites. TSS concentrations and turbidity values were low at all sites. LT Creek site IZ had the lowest TDS concentrations during both autumn and spring, which likely reflected the diluting effect of Newstan LDP001 in the creek. The influence of LDP001 was also evident in the major ion chemistry, as site IZ had higher total alkalinity results than the other estuarine monitoring sites. The dominant major ions at all estuarine sites were sodium and chloride.

Cadmium concentrations at site PCMH in autumn and spring, at site IZ in spring, and at site SCCIZ in autumn exceeded the DGV. Copper concentrations at site IZ in autumn and spring and at site SCCIZ in autumn exceeded the DGV. As no elevated concentrations of these metals were observed at the LT Creek freshwater sites, the concentrations of these metals at site IZ are not attributable to Newstan LDP001. The observation of similarly elevated concentrations of cadmium and copper at the other estuarine monitoring sites suggests that these metal concentrations may be an impact of residential and other surrounding land uses.

Elevated TN concentrations were observed at site IZ in autumn, and at site SCCIZ in spring, though the observed concentrations were within the same order of magnitude as those observed at reference site PCMH and were not indicative of nutrient enrichment which is likely to result in nuisance algal blooms.

Table 4-9 Results of laboratory water quality analysis at Lords Creek sites

Analyte	Unit	LOR	CCSC1		LCDS	LCRef		DGV
			23/05/19	16/10/2019	16/10/2019	22/05/19	16/10/2019	
Physicochemical parameters								
TDS	mg/L	1	188	200	316	168	137	NA
TSS	mg/L	5	13	12	<5	15	<5	NA
Turbidity	NTU	0.1	20.5	8.6	23.2	17.8	14.8	50
Major ions								
Total alkalinity as CaCO3	mg/L	1	34	33	47	24	16	NA
Sulfate as SO4	mg/L	1	<5	12	61	<10	2	NA
Chloride	mg/L	1	42	57	23	31	30	NA
Calcium	mg/L	1	5	4	13	4	2	NA
Magnesium	mg/L	1	6	6	14	4	3	NA
Potassium	mg/L	1	4	5	3	5	5	NA
Sodium	mg/L	1	31	32	23	24	20	NA
Dissolved metals								
Aluminium	mg/L	0.01	**0.11**	**0.23**	**0.37**	**0.20**	0.85^	0.055 (pH>6.5)
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
Arsenic	mg/L	0.001	0.001	0.001	0.003	0.001	<0.001	0.013
Barium	mg/L	0.001	0.018	0.027	0.018	0.017	0.022	NA
Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Boron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.370
Cadmium	mg/L	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	<0.001	**0.002**	<0.001	<0.001	0.001
Cobalt	mg/L	0.001	<0.001	0.001	0.004	0.001	<0.001	NA
Copper	mg/L	0.001	<0.001	<0.001	**0.003**	<0.001	**0.002**	0.0014
Iron	mg/L	0.05	1.10	1.44	6.98	2.59	1.01	NA
Lead	mg/L	0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.0034
Lithium	mg/L	0.001	0.001	<0.001	0.003	0.001	<0.001	NA
Manganese	mg/L	0.001	0.176	0.224	0.278	0.121	0.059	1.900

Analyte	Unit	LOR	CCSC1		LCDS	LCRef		DGV
			23/05/19	16/10/2019	16/10/2019	22/05/19	16/10/2019	
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00006
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034
Nickel	mg/L	0.001	0.001	0.002	0.008	0.001	0.002	0.011
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.005
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00005
Tin	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Titanium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.03	NA
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.006
Zinc	mg/L	0.005	<0.005	0.005	**0.010**	<0.005	0.006	0.008
Nutrients								
Ammonia as N	mg/L	0.01	0.05	0.13	0.27	0.03	0.05	0.90
NOx as N	mg/L	0.01	<0.01	0.02	<0.05	<0.01	0.02	0.04
TKN as N	mg/L	0.1	1.6	1.2	2.1	1.4	1.2	NA
TN as N	mg/L	0.1	**1.6**	**1.2**	**2.1**	**1.4**	**1.2**	0.35
TP as P	mg/L	0.01	**0.14**	**0.27**	**0.16**	**0.04**	**0.06**	0.025
RP as P	mg/L	0.01	0.01	0.02	<0.02	<0.01	<0.01	0.02
Other parameters								
DOC	mg/L	1	25	24	57	31	27	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

^ DGV for aluminium applies for water with pH >6.5. No DGV exists for pH <6.5.

NA = No guideline value is available.

Table 4-10 Results of laboratory water quality analysis at Kilaben Creek and Stockyard Creek sites

Analyte	Unit	LOR	WMP27		KCDS		SKDS		DGV
			14/05/19	01/11/19	23/05/19	18/10/19	23/05/19	11/10/19	
Physicochemical parameters									
TDS	mg/L	1	159	136	204	244	295	203	NA
TSS	mg/L	5	21	12	<5	<5	21	9	NA
Turbidity	NTU	0.1	40.9	32.8	26.8	30.6	28.0	15.1	50
Major ions									
Total alkalinity as CaCO3	mg/L	1	5	12	57	55	25	16	NA
Sulfate as SO4	mg/L	1	<1	<1	18	17	6	6	NA
Chloride	mg/L	1	35	33	59	55	124	61	NA
Calcium	mg/L	1	<1	<1	11	11	3	2	NA
Magnesium	mg/L	1	2	2	10	9	9	4	NA
Potassium	mg/L	1	2	2	2	2	2	2	NA
Sodium	mg/L	1	20	21	44	40	74	38	NA
Dissolved metals									
Aluminium	mg/L	0.01	0.35^	**0.88**	0.01	0.04	0.08^	0.31^	0.055 (pH>6.5)
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
Arsenic	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.013
Barium	mg/L	0.001	0.022	0.019	0.032	0.033	0.025	0.018	NA
Beryllium	mg/L	0.001	-	-	<0.001	<0.001	<0.001	<0.001	NA
Boron	mg/L	0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	0.370
Cadmium	mg/L	0.0001	<0.0001	<0.0001	**0.0003**	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Copper	mg/L	0.001	**0.003**	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014
Iron	mg/L	0.05	0.51	0.58	0.09	0.44	0.55	1.01	NA
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0034
Lithium	mg/L	0.001	0.002	<0.001	<0.001	<0.001	0.004	0.002	NA
Manganese	mg/L	0.001	0.019	0.017	0.168	0.148	0.110	0.027	1.900
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00006

Analyte	Unit	LOR	WMP27		KCDS		SKDS		DGV
			14/05/19	01/11/19	23/05/19	18/10/19	23/05/19	11/10/19	
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034
Nickel	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.011
Selenium	mg/L	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.005
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00005
Tin	mg/L	0.001	-	-	<0.001	<0.001	<0.001	<0.001	NA
Titanium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA
Vanadium	mg/L	0.01	0.061	<0.01	<0.01	<0.01	<0.005	<0.01	0.006
Zinc	mg/L	0.005	<0.001	0.006	<0.005	<0.005	<0.005	**0.010**	0.008
Nutrients									
Ammonia as N	mg/L	0.01	<0.01	0.02	0.02	0.05	0.02	0.04	0.90
NOx as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.04
TKN as N	mg/L	0.1	0.4	0.6	0.1	0.2	1.0	0.6	NA
TN as N	mg/L	0.1	**0.4**	**0.6**	0.1	0.2	**1.0**	**0.6**	0.35
TP as P	mg/L	0.01	0.01	0.02	0.02	**0.04**	**0.08**	**0.03**	0.025
RP as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.020
Other parameters									
DOC	%	0.02	11	11	7	10	13	22	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

^ DGV for aluminium applies for water with pH >6.5. No DGV exists for pH <6.5.

NA = No guideline value is available.

Table 4-11 Results of laboratory water quality analysis at Stony Creek sites

Analyte	Unit	LOR	SCMid		SCDS		WMP20	WMP38	DGV
			22/05/19	17/10/19	23/05/19	18/10/19	14/10/19	14/10/19	
Physicochemical parameters									
TDS	mg/L	1	157	121	168	208	366	204	NA
TSS	mg/L	5	29	<5	<5	<5	26	24	NA
Turbidity	NTU	0.1	**65.4**	43.6	26.8	43.0	**79.7**	**75.9**	50
Major ions									
Total alkalinity as CaCO3	mg/L	1	32	9	57	22	12	40	NA
Sulfate as SO4	mg/L	1	24	22	18	46	102	<5	NA
Chloride	mg/L	1	20	18	59	38	34	25	NA
Calcium	mg/L	1	8	4	11	10	18	7	NA
Magnesium	mg/L	1	7	3	10	8	9	4	NA
Potassium	mg/L	1	2	2	2	3	3	3	NA
Sodium	mg/L	1	19	14	44	30	34	20	NA
Dissolved metals									
Aluminium	mg/L	0.01	**0.12**	**0.58**	**0.07**	**0.07**	0.68*	0.74*	0.055 (pH>6.5)
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
Arsenic	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.002	0.013
Barium	mg/L	0.001	0.022	0.018	0.024	0.043	0.056	0.024	NA
Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Boron	mg/L	0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	0.370
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.007	0.003	NA
Copper	mg/L	0.001	<0.001	0.001	<0.001	**0.008**	**0.004**	**0.003**	0.0014
Iron	mg/L	0.05	2.59	1.30	0.58	0.42	0.47	1.23	NA
Lead	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.002	0.002	0.0034
Lithium	mg/L	0.001	0.007	0.004	0.003	0.005	0.019	0.009	NA
Manganese	mg/L	0.001	0.111	0.059	0.046	0.066	0.450	0.921	1.900

Analyte	Unit	LOR	SCMid		SCDS		WMP20	WMP38	DGV
			22/05/19	17/10/19	23/05/19	18/10/19	14/10/19	14/10/19	
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00006
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.034
Nickel	mg/L	0.001	<0.001	0.002	0.001	0.003	**0.015**	0.010	0.011
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.005
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00005
Tin	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Titanium	mg/L	0.01	<0.01	0.01	<0.01	<0.01	0.02	0.01	NA
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.006
Zinc	mg/L	0.005	<0.005	**0.034**	<0.005	**0.07**	**0.476**	**0.012**	0.008
Nutrients									
Ammonia as N	mg/L	0.01	0.17	0.04	0.03	0.05	0.04	0.02	0.90
NOx as N	mg/L	0.01	<0.01	<0.01	<0.01	0.04	0.09	0.01	0.04
TKN as N	mg/L	0.1	0.9	0.4	0.7	0.4	0.5	1.2	NA
TN as N	mg/L	0.1	**0.9**	**0.4**	**0.7**	**0.4**	**0.6**	**1.2**	0.35
TP as P	mg/L	0.01	**0.05**	0.02	**0.10**	**0.21**	0.02	**0.06**	0.025
RP as P	mg/L	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.05	0.02
Other parameters									
DOC	mg/L	1	12	16	17	11	<5	<5	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

^ DGV for aluminium applies for water with pH >6.5. No DGV exists for pH <6.5.

NA = No guideline value is available.

Table 4-12 Results of laboratory water quality analysis at LT Creek sites

Analyte	Unit	LOR	By-Wash		WMP03		SP004		DGV
			21/05/19	14/10/19	21/05/19	14/10/19	21/05/19	14/10/19	
Physicochemical parameters									
TDS	mg/L	1	1670	1140	1780	1230	1750	1190	NA
TSS	mg/L	5	13	8	<5	<5	5	<5	NA
Turbidity	NTU	0.1	0.9	0.4	0.3	0.6	0.3	1.2	50
Major ions									
Total alkalinity as CaCO3	mg/L	1	888	434	547	477	571	490	NA
Sulfate as SO4	mg/L	1	90	74	75	74	73	70	NA
Chloride	mg/L	1	217	399	478	428	472	435	NA
Calcium	mg/L	1	29	22	26	20	27	20	NA
Magnesium	mg/L	1	13	11	12	11	13	11	NA
Potassium	mg/L	1	7	4	4	4	4	4	NA
Sodium	mg/L	1	570	450	555	463	542	470	NA
Dissolved metals									
Aluminium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.055 (pH>6.5)
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013
Barium	mg/L	0.001	0.164	0.100	0.104	0.103	0.104	0.100	NA
Beryllium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Boron	mg/L	0.05	0.18	0.17	0.22	0.18	0.21	0.17	0.370
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014
Iron	mg/L	0.05	0.09	<0.05	<0.05	<0.05	<0.05	0.06	NA
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0034
Lithium	mg/L	0.001	0.101	0.105	0.136	0.124	0.142	0.123	NA
Manganese	mg/L	0.001	0.297	0.002	0.005	0.023	0.011	0.01	1.900
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00006

Analyte	Unit	LOR	By-Wash		WMP03		SP004		DGV
			21/05/19	14/10/19	21/05/19	14/10/19	21/05/19	14/10/19	
Molybdenum	mg/L	0.001	0.009	0.021	0.030	0.020	0.028	0.020	0.034
Nickel	mg/L	0.001	**0.020**	0.006	0.009	0.007	0.009	0.008	0.011
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.005
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00005
Tin	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	NA
Titanium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	NA
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.006
Zinc	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008
Nutrients									
Ammonia as N	mg/L	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.90
NOx as N	mg/L	0.01	**0.44**	0.01	0.03	**0.08**	**0.05**	<0.01	0.04
TKN as N	mg/L	0.1	0.2	0.1	<0.1	0.1	<0.1	0.1	NA
TN as N	mg/L	0.1	**0.6**	0.1	<0.1	0.2	<0.1	0.1	0.35
TP as P	mg/L	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.025
RP as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.020
Other parameters									
DOC	%	0.02	1	4	<1	4	2	6	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

^ DGV for aluminium applies for water with pH >6.5. No DGV exists for pH <6.5.

NA = No guideline value is available.

Table 4-13 Results of laboratory water quality analysis at sites on the unnamed tributary of Muddy Lake

Analyte	Unit	LOR	SP6		SP5		DGV
			15/05/19	31/10/19	13/05/19	31/10/19	
Physicochemical parameters							
TDS	mg/L	1	748	622	2800	2790	NA
TSS	mg/L	5	<1	8	3	<5	NA
Turbidity	NTU	0.1	6.7	5.6	5.1	6.5	50
Major ions							
Total alkalinity as CaCO3	mg/L	1	73	156	414	1200	NA
Sulfate as SO4	mg/L	1	102	84	1090	793	NA
Chloride	mg/L	1	261	218	512	510	NA
Calcium	mg/L	1	19	18	128	138	NA
Magnesium	mg/L	1	27	27	189	207	NA
Potassium	mg/L	1	4	5	14	14	NA
Sodium	mg/L	1	160	142	453	482	NA
Dissolved metals							
Aluminium	mg/L	0.01	**0.08**	**0.13**	<0.01	<0.01	0.055 (pH>6.5)
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.009
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.013
Barium	mg/L	0.001	0.025	0.027	0.015	0.022	NA
Boron	mg/L	0.05	0.07	<0.05	0.14	0.19	0.370
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	NA
Copper	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.0014
Iron	mg/L	0.05	0.70	1.11	<0.05	0.83	NA
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.0034
Lithium	mg/L	0.001	0.007	0.003	0.059	0.064	NA
Manganese	mg/L	0.001	0.041	0.035	0.175	0.252	1.900
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00006

Analyte	Unit	LOR	SP6		SP5		DGV
			15/05/19	31/10/19	13/05/19	31/10/19	
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	0.005	0.034
Nickel	mg/L	0.001	0.001	<0.001	0.004	0.007	0.011
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.005
Silver	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.00005
Titanium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	NA
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.006
Zinc	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	0.008
Nutrients							
Ammonia as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.90
NOx as N	mg/L	0.01	<0.01	<0.01	0.02	0.01	0.04
TKN as N	mg/L	0.1	0.6	0.5	0.1	<0.1	NA
TN as N	mg/L	0.1	**0.6**	**0.5**	0.1	<0.1	0.35
TP as P	mg/L	0.01	0.01	0.02	<0.01	**0.04**	0.025
RP as P	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.02
Other parameters							
DOC	mg/L	1	22	33	8	8	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

^ DGV for aluminium applies for water with pH >6.5. No DGV exists for pH <6.5.

NA = No guideline value is available.

Table 4-14 Results of laboratory water quality analysis at estuarine sites

Analyte	Unit	LOR	Reference estuary		LT Creek estuary		Stony Creek estuary		DGVs for marine / estuarine waters
			PCMH		IZ		SCCIZ		
			20/05/2019	15/10/2019	23/05/2019	16/10/2019	20/05/2019	16/10/2019	
Physicochemical parameters									
TDS	mg/L	1	41100	29200	27300	23600	39000	32700	NA
TSS	mg/L	5	10	<5	<5	<5	<5	<5	NA
Turbidity	NTU	0.1	1.5	1.8	2.4	2.6	0.8	1.2	10
Major ions									
Total alkalinity	mg/L	1	108	99	236	222	116	222	NA
Sulfate as SO4	mg/L	1	2870	2800	2040	1930	2860	1930	NA
Chloride	mg/L	1	16800	16300	12800	12400	16000	12400	NA
Calcium	mg/L	1	411	364	285	310	378	310	NA
Magnesium	mg/L	1	1220	1120	822	938	1150	938	NA
Potassium	mg/L	1	368	345	245	268	344	268	NA
Sodium	mg/L	1	10700	9580	6930	7900	10200	7900	NA
Dissolved metals									
Aluminium	mg/L	0.005	0.008	0.016	<0.005	0.010	0.006	0.011	NA
Antimony	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NA
Arsenic	mg/L	0.0005	0.0013	0.0013	0.0011	0.0015	0.0014	0.0020	NA
Barium	mg/L	0.001	0.015	0.010	0.048	0.033	0.011	0.014	NA
Beryllium	mg/L	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	NA
Boron	mg/L	0.1	4.65	4.35	3.54	3.37	4.84	3.91	NA
Cadmium	mg/L	0.0001	**0.0002**	**0.0002**	<0.0001	**0.0002**	**0.0002**	<0.0001	0.00007
Chromium	mg/L	0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0044
Cobalt	mg/L	0.0002	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	0.001
Copper	mg/L	0.001	<0.001	<0.001	**0.002**	**0.002**	**0.002**	<0.001	0.0013
Iron	mg/L	0.005	0.010	0.005	0.015	0.015	0.009	0.013	NA
Lead	mg/L	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0044
Lithium	mg/L	0.001	0.168	0.172	0.227	0.172	0.149	0.160	NA

Analyte	Unit	LOR	Reference estuary		LT Creek estuary		Stony Creek estuary		DGVs for marine / estuarine waters
			PCMH		IZ		SCCIZ		
			20/05/2019	15/10/2019	23/05/2019	16/10/2019	20/05/2019	16/10/2019	
Manganese	mg/L	0.0005	0.0050	0.0079	0.0608	0.0453	0.0039	0.0182	0.080
Mercury	mg/L	0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	<0.000005	0.0001
Molybdenum	mg/L	0.0001	0.0136	0.0117	0.0178	0.0145	0.0112	0.0107	NA
Nickel	mg/L	0.0005	<0.0005	<0.0005	0.0036	0.0023	<0.0005	<0.0005	0.007
Selenium	mg/L	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	NA
Silver	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0014
Tin	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA
Titanium	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	NA
Vanadium	mg/L	0.0005	0.0019	0.0015	0.0026	0.0009	<0.0005	0.0007	0.100
Zinc	mg/L	0.005	<0.005	<0.005	<0.005	0.011	<0.005	0.009	0.015
Nutrients									
Ammonia as N	mg/L	0.01	<0.10	<0.05	0.09	0.04	<0.10	0.09	0.910
NOx as N	mg/L	0.01	-	0.003	-	0.022	-	0.008	0.015
TKN as N	mg/L	0.1	-	0.284	-	0.266	-	0.348	NA
TN as N	mg/L	0.1	0.300	0.287	**0.358**	0.288	0.300	**0.356**	0.300
TP as P	mg/L	0.01	<0.020	<0.005	0.008	0.01	<0.02	0.011	0.030
Other parameters									
DOC	mg/L	1	4	6	2	6	3	6	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

^ DGV for aluminium applies for water with pH >6.5. No DGV exists for pH <6.5.

NA = No guideline value is available.

4.6 Sediment quality

4.6.1 Lords Creek

Table 4-15 presents the sediment quality results for Lords Creek catchment sites CCSC1, LCDS and LCRef. Site LCDS was dry in autumn 2019 and was not sampled. These results indicate that metal concentrations in Lords Creek sediments are not likely to have any adverse effects on aquatic life, as no exceedances of the sediment DGVs were observed. Site LCDS had the highest concentrations of arsenic, cadmium, copper, lead nickel and zinc. Low concentrations of lead and zinc were observed at all sites, whereas the majority of other metals were present at concentrations above the respective LORs.

TN and TP concentrations were highest at site LCDS in spring, where the majority of nitrogen was organic nitrogen, as indicated by the TKN concentration that was equal to the TN concentration. The highest proportion of organic matter was also observed at site LCDS.

4.6.2 Kilaben Creek and Stockyard Creek

Sediment quality results for Kilaben Creek and Stockyard Creek sites are presented in Table 4-16. The metal concentrations in the sediments at these sites were not likely to have any adverse effects on aquatic life, as no exceedances of the sediment DGVs were observed. Low, though above LOR, concentrations of lead and zinc were observed at each site during both sampling events.

Variability was observed in the nutrient results, with site WMP27 having the highest TN and TP concentrations in autumn and site SKDS the highest in spring.

4.6.3 Stony Creek

Table 4-17 presents the sediment quality monitoring results for Stony Creek sites. Sites WMP20 and WMP38 were dry in autumn 2019 and were not sampled.

Metal concentrations in Stony Creek sediments are unlikely to have any adverse effect on aquatic life, as no exceedances of the DGVs were observed. Low, though above LOR concentrations of copper, lead and zinc were observed at each site, suggesting that the local lithology contains low concentrations of these metals. Zinc concentrations were highest at site WMP20 and WMP38.

The highest TN concentrations were observed at site SCDS, whereas the highest TP concentration was observed at site WMP20 in spring. Sediment collected from site SCDS also had the highest percentage of organic carbon.

4.6.4 LT Creek

Sediment quality results for the freshwater LT Creek monitoring sites are presented in Table 4-18. Some residual impacts of Newstan LDP001 discharges prior to the commissioning of the CWP have been observed in LT Creek sediments. The lead concentration observed at site WMP03 in spring exceeded the DGV, and was attributable to the historical discharges. Prior monitoring has observed similar lead concentrations at site WMP03 (GHD 2019a), and the heterogeneity of the sediments in LT Creek is evident based on the difference between the results for the autumn and spring monitoring events in Table 4-18. Based on the persistence of the lead observed in sediments at site WMP03 it is considered unlikely that the lead is bioavailable, and therefore unlikely that there have been adverse effects on aquatic biota as a result of metal concentrations in LT Creek, as no other concentrations exceeded the DGVs in 2019.

Nutrient concentrations were consistently higher in autumn, with site By-Wash having the highest TN concentrations and the highest TP concentration being observed at site WMP03 in autumn.

4.6.5 Unnamed tributary of Muddy Lake

Table 4-19 presents the sediment quality results for monitoring sites SP6 and SP5 on the unnamed tributary of Muddy Lake. No adverse effects on aquatic biota are expected as a result of metal concentrations in sediments at SP6, as no exceedances of the DGVs were observed. In contrast, exceedances of the DGVs for nickel and zinc were observed at site SP5 in autumn and spring. The zinc concentrations exceeded the DGV, which indicates the potential for biological effects, and the nickel concentrations exceeded the GV-high, which represents the median value of the effects ranking, meaning that the exceedances are more likely to be associated with biological effects. These nickel and zinc concentrations are associated with the Awaba seepage, and are unlikely to increase as a result of the seepage under the current conditions (GHD 2018).

TN and TP concentrations were higher in sediments at site SP5, as were the percentages of TOC. At both sites SP6 and SP5, nutrient concentrations and organic matter levels were higher in autumn than in spring 2019.

4.6.6 Estuarine

Sediment quality results for estuarine monitoring sites are presented in Table 4-20. At reference site PCMH, no exceedances of the DGVs were observed, so no adverse effects to aquatic biota are expected as a result of metal concentrations in sediments at the site. At site IZ, cadmium concentrations exceeded the DGV in autumn and spring, as did the concentration observed at site SCCIZ in spring. These concentrations are associated with potential biological effects, though are not attributable to discharges from either LDP001 or LDP017, as sediment monitoring data for freshwater sites has indicated that cadmium concentrations in sediments closer to the discharges are not elevated (refer Table 4-17 and Table 4-18).

Table 4-15 Results of laboratory sediment analysis at Lords Creek sites

Analyte	Unit	LOR	CCSC1		LCDS	LCRef		ANZG (2018)	
			23/05/19	16/10/2019	17/10/19	22/05/19	17/10/19	DGV	GV-high
1M HCl-extractable metals									
Antimony	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	25
Arsenic	mg/kg	1.0	<1.0	<1.0	3.0	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	0.1	<0.1	<0.1	1.5	10
Chromium	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	80	370
Copper	mg/kg	1.0	<1.0	<1.0	9.8	1.7	<1.0	65	270
Lead	mg/kg	1.0	2.9	1.0	18.9	3.3	1.8	50	220
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	1.0
Nickel	mg/kg	1.0	<1.0	<1.0	6.9	<1.0	<1.0	21	52
Silver	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	4.0
Zinc	mg/kg	1.0	12.9	8.0	28.5	7.2	6.1	200	410
Nutrients									
Nitrate	mg/kg	0.1	0.2	0.2	1.4	0.3	0.4	NA	NA
NO_x	mg/kg	0.1	0.2	0.2	1.4	0.3	0.4	NA	NA
TKN	mg/kg	20	760	280	5050	790	690	NA	NA
TN	mg/kg	20	760	280	5050	790	690	NA	NA
TP	mg/kg	2	84	51	493	89	95	NA	NA
Other parameters									
TOC	%	0.02	5.29	0.46	6.51	1.83	2.20	NA	NA
Moisture Content	%	1.0	42.7	19.2	69.7	34.1	30.2	NA	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

NA = No guideline value is available.

Table 4-16 Results of laboratory sediment analysis at Kilaben Creek and Stockyard Creek sites

Analyte	Unit	LOR	WMP27		KCDS		SKDS		ANZG (2018)	
			14/05/19	01/11/19	23/05/19	18/10/19	23/05/19	16/10/19	DGV	GV-high
1M HCl-extractable metals										
Antimony	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	25
Arsenic	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	10
Chromium	mg/kg	1.0	<1.0	<1.0	<1.0	1.6	<1.0	<1.0	80	370
Copper	mg/kg	1.0	<1.0	<1.0	<1.0	2.1	1.1	<1.0	65	270
Lead	mg/kg	1.0	5.3	2.7	8.3	3.2	6.1	4.4	50	220
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<1.0	<0.1	0.15	1.0
Nickel	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	21	52
Silver	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	4.0
Zinc	mg/kg	1.0	3.6	8.9	8.2	4.4	8.7	6.1	200	410
Nutrients										
Nitrate	mg/kg	0.1	0.4	0.3	<0.1	0.2	0.7	0.1	NA	NA
NO_x	mg/kg	0.1	0.5	0.3	<0.1	0.2	1.1	0.1	NA	NA
TKN	mg/kg	20	1010	370	700	210	380	870	NA	NA
TN	mg/kg	20	1010	370	700	210	380	870	NA	NA
TP	mg/kg	2	94	45	54	52	40	69	NA	NA
Other parameters										
TOC	%	0.02	4.16	2.37	11.1	1.01	6.52	2.52	NA	NA
Moisture Content	%	1.0	49.1	-	29.1	24	32.4	47.8	NA	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

NA = No guideline value is available.

Table 4-17 Results of laboratory sediment analysis at Stony Creek sites

Analyte	Unit	LOR	SCMid		SCDS		WMP20	WMP38	ANZG (2018)	
			22/05/19	17/10/19	23/05/19	18/10/19	14/10/19	14/10/19	DGV	GV-high
1M HCl-extractable metals										
Antimony	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	25
Arsenic	mg/kg	1.0	<1.0	<1.0	1.7	2.6	<1.0	2.3	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	<0.1	0.1	0.2	0.2	1.5	10
Chromium	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	80	370
Copper	mg/kg	1.0	1.6	<1.0	3.0	6.3	6.3	9.4	65	270
Lead	mg/kg	1.0	5.8	1.8	9.0	13.2	12.8	25.0	50	220
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	1.0
Nickel	mg/kg	1.0	<1.0	<1.0	<1.0	1.1	4.8	14.7	21	52
Silver	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<0.1	<1.0	1.0	4.0
Zinc	mg/kg	1.0	58.1	8.3	20.7	28.8	85.3	72.3	200	410
Nutrients										
Nitrate	mg/kg	0.1	<0.1	0.4	0.1	0.4	0.3	0.4	NA	NA
NO_x	mg/kg	0.1	<0.1	0.4	0.3	0.6	0.3	0.4	NA	NA
TKN	mg/kg	20	580	280	2560	1540	870	870	NA	NA
TN	mg/kg	20	580	280	2560	1540	870	870	NA	NA
TP	mg/kg	2	62	41	76	35	79	63	NA	NA
Other parameters										
TOC	%	0.02	1.82	0.75	10.30	7.70	3.84	3.65	NA	NA
Moisture content	%	1.0	36.3	24.8	37.6	46.3	6.5	5.2	NA	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

NA = No guideline value is available.

Table 4-18 Results of laboratory sediment analysis at LT Creek sites

Analyte	Unit	LOR	By-Wash		WMP03		SP004		ANZG (2018)	
			21/05/19	14/10/19	21/05/19	14/10/19	21/05/19	14/10/19	DGV	GV-high
1M HCl-extractable metals										
Antimony	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	25
Arsenic	mg/kg	1.0	1.4	<1.0	2.4	3.6	1.1	3.6	20	70
Cadmium	mg/kg	0.1	0.8	0.2	1.1	0.3	0.3	0.4	1.5	10
Chromium	mg/kg	1.0	<1.0	<1.0	3.4	1.6	1.3	2.1	80	370
Copper	mg/kg	1.0	1.1	5.0	<1.0	9.4	<1.0	11.6	65	270
Lead	mg/kg	1.0	25.2	17.7	43.0	**122.0**	20.0	28.0	50	220
Mercury	mg/kg	0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.15	1.0
Nickel	mg/kg	1.0	<1.0	1.4	8.2	5.7	8.6	11.0	21	52
Silver	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	4.0
Zinc	mg/kg	1.0	31.2	27.4	173.0	82.8	89.3	147.0	200	410
Nutrients										
Nitrate	mg/kg	0.1	1.3	0.2	1.4	<0.1	0.9	0.5	NA	NA
NO_x	mg/kg	0.1	1.5	0.2	1.7	<0.1	1	0.5	NA	NA
TKN	mg/kg	20	3020	970	2800	740	1680	940	NA	NA
TN	mg/kg	20	3020	970	2800	740	1680	940	NA	NA
TP	mg/kg	2	188	22	261	40	104	44	NA	NA
Other parameters										
TOC	%	0.02	8.80	3.12	5.60	3.68	6.16	7.23	NA	NA
Moisture Content	%	1.0	62.1	5.0	70.5	4.0	48.4	6.1	NA	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

NA = No guideline value is available.

Table 4-19 Results of laboratory sediment analysis at sites on the unnamed tributary of Muddy Lake

Analyte	Unit	LOR	SP6		SP5		ANZG (2018)	
			15/05/2019	31/10/2019	13/05/2019	31/10/2019	DGV	GV-high
1M HCl-extractable metals								
Antimony	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	2.0	25
Arsenic	mg/kg	1.0	<1.0	<1.0	1.2	1.3	20	70
Cadmium	mg/kg	0.1	<0.1	<0.1	0.2	<0.1	1.5	10
Chromium	mg/kg	1.0	<1.0	<1.0	1.7	<1.0	80	370
Copper	mg/kg	1.0	2.0	1.1	2.0	6.9	65	270
Lead	mg/kg	1.0	6.7	3.4	8.7	12.3	50	220
Mercury	mg/kg	0.1	<0.10	<0.10	<0.10	<0.10	0.15	1.0
Nickel	mg/kg	1.0	1.2	<1.0	**79.9**	**90.7**	21	52
Silver	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	1.0	4.0
Zinc	mg/kg	1.0	12.6	14.1	**214**	**267**	200	410
Nutrients								
Nitrate	mg/kg	0.1	0.2	0.1	0.3	0.4	NA	NA
NO_x	mg/kg	0.1	0.2	0.1	0.5	0.4	NA	NA
TKN	mg/kg	20	1970	1010	3020	2030	NA	NA
TN	mg/kg	20	1970	1010	3020	2030	NA	NA
TP	mg/kg	2	156	68	212	139	NA	NA
Other parameters								
TOC	%	0.02	5.26	2.21	9.95	2.78	NA	NA
Moisture Content	%	1.0	54.8	-	73.0	58.6	NA	NA

Notes:

Exceedances of the DGVs are in **orange bold**. Exceedances of the GV-high are in **pink bold**.

NA = No guideline value is available.

Table 4-20 Results of laboratory sediment analysis at estuarine sites

Analyte	Unit	LOR	Reference estuary		LT Creek estuary		Stony Creek estuary		ANZG (2018)	
			PCMH		IZ		SCCIZ		DGV	GV-high
			20/05/2019	15/10/2019	23/05/2019	16/10/2019	20/05/2019	16/10/2019		
1M HCl-extractable metals										
Antimony	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	25
Arsenic	mg/kg	1.0	2.3	<1.0	2	<1.0	<1.0	<1.0	20	70
Cadmium	mg/kg	0.1	1.4	0.6	**2.3**	**2.3**	0.3	**1.7**	1.5	10
Chromium	mg/kg	1.0	<1.0	<1.0	1.8	2.0	<1.0	1.1	80	370
Copper	mg/kg	1.0	6.3	<1.0	15.1	2.4	<1.0	11.0	65	270
Lead	mg/kg	1.0	38.8	5.3	39.4	37.1	2.8	26.1	50	220
Mercury	mg/kg	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	1.0
Nickel	mg/kg	1.0	<1.0	<1.0	1.4	<1.0	<1.0	1.2	21	52
Silver	mg/kg	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	4.0
Zinc	mg/kg	1.0	158.0	76.6	173.0	178.0	25.0	131.0	200	410
Nutrients										
Nitrate	mg/kg	0.1	0.6	0.8	0.1	0.4	0.6	0.2	NA	NA
NO_x	mg/kg	0.1	0.8	0.8	0.1	0.4	0.8	0.2	NA	NA
TKN	mg/kg	20	1640	1740	1360	1500	1510	1290	NA	NA
TN	mg/kg	20	1640	1740	1640	1500	1510	1290	NA	NA
TP	mg/kg	2	174	266	190	220	133	159	NA	NA
Other parameters										
TOC	%	0.02	5.31	3.56	1.90	2.57	5.39	1.41	NA	NA
Moisture Content	%	1.0	46.8	45.0	40.0	49.1	45.2	36.9	NA	NA

Notes:

Exceedances of the DGVs are in **orange bold.**

NA = No guideline value is available.

4.7 Freshwater macroinvertebrates

4.7.1 Univariate metrics

Taxa richness, EPT richness and SIGNAL-2 results from macroinvertebrate samples collected in autumn and spring 2019 are presented in Figure 4-3, Figure 4-4 and Figure 4-5 respectively. Figures include a comparison to historical median results where available. Results displayed are average results of two replicate samples, except for results from sites WMP27, SP6 and SP5 where only one sample was collected in each sampling event.

Average taxa richness ranged between 10 and 27 (Figure 4-3). Average taxa richness was lowest at sites SKDS, WMP38 and LCRef (spring only) and highest at sites By-Wash and SP6. There was no consistent trend in average taxa richness between catchments, with the exception of LT Creek. Average taxa richness was generally higher and more consistent at LT Creek sites and at other sites where permanent water is available (sites CCSC1, By-Wash, WMP03, SP5).

Average taxa richness was relatively consistent between sampling events at each site, with some exceptions. At ephemeral sites, average taxa richness was generally higher in spring than in autumn (e.g. sites KCDS, SCMid, SCDS), likely due to the higher rainfall preceding spring sampling. At site LCRef, the taxa richness in autumn 2019 was eight taxa higher than in spring 2019. The water at site LCRef was too deep to enter in spring 2019 and the sample was taken from the banks, which may explain the low richness observed.

EPT richness was generally low (at or below 3) at all sites except LT Creek sites (Figure 4-4). These results are consistent with the limited water availability and isolated pools available at most sites. At LT Creek sites, flows and water chemistry are regulated by the discharges from Newstan LDP001 which has created stable water levels and allowed for formation of permanent habitat and connectivity between sites. This is likely the reason for the higher EPT richness at LT Creek sites.

Average SIGNAL-2 scores ranged between 3.19 (at site WMP20 in spring) and 4.20 (at site SP004 in spring) (Figure 4-5). There were no trends identified in average SIGNAL-2 scores between catchments. In LT Creek, average SIGNAL-2 scores were higher at the creek sites than at the impounded site By-Wash, likely reflecting the effects of consistent flows on the sensitivity of macroinvertebrate communities.

Overall, the 2019 data indicated that the macroinvertebrate community was in poor to moderate condition based on moderate diversity (richness) and low to moderate pollution sensitivity (EPT richness and SIGNAL-2). The macroinvertebrate communities in LT Creek were generally in the best condition of the assessed sites. The stable water levels and permanent habitat and connectivity which results from the LDP001 discharge result in relatively stable macroinvertebrate metrics results.

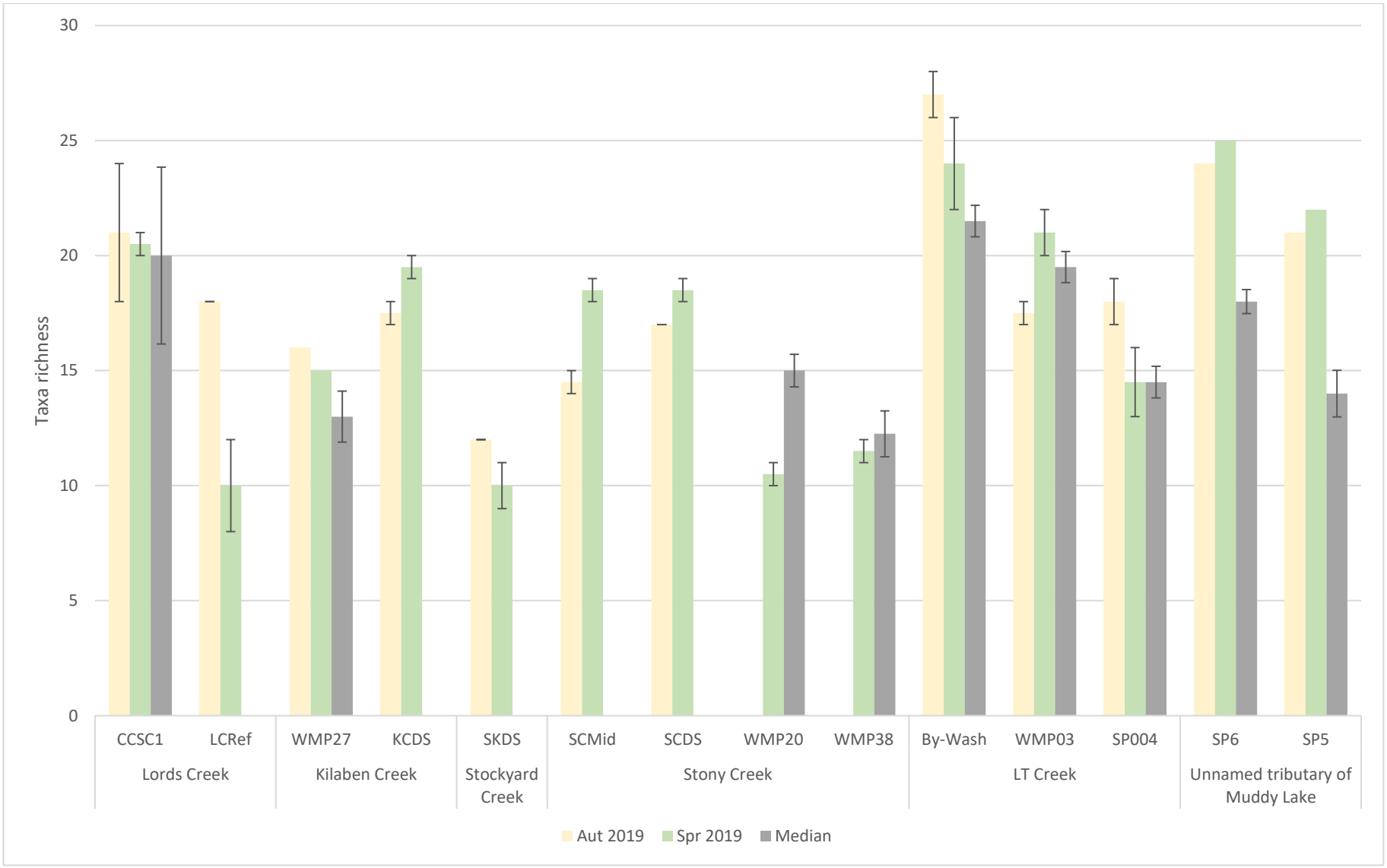


Figure 4-3 Macroinvertebrate taxa richness in freshwater samples, autumn and spring 2019, compared with historical median results, where available

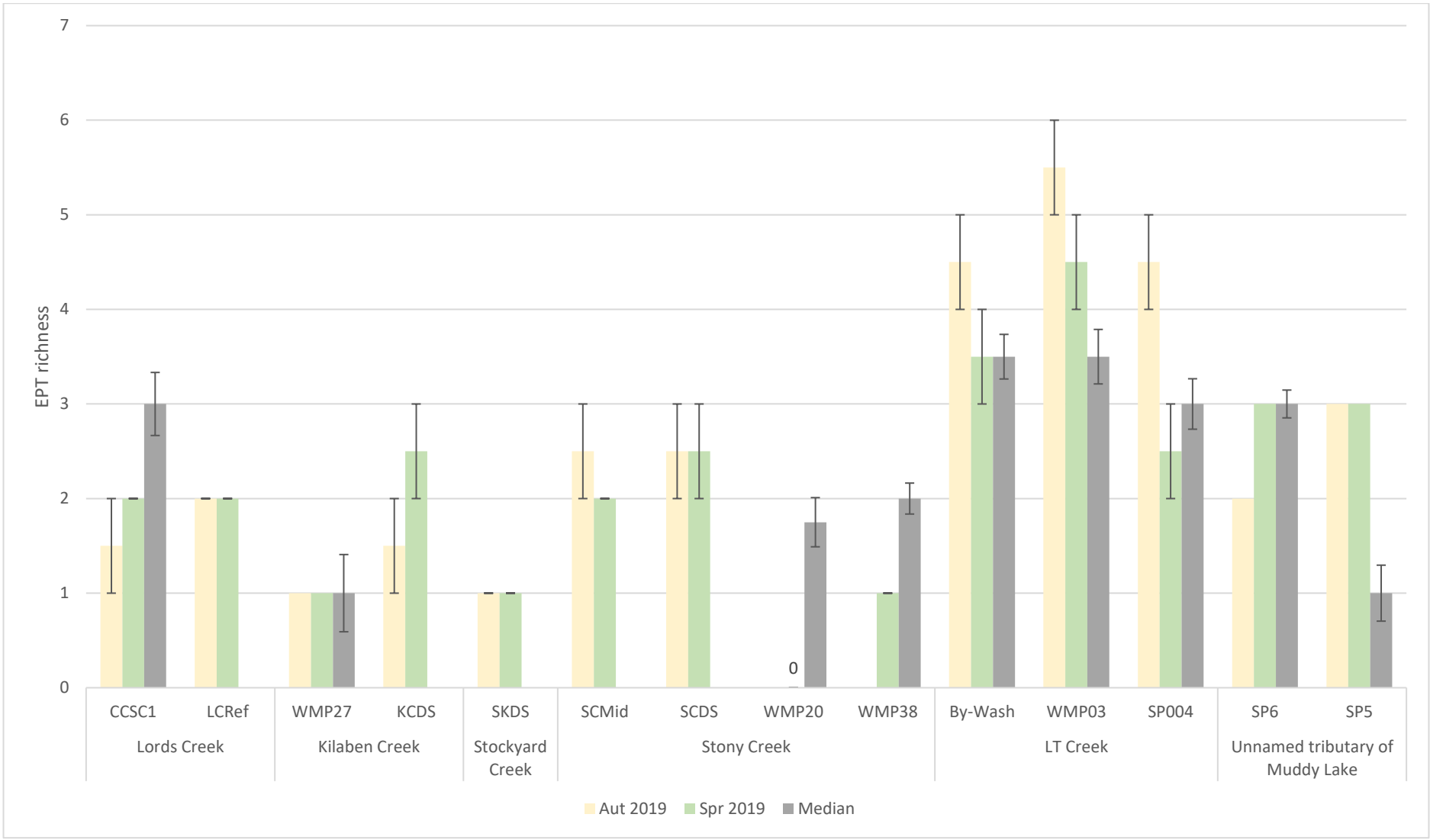


Figure 4-4 Macroinvertebrate EPT richness in freshwater samples, autumn and spring 2019, compared with historical median results, where available

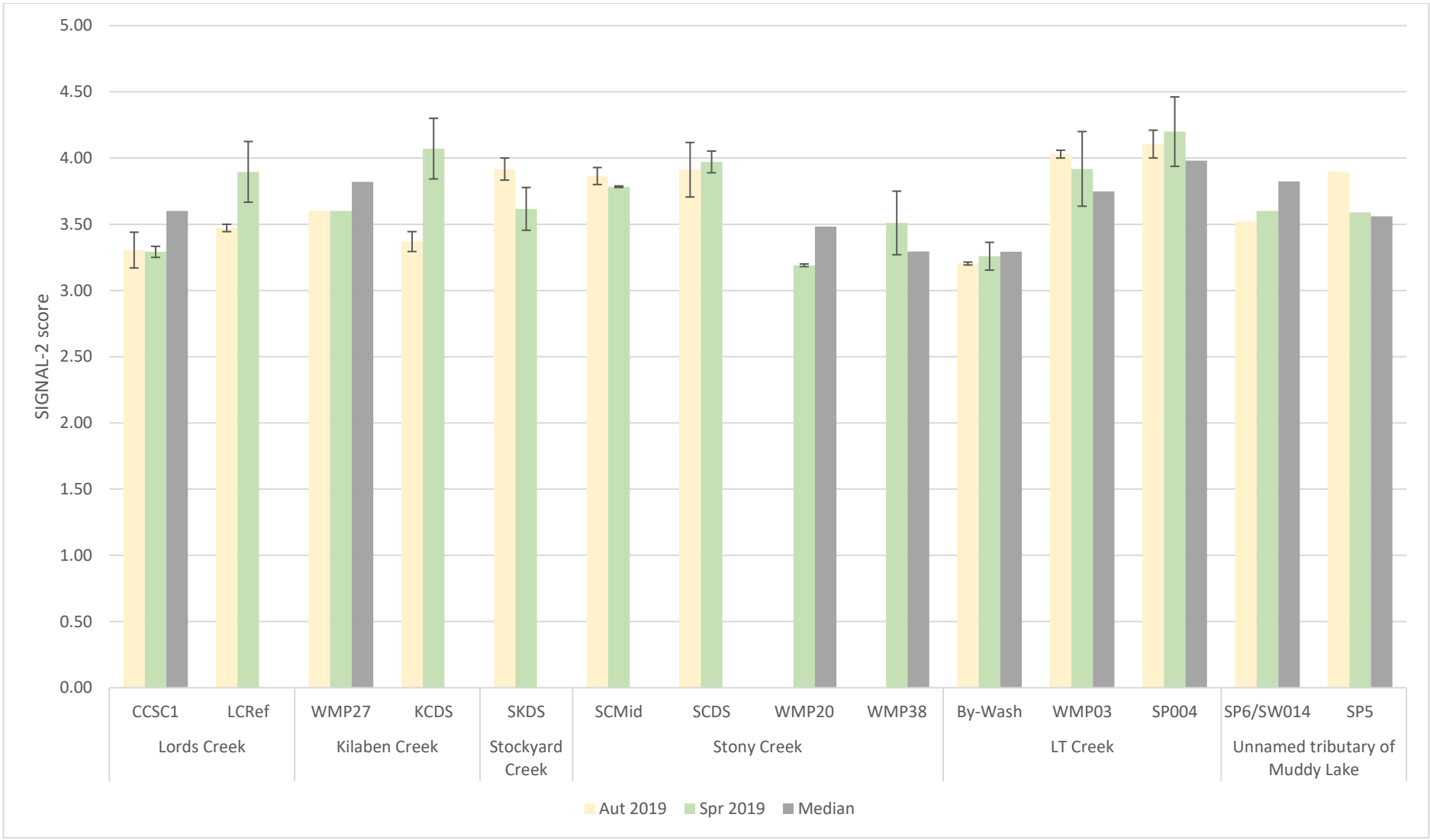


Figure 4-5 Macroinvertebrate SIGNAL-2 scores in freshwater samples, autumn and spring 2019, compared with historical median results, where available

4.7.2 Multivariate metrics

The cluster plot in Figure 4-6 demonstrates the similarity in the community composition of freshwater macroinvertebrate samples collected in autumn and spring 2019. The patterns in the cluster diagram indicate that there are differences in macroinvertebrate community composition between sites, with samples generally grouping together at a site level. Differences in community composition between autumn 2019 and spring 2019 sampling events were less pronounced than the spatial differences.

There were no consistent differences observed between catchments, with the exception of LT Creek sites (symbols coloured in red) which have a distinct macroinvertebrate community composition due to the regulatory influence of discharges from Newstan LDP001 on flow and water chemistry. There were several taxa observed only at LT Creek sites, including Simuliidae, Stratiomyidae, Lindeniidae and Ecnomidae (see Appendix C). While some of these families (namely Simuliidae) prefer flowing waters, which explains their prevalence in LT Creek, others may be present within this catchment due to the altered water chemistry or permanent water and associated habitat such as macrophytes.

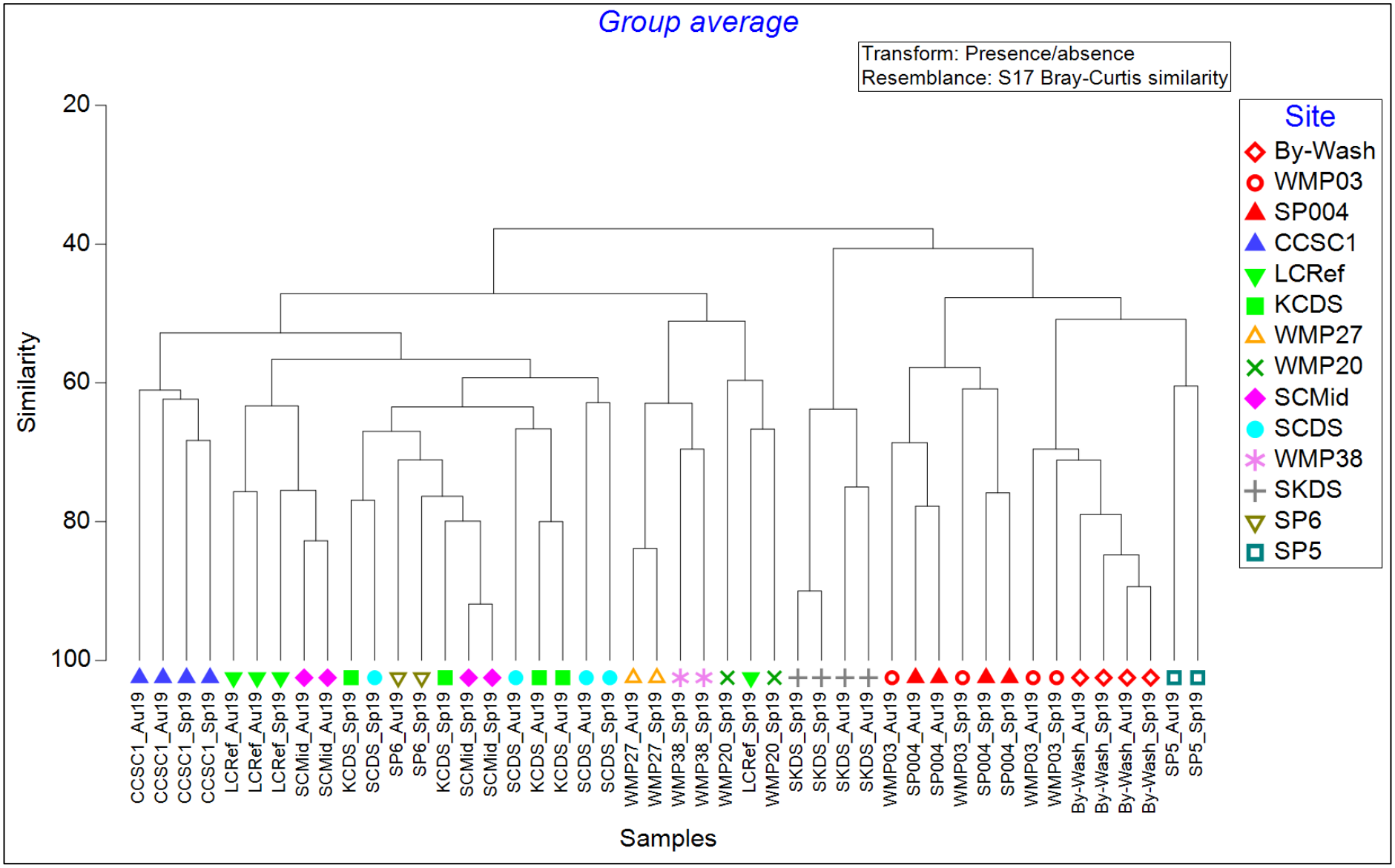


Figure 4-6 Cluster diagram identifying relative similarity in community composition between aquatic ecology sites

4.8 Estuarine macroinvertebrates

Benthic infauna abundance results are displayed in Figure 4-7, as an average of the three samples collected at each site, per season. A long-term median is also provided, calculated from results collected between 2015 and 2018.

The number of individuals was low at all estuarine sites in autumn and spring 2019 at reference site PCMH and site SCCIZ with counts below the median. At LT Creek estuarine site IZ, abundance in autumn 2019 was higher than the median, while abundance in spring 2019 was less than median by more than 50 percent. As indicated by the error bars, there was considerable intra-site variability in abundance, particularly at site IZ in autumn 2019. Temporal variability was also observed at all sites, but was most pronounced at sites PCMH and IZ.

Median abundance was highest at reference site PCMH and lowest at Stony Creek site SCCIZ. In autumn 2019, the highest average abundance was observed at site IZ and the lowest average abundance was observed at site PCMH. In spring 2019, average abundance was equal at sites PCMH and SCCIZ with lower abundance observed at site IZ.

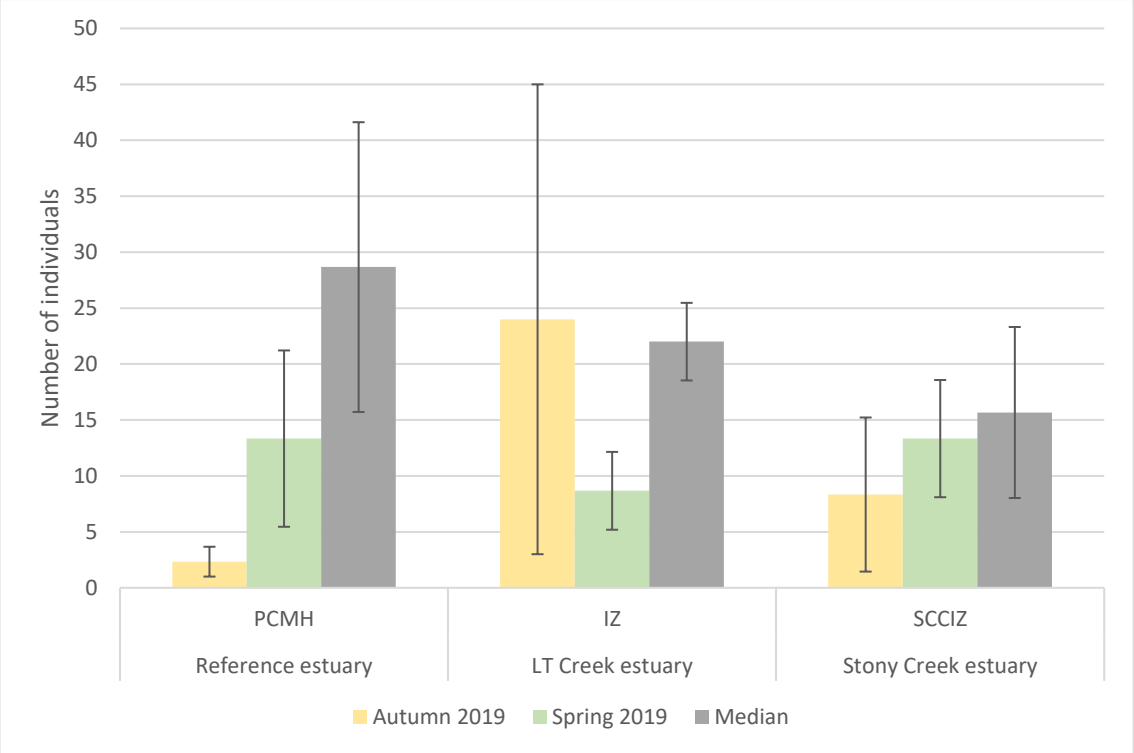


Figure 4-7 Estuarine infauna abundance, autumn 2019 and spring 2019, compared with historical median results (2015-2018)

Benthic infauna richness is displayed in Figure 4-8, as an average of the three samples collected at each sites, per season. A long-term median is also provided, calculated from results collected between 2015 and 2018.

Median richness was similar between the three sites. In autumn 2019, average richness was very low (less than three) at all sites. An average taxa richness of 1.3 was observed at sites PCMH and SCCIZ, compared to 2.3 at site IZ. In spring 2019, average richness was highest at site IZ and only slightly below the median. At site PCMH in spring 2019, average taxa richness was four which is less than one taxon lower than both the average richness at site IZ and the long-term median for site PCMH. At site SCCIZ in spring 2019, the average taxa richness was half of the long-term median.

At all sites, average taxa richness was higher in spring 2019 than in autumn 2019.

GHD (2019a) found the estuarine macroinvertebrate community at site PCMH to be similar, and not significantly different from that of site IZ and SCCIZ. This indicated that there has been no apparent impact of discharges via Newstan LDP001 or LDP017 on estuarine macroinvertebrate communities at site IZ or site SCCIZ.

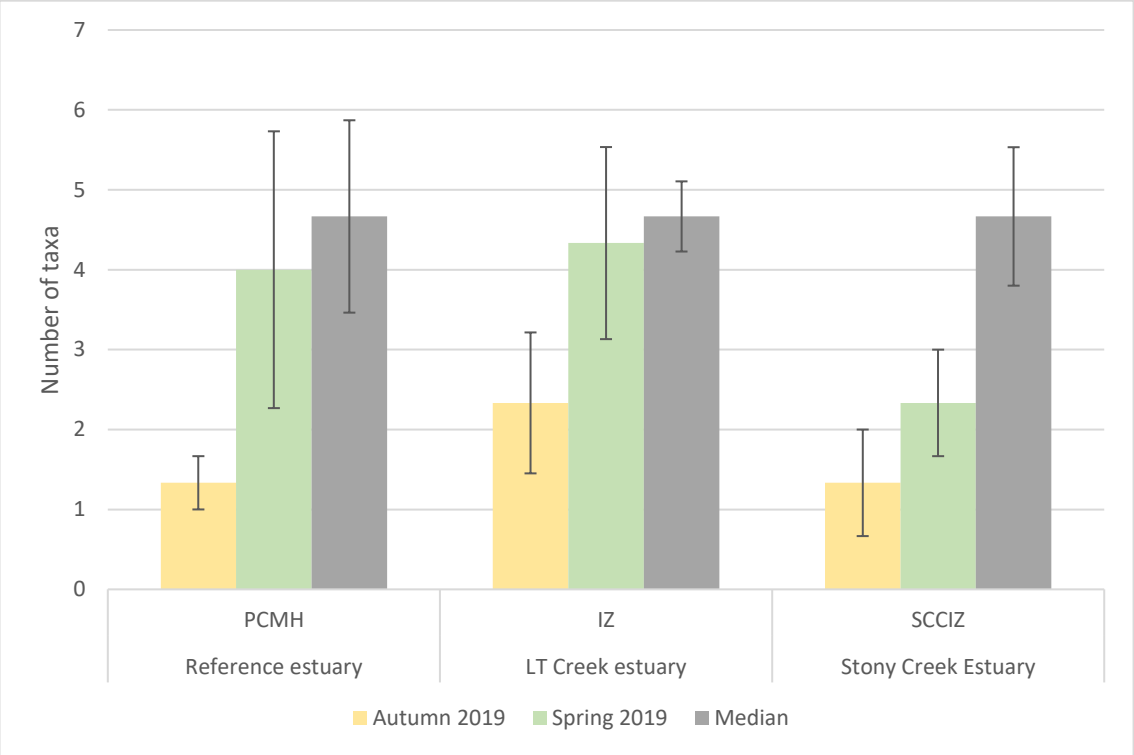


Figure 4-8 Estuarine infauna diversity, autumn 2019 and spring 2019, compared with historical median results (2015-2018)

4.9 Ecotoxicity

Figure 4-9 shows that the acute EC_{50} for the cladoceran at LDP001 has been greater than 100 percent (i.e. greater than the undiluted sample) throughout the monitoring period. EC_{50} values for cladoceran reproduction were greater than 100 percent for all years except 2016. All results for cladoceran reproduction have been above 50 percent, and have therefore not exceeded the EPL limit. There is no EPL limit for the microalga growth test. Microalgal growth was inhibited by the LDP001 sample in 2016 and 2019 though in neither year was the observed toxicity associated with an elevated toxicant concentration. The 2019 ecotoxicology assessment (GHD 2019b) hypothesised that the toxicity to the microalga test species could have been caused by the production of phytotoxins by microorganism activity prior to the commencement of the DTA.

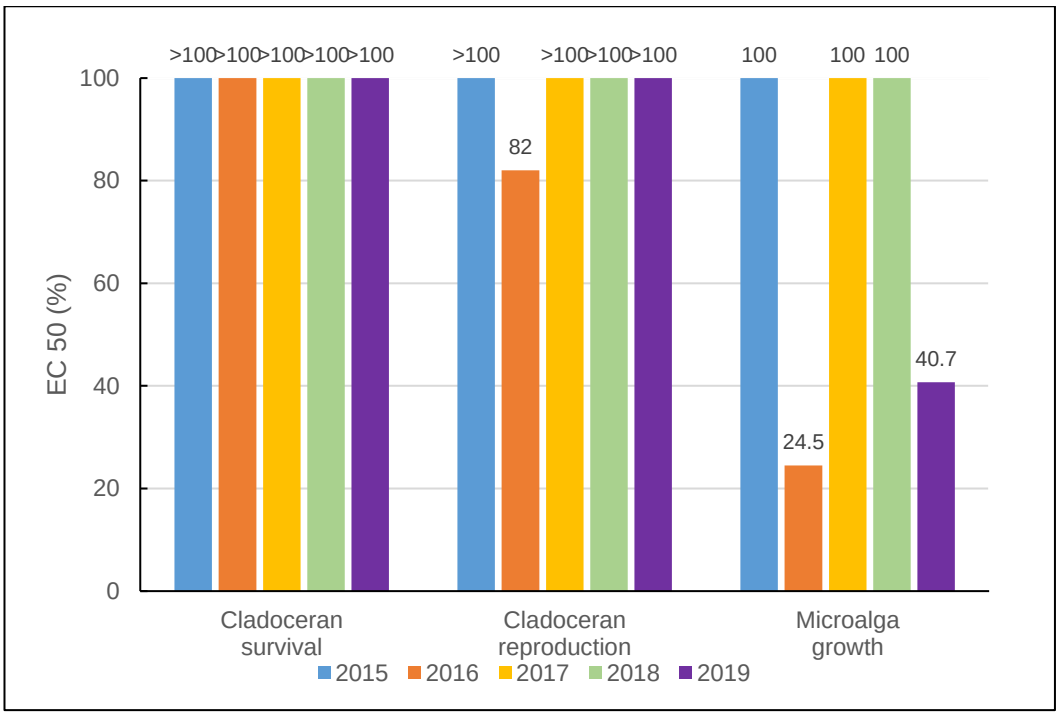


Figure 4-9 Cladoceran EC_{50} results for Newstan LDP001.

5. Impact assessment

5.1 Licensed discharges

5.1.1 Awaba LDP009 discharges to Stony Creek

As part of the Project, the PCD at the Awaba Colliery Surface Site will be upgraded and transfers of dirty water to the Awaba underground void will cease. As such, discharges to Stony Creek via LDP009 are predicted to increase. The volumetric discharge limit of 8 ML/year is not appropriate for a rainfall based discharge point, as site operations do not control the volume of rainfall runoff reporting to the PCD and discharging via LDP009. The volumetric discharge limit on LDP009 should be removed and water quality concentrations limits should not apply when discharges occur as a result of rainfall that exceeds the design criteria rainfall depth of 76.7 mm over 5 days. A requirement for the timely dewatering and periodic desilting of the dirty water surface storages should be stipulated by EPL 443.

Runoff from the disturbed areas at Awaba Colliery Surface Site is considered dirty water that may contain suspended sediment, oils, grease and hydrocarbons. No coal storage, transportation, handling or processing will be undertaken at the site. The most likely source of water quality degradation risk from the Awaba Colliery Surface Site is elevated suspended solids concentrations, especially during construction activities. No increased concentrations of metals, salinity or other contaminants are expected to be present in discharges from Awaba LDP009, and discharges would not exceed the concentration limits specified by EPL 443. An additional sediment control dam is proposed upstream of the PCD to allow suspended solids to settle prior to discharges via LDP009.

Increased suspended solids concentrations downstream of LDP009 have the potential to result in smothering of the benthic substrate, which results in loss of habitat for benthic macroinvertebrates, which in turn could result in a loss of diversity and shifts in functional feeding guilds (Hynes 1970). Loss of diversity may result from displacement of certain groups of animals due to a reduction of food availability (e.g. scrapers and shredders) or loss of habitat (e.g. through filling of interstitial spaces).

Elevated suspended solids concentrations can also limit light penetration and the ability of aquatic plants to photosynthesise, if sediments remain in suspension this can affect photosynthetic productivity and the health of aquatic plants, leading to potential impacts to the quality and availability of habitat for macroinvertebrates and fish.

These potential impacts of discharges via LDP009 could be observed in Stony Creek in the vicinity of monitoring site SCDN and further downstream. If suspended solids are elevated due to the increased discharges, there is the potential for impacts to the macroinvertebrate community of Stony Creek. However, given the ephemeral nature of the catchment and the dominance of fine sediments, elevated turbidity is a common occurrence in Stony Creek, as demonstrated through the exceedance of the DGV for turbidity observed during baseline sampling events. Additionally, the catchment area of the PCD is less than 0.03 percent of the Stony Creek catchment area (GHD (2020b), so it is unlikely that the contribution of suspended solids in discharges from the Awaba Colliery Surface Site would be significant compared to the sediment transport within the greater catchment.

Impacts of discharges via LDP009 are not likely at estuarine monitoring site SCCIZ as elevated suspended solids concentrations are unlikely to persist in saline water, because higher salinity is associated with greater aggregation of suspended particles and higher settling velocities (Hakanson 2005). Additionally, the macroinvertebrates monitored at the site are not likely to be affected by the potential increase in sedimentation, since they occupy the benthos itself.

5.1.2 Newstan LDP017 discharges to Stony Creek

The likelihood of discharges to Stony Creek via Newstan LDP017 is not predicted to increase as a result of the project (GHD 2020b). As discharges through Newstan LDP017 are in response to heavy rainfall, any change to the water quality in the receiving environment of Stony Creek is predicted to be minor and temporary, and unlikely to adversely affect freshwater aquatic communities.

Increased volumes of fresh water have the potential to influence the benthic macroinvertebrate community composition at estuarine monitoring site SCCIZ. However, as LDP017 discharges are in response to heavy rainfall, the influence of the discharge is unlikely to be discernible from the response of the community to seasonal variation (which includes natural flood events) and long term climate variability (Hernandez-Guevara *et al.* 2008, Pollack *et al.* 2011).

5.1.3 Newstan LDP001 to LT Creek

LDP001 discharge rates of up to 14.5 ML/day will be required for the project. This maximum rate of discharge is already approved under the Northern Coal Logistics Project (SSD-5145). Notwithstanding, EPL 395 limits daily discharge from LDP001 to 11 ML/day. As such, to achieve the maximum daily discharge of 14.5 ML/day, this limit would need to be increased by 3.5 ML/day. The increase of 3.5 ML/day above the EPL 395 limit of 11 ML/day would result in increases to flow depths and velocities in LT Creek. The Northern Coal Logistics Project Water Impact Assessment (GHD 2014) expected the maximum increase in water level resulting from the increased LDP001 discharge rate to be approximately 30 mm.

Increased flow rates in LT Creek have the potential to affect macroinvertebrate community composition. In areas of the creek where flow velocities increase, there is the potential for rheophilic taxa (those with a preference for fast flowing water) to become more dominant (Kelso and Entrekin 2017, Nadeau 2012). This could result in reduced diversity of taxa which prefer lentic water, such as chironomids (midges), odonata (dragonflies and damselflies), and air breathing species of true bugs and beetles (Nadeau 2012), but may be reflected by an increase in SIGNAL-2 scores (meaning that abundances of pollution-sensitive taxa could increase). However, hydraulic modelling undertaken for the SWIA (GHD 2020b) indicated that there is no significant increase in flow velocities expected as a result of the increased discharge rate. As such, these potential impacts on macroinvertebrate communities in LT Creek are unlikely.

Water will continue to be treated at the CWP prior to discharge via Newstan LDP001, and there is no adverse change to water quality in LT Creek predicted (GHD 2020b). The effect of potential interactions between the Eraring Ash Dam (EAD), the Awaba Colliery underground void, and the Extension of Mining Area on water quality was assessed by GHD (2020c). They found that any interaction between the EAD and the Extension of Mining Area would be unlikely to have any adverse effect on the water quality of LDP001, due to the low potential contribution of water from the EAD compared to the volume of water treated at the CWP. The interaction could result in higher EC and higher boron concentrations in the discharge compared to existing conditions (Section 4.5.2), however the EC and boron concentrations are not expected to exceed the EPL 395 limits for LDP001 GHD (2020c). As such, no adverse effect on aquatic communities in LT Creek is expected as a result of a change in water quality.

The additional 15 years of licensed discharges from Newstan LDP001 to LT Creek due to the extended operational life of Newstan Colliery from the project would result in a corresponding continuation of water flow and quality impacts that would be comparable to existing conditions.

Ecotoxicity

The results of the ecotoxicological monitoring program conducted with the LDP001 discharge since 2015 indicate that there have been no exceedances of EPL 395 condition L5.1, as the EC_{50} values for reproductive impairment of *Ceriodaphnia dubia* have remained at or above 50. It is expected that the project would not result in any change to these results.

5.2 Subsidence related impacts

The subsidence impact assessment for the project (MSEC 2019) predicted that over 20 mm of subsidence would be observed in areas of the following catchments:

- Lords Creek.
- Stony Creek.
- Kilaben Creek.
- Stockyard Creek.

The mine design has been prepared to reduce the potential subsidence by designating first working zones underneath higher order watercourses. Less than 20 mm of subsidence was predicted in the catchment of the unnamed tributary of Muddy Lake.

Based on the MSEC (2019) subsidence predictions, the SWIA (GHD 2020b) predicted that the central flow paths (thalwegs) of the following watercourses would be affected by subsidence:

- Stony Creek.
- Lords Creek 2.
- Lords Creek 3.

Lords Creek 2 and Lords Creek 3 are tributaries of Lords Creek which join upstream of monitoring site LCDS, as detailed in MSEC (2019).

The following impacts could occur as a result of subsidence within the catchments of the assessed watercourses:

- Reduced habitat availability.
- Fragmentation of habitat/ponding.
- Impacts on water quality.
- Impacts on sediment quality.
- Increases in flow velocity as a result of increased gradients.

Each of these impacts has the potential to adversely affect aquatic ecology values, as discussed in Sections 5.2.1, 5.2.2, and 5.2.3. The overall risk of subsidence-related impacts to each of the catchments overlying the Extension of Mining Area has been assessed in Section 5.2.4.

5.2.1 Reduced habitat availability and fragmentation of habitat

Subsidence impacts may result in a reduced water availability within waterways leading to reduced diversity of macroinvertebrate groups and potential loss of communities if there is complete loss of habitat in a waterway, or section of a waterway.

The reduced connectivity between pools may restrict movement of macroinvertebrates and any fish present within the waterways. This could influence recolonisation and reproductive success for any species that migrate as part of their breeding cycle (e.g. fish during spawning).

Although Lords Creek, Stony Creek and Kilaben Creek were mapped as Key Fish Habitat, fish are likely to be scarce within the study area, given the ephemeral nature of the waterways. Macroinvertebrate communities in the sections of the waterways potentially impacted by subsidence would be largely those that can subsist in isolated pools, as water is generally available in these minor drainage lines only for short periods following rainfall. This was evidenced by the macroinvertebrate community observed at sites on Lords Creek, Stony Creek, Kilaben Creek and Stockyard Creek that were largely comprising families preferential to slow flowing or still waters (see Section 4.7.1). Although, it is acknowledged that the 2019 field survey was undertaken under dry conditions, Kilaben Creek site WMP27 has been an isolated pool since macroinvertebrate sampling commenced in spring 2015 - which was prior to the onset of the current drought. It is also likely that some fragmentation of habitat occurred as a result of historical mining at Awaba Colliery, which resulted in subsidence and the formation of sinkholes.

5.2.2 Impacts on water and sediment quality

Due to the inherent difficulty in accurately predicting the size and location of surface deformations, the typical subsidence-related impacts to surface water and sediment quality have been assessed. Surface deformations in the catchments overlying the proposed workings could have the following impacts on water and sediment quality:

- Subsidence fracturing could result in localised subsurface flow diversions and decreased surface water connectivity, which can lead to reduced DO concentrations (due to decreased re-aeration from turbulent flow) and increased parameter concentrations through evaporative concentration. Low DO concentrations and elevated parameter concentrations can have adverse effects on aquatic life.
- Subsidence fracturing may expose previously unweathered bedrock, which when weathered can release substances such as the metals aluminium, iron, manganese, nickel and zinc into the surface water. Elevated salinity and potentially ecotoxic metal concentrations could be observed downstream of areas with such subsidence fracturing. Nickel and zinc, which are potentially ecotoxic in sediments, can coprecipitate with iron and manganese oxyhydroxides (Crawford *et al.* 1993). Such precipitates may still be bioavailable to aquatic life, such as benthic macroinvertebrates (GHD 2018).
- Elevated iron concentrations can result in the consumption of DO associated with iron precipitation, which occurs rapidly following exposure to atmospheric oxygen and also through the action of iron oxidising bacteria. These processes can occur naturally in gaining creeks as a result of groundwater interaction, but can be exacerbated by subsidence fracturing, resulting in thick mats of orange-red precipitate and reduced dissolved oxygen concentrations (Jankowski 2007). This could result in in smothering of the benthic substrate, which results in loss of habitat for benthic macroinvertebrates, as discussed in Section 5.1.1)

5.2.3 Increases in flow velocity

Soil Conservation Service (2019) undertook hydraulic modelling to assess the potential for localised increases in flow velocities as a result of subsidence induced increases in gradient within the catchments of Stockyard Creek and Lords Creek. Other watercourses were not targeted in the hydraulic model due to low risk factors. The maximum increase in localised flow velocity for the 2 Exceedances per Year (2EY) event was predicted for an unnamed tributary of Stockyard Creek. The localised flow velocity in the tributary was predicted to be roughly double that observed under existing conditions.

Increased flow velocities have the potential to affect macroinvertebrate community composition. It is unlikely that increased flow velocities in Stockyard Creek and Lords Creek would be sustained for sufficient periods of time to allow for the dominance of rheophilic taxa, as discussed in Section 5.1.3. However, the increased flow velocities may make existing slow-flowing habitats unsuitable for taxa which prefer lentic water, such as chironomids (midges), odonata (dragonflies and damselflies), and air breathing species of true bugs and beetles (Nadeau 2012). Such impacts could result in reduced macroinvertebrate community condition in these creeks. However, it is noted that habitat availability is low at the Lords Creek site closest to the predicted impacts to flow velocity, and the site could not be sampled for macroinvertebrates in autumn or spring 2019 due to drought conditions and the ephemeral nature of the subcatchments. The potential impacts of increased flow velocity on macroinvertebrate communities would not be observed at downstream monitoring site CCSC1. Similarly, monitoring site SKDS is downstream of the extension of mining area, and macroinvertebrate communities at the site are not expected to be affected by the changes to flow velocities in the upstream catchment predicted by Soil Conservation Service (2019).

The predicted increases in localised flow velocities pose a potential hydraulic barrier to fish passage, however the maximum flow velocity associated with the 2EY event was predicted to be 1.2 m/s, which is within the burst speed of juvenile Australian Bass (Mallen-Cooper 1992), which may be present in the study area. Therefore, the areas of increased flow velocities would likely be passable by small fish. While the potentially impacted sections of Lords Creek is mapped as Key Fish Habitat (DPI 2019a), the inspections undertaken for this assessment indicated that the there is no defined channel in much of these subcatchments, meaning that fish habitat is likely only available for short periods in response to rainfall. The areas of Stockyard Creek where Soil Conservation Service (2019) predicted increases in flow velocities are not mapped as Key Fish Habitat (DPI 2019a).

5.2.4 Assessed risk of subsidence related impacts

A qualitative assessment of the overall risk of subsidence related impacts to aquatic communities is provided in Table 5-1, where the risk of the potential impacts discussed in Section 5.2.1, Section 5.2.2 and Section 5.2.3 are given a low, moderate or high rating for each potentially affected catchment.

It is noted that the assessed overall risk ratings apply to aquatic communities in the catchments within the study area, and not particularly to the monitoring sites, as there is the possibility for localised impacts which do not directly affect downstream sites. For example, subsidence fracturing in the upper Stony Creek catchment could result in the loss of water and therefore habitat in pool refugia, thereby impacting aquatic communities. However, there may be no loss of water and habitat at downstream monitoring sites SCMid and SCDS associated with such an event.

Table 5-1 Qualitative assessment of the risk of subsidence related impacts to aquatic communities based on catchment

Watercourse	Reduced habitat availability and habitat fragmentation	Impacts on water and sediment quality	Increases in flow velocity	Overall potential risk of impact to aquatic communities
Lords Creek	Low	Moderate	High	**Moderate** Habitat availability is low under existing conditions, with limited connectivity to the subcatchments potentially affected by subsidence, and no defined channel throughout most of the subcatchments. Habitat that would be available during wet periods is mostly of poor quality. Up to 2000 mm of subsidence is predicted in the catchment upstream of site LCDS, so there is potential for subsidence impacts on water and sediment quality, though considering the poorly defined channels in this area of the catchment it is unlikely that such impacts would be observable at a surface water monitoring site. Soil Conservation Service (2019) predicted the geomorphic risk in tributaries of Lords Creek to be high, with hydraulic modelling for the 2EY event predicting a maximum increase in localised flow velocity of 0.4 m/sec (compared to existing conditions), and a maximum velocity of 1.0 m/sec.
Stony Creek	Moderate	High	Low	**Moderate** The risk of reduced habitat availability and habitat fragmentation in Stony Creek is moderate, due to the potential for subsurface flow diversions and loss of surface flows to pool refugia such as those present at SCMid and SCDS. Up to 3200 mm of subsidence in the Stony Creek catchment was predicted by MSEC (2019). While substantially less subsidence is predicted under the thalweg of the creek, impacts to water and sediment quality through the weathering of fractured rock are considered likely. Stony Creek was not targeted by hydraulic modelling due to low predicted increase in gradient within the catchment (Soil Conservation Service 2019).

Watercourse	Reduced habitat availability and habitat fragmentation	Impacts on water and sediment quality	Increases in flow velocity	Overall potential risk of impact to aquatic communities
Kilaben Creek	Moderate	High	Low	**Moderate** While habitat availability in Kilaben Creek is low due to the ephemeral nature of the watercourse, subsidence is predicted in the upper catchment (MSEC 2019) which has the potential to result in loss of surface water in pool refugia, such as that present at WMP27. This subsidence is also likely to impact water and sediment quality downstream of surface expressions of water from subsidence fracturing. Kilaben Creek was not targeted by hydraulic modelling due to low predicted increase in gradient within the catchment (Soil Conservation Service 2019).
Stockyard Creek	Low	Moderate	Moderate	**Moderate** Habitat availability in Stockyard Creek is low as the creek is ephemeral, and the quality of the habitat is generally poor overlying the extension of mining area, as much of the creek has no defined channel. Subsidence is predicted in the Stockyard Creek catchment, but subsidence under the thalweg of the creek is predicted to be low (MSEC 2019). As such the risk of subsidence impacts to water and sediment quality is considered moderate. Soil Conservation Service (2019) predicted the geomorphic risk in Stockyard Creek to be moderate, with hydraulic modelling for the 2EY event predicting a maximum increase in localised flow velocity of 0.61 m/sec, associated with a maximum velocity of 1.2 m/sec.
Unnamed tributary of Muddy Lake	Low	Low	Low	**Low** Subsidence in the unnamed tributary of Muddy Lake catchment is predicted to be low (MSEC 2019), and therefore no loss of habitat or habitat fragmentation is expected. No impacts to water or sediment quality or flow velocities are expected, assuming that there is no impact on the existing status of the Awaba seepage (which has been assessed by GHD 2020c).

6. Mitigation, management and monitoring

6.1 Licensed discharges

6.1.1 Awaba LDP009

Water quality monitoring of the PCD will occur prior to any controlled discharges to ensure water quality is within the concentration limits for Awaba LDP009. The Proposed Sediment Control Dam upstream of the PCD will be designed and constructed in accordance with the Blue Book Volume 2E.

If settling does not, or is not expected to, occur within the required five day management period, management of suspended solids within the PCD may be undertaken if required (i.e. if TSS is greater than 50 mg/L). The application of coagulating and/or flocculating agents, such as gypsum, polyacrylamides and alum, may be necessary to improve sediment removal prior to discharge. The application rate is required to be sufficient to remove suspended solids and allow discharge of water within an acceptable time frame without polluting receiving waters with the coagulating/flocculating agent itself.

Centennial Newstan undertake regular site inspections of the water management structures at the Awaba Colliery Surface Site. During operation of the project, site inspections will be completed regularly and as soon as practicable following rainfall events that exceed the design rainfall event for the PCD. The PCD will be inspected for capacity, structural integrity and effectiveness. Sediment accumulated within the dam will be removed as required to maintain water storage capacity.

6.1.2 Newstan LDP001

The existing monitoring of Newstan LDP001 will be continued. Any change to the quality of water discharged via LDP001 resulting from the project will be monitored and managed with Trigger action response plans (TARPs) in the site-specific water management plan.

6.1.3 Newstan LDP017

The existing monitoring of Newstan LDP001 will be continued. The potential impacts to aquatic ecology resulting from any discharges via LDP017 will be monitored and managed with TARPs in the site-specific water management plan.

6.2 Aquatic ecology monitoring

Continuation of the aquatic ecology monitoring program developed for this assessment is recommended following approval of the project. This monitoring would be undertaken twice a year, in autumn and spring AUSRIVAS seasons (Turak *et al.* 2004). Reporting would be undertaken annually, and would assess water quality monitoring data collected by Centennial Newstan in addition to the water quality and sediment quality data collected during the aquatic ecology monitoring program.

7. Conclusions

The potential impacts of the project on aquatic ecology have been assessed, including the following:

- Potential impacts from changes to licensed discharges via Awaba LDP009, Newstan LDP017 and Newstan LDP001 on Stony Creek and LT Creek, respectively.
- Subsidence related impacts which have the potential to adversely affect aquatic communities, including:
  - Reduced habitat availability and fragmentation of habitat
  - Impacts on water and sediment quality
  - Increases in flow velocity

The potential impacts of increased discharges via Awaba LDP009 to Stony Creek are mainly associated with the risk of elevated suspended solids concentrations, which will be mitigated by water quality monitoring and treatment if required.

The frequency of discharges to Stony Creek via LDP017 is likely to increase as a result of the project. As discharges through Newstan LDP017 are in response to heavy rainfall, any change to the water quality in the receiving environment of Stony Creek is predicted to be minor and temporary, and unlikely to adversely affect freshwater aquatic communities. The influence of increased volumes of fresh water on benthic macroinvertebrates in the intertidal zone of Stony Creek is unlikely to be discernible from the response of the community to seasonal variation and long term climate variability.

Increased flow velocities in LT Creek resulting from Newstan LDP001 discharges of up to 14.5 ML/day (which are already approved under the Northern Coal Logistics Project) have the potential to affect macroinvertebrate community composition. However, as no substantial increase in LT Creek flow velocity is expected (GHD 2020b), such impacts are unlikely.

The risk of subsidence related impacts on aquatic ecology was assessed as moderate for Lords Creek, Stony Creek, Kilaben Creek and Stockyard Creek, with the risk of impacts associated with increased flow velocities being high in the Lords Creek catchment, and the risk of water and sediment quality impacts being high in the Stony Creek and Kilaben Creek catchments. There is a low risk of subsidence related impacts in the unnamed tributary of Muddy Lake, assuming that there is no impact of the project on the existing status of the Awaba seepage.

The DPI freshwater threatened species distribution maps (DPI 2019b) indicated no threatened fish species as likely to occur within the study area and there were no EPBC-listed threatened aquatic species identified in areas that are likely to be impacted by subsidence or discharges due to the project. Therefore, the project is unlikely to impact threatened aquatic biota. As the potential impacts of the project would mostly be to areas of poor quality and limited aquatic habitat, no substantial decline in aquatic ecology values is expected.

Mitigation, management and monitoring measures were recommended to allow for the identification of, and response to, the potential impacts to aquatic ecology identified by this report.

8. References

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Appendices

Appendix A – Aquatic ecology monitoring history

Sampling event	CCSC1	WMP20	WMP38	WMP27	By-Wash	WMP03	SP004	SP6	SP5	PCMH	IZ	SCCIZ
Winter 2012	✓	-	-	-	-	-	-	-	✓	-	-	-
Summer 2013	-	-	-	-	-	-	-	-	-	-	-	-
Autumn 2013	-	-	-	-	-	-	-	-	-	-	-	-
Spring 2013	✓	-	-	-	✓	✓	✓	-	✓	-	-	-
Autumn 2014	-	✓	-	-	✓	✓	✓	-	-	-	-	-
Spring 2014	✓	✓	-	-	✓	✓	✓	✓	✓	-	-	-
Autumn 2015	-	✓	✓	-	✓	✓	✓	✓	✓	-	-	-
Spring 2015	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Autumn 2016	-	Dry	Dry	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spring 2016	-	Dry	Dry	✓	✓	✓	✓	✓	✓	✓	✓	✓
Autumn 2017	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spring 2017	-	Dry	Dry	Dry	✓	✓	✓	✓	✓	✓	✓	✓
Autumn 2018	-	Dry	Dry	Dry	✓	✓	✓	✓	✓	✓	✓	✓
Spring 2018	-	✓	✓	Dry	✓	✓	✓	✓	✓	✓	✓	✓
Autumn 2019	✓	Dry	Dry	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spring 2019	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note:

- denotes site was not visited

Dry = site was dry or contained insufficient water to collected macroinvertebrate samples

Appendix B - Laboratory certificates of analysis

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1915560**	Page	: 1 of 8
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Andrew Epps
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61 7 3552 8639
Project	: 2220188	Date Samples Received	: 22-May-2019 16:18
Order number	: AUTUMN 2019	Date Analysis Commenced	: 22-May-2019
C-O-C number	: ----	Issue Date	: 30-May-2019 15:47
Sampler	: ZOE LAGERROTH		
Site	:		
Quote number	: EN/005/18		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Katie Draper	Quality Coordinator	Chemistry, Newcastle West, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK059G: Poor spike recovery for Nitrite + Nitrate as NOx on sample 3 due to matrix interferences.
- ED041G: LOR raised for Sulfate on sample 1 due to sample matrix.
- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EK061G: Poor matrix spike recovery for TKN due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- EG035: Poor matrix spike recovery was obtained for Mercury on sample ES1915560 # 3. Confirmed by re-analysis.
- TDS by method EA-015 may bias high for samples 1 and 2 due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EN055: Ionic Balance out of acceptable limits for sample 1 due to analytes not quantified in this report.
- Poor duplicate precision for Total P due to sample heterogeneity. Confirmed by re-extraction and re-analysis.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	LCREF	SCMID	----	----	----
				Client sampling date / time	22-May-2019 10:00	22-May-2019 12:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1915560-003	ES1915560-004	--------	--------	--------
					Result	Result	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		34.1	36.3	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		5100	5640	----	----	----
Iron	7439-89-6	50	mg/kg		3520	5830	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	<1.0	----	----	----
Arsenic	7440-38-2	1.0	mg/kg		<1.0	<1.0	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	----	----	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	----	----	----
Copper	7440-50-8	1.0	mg/kg		1.7	1.6	----	----	----
Lead	7439-92-1	1.0	mg/kg		3.3	5.8	----	----	----
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	----	----	----
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	----	----	----
Zinc	7440-66-6	1.0	mg/kg		7.2	58.1	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	<0.50	----	----	----
Arsenic	7440-38-2	1.00	mg/kg		<1.00	2.62	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	----	----	----
Chromium	7440-47-3	1.0	mg/kg		3.0	4.1	----	----	----
Copper	7440-50-8	1.0	mg/kg		2.9	4.0	----	----	----
Cobalt	7440-48-4	0.5	mg/kg		0.7	2.6	----	----	----
Lead	7439-92-1	1.0	mg/kg		3.6	5.8	----	----	----
Manganese	7439-96-5	10	mg/kg		20	20	----	----	----
Nickel	7440-02-0	1.0	mg/kg		1.3	3.0	----	----	----
Selenium	7782-49-2	0.1	mg/kg		0.2	0.4	----	----	----
Silver	7440-22-4	0.1	mg/kg		<0.1	<0.1	----	----	----
Vanadium	7440-62-2	2.0	mg/kg		7.3	14.6	----	----	----
Zinc	7440-66-6	1.0	mg/kg		8.5	63.4	----	----	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		0.01	0.02	----	----	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	LCREF	SCMID	----	----	----
				Client sampling date / time	22-May-2019 10:00	22-May-2019 12:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1915560-003	ES1915560-004	--------	--------	--------
					Result	Result	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.3**	<0.1	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.3**	<0.1	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**790**	**580**	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**790**	**580**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**89**	**62**	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**1.83**	**1.82**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	LCREF	SCMID	----	----	----
				Client sampling date / time	22-May-2019 10:00	22-May-2019 12:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1915560-001	ES1915560-002	--------	--------	--------
					Result	Result	----	----	----
EA005: pH									
pH Value	----	0.01	pH Unit		**6.44**	**6.09**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
^ Sodium Adsorption Ratio	----	0.01	-		**2.03**	**1.18**	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**158**	**180**	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	1	mg/L		**168**	**157**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		**103**	**117**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		**15**	**29**	----	----	----
EA045: Turbidity									
Turbidity	----	0.1	NTU		**17.8**	**65.4**	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**26**	**49**	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**24**	**32**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**24**	**32**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		<10	**24**	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**31**	**20**	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**4**	**8**	----	----	----
Magnesium	7439-95-4	1	mg/L		**4**	**7**	----	----	----
Sodium	7440-23-5	1	mg/L		**24**	**19**	----	----	----
Potassium	7440-09-7	1	mg/L		**5**	**2**	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.20**	**0.12**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.001**	<0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	LCREF	SCMID	----	----	----
				Client sampling date / time	22-May-2019 10:00	22-May-2019 12:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1915560-001	ES1915560-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Boron	7440-42-8	0.05	mg/L		<0.05	**0.06**	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.017**	**0.022**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.121**	**0.111**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		<0.005	<0.005	----	----	----
Lithium	7439-93-2	0.001	mg/L		**0.001**	**0.007**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L		**2.59**	**2.59**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.45**	**1.00**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.001**	**0.001**	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	**0.05**	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.021**	**0.030**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	**0.002**	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.195**	**0.131**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	LCREF	SCMID	----	----	----
				Client sampling date / time	22-May-2019 10:00	22-May-2019 12:00	----	----	----
Compound	CAS Number	LOR	Unit		ES1915560-001	ES1915560-002	--------	--------	--------
					Result	Result	----	----	----
EG020T: Total Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		<0.005	**0.007**	----	----	----
Lithium	7439-93-2	0.001	mg/L		**0.001**	**0.007**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L		**4.57**	**9.12**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	**0.0002**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.1**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.03**	**0.17**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**1.4**	**0.9**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**1.4**	**0.9**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.04**	**0.05**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**1.35**	**1.70**	----	----	----
ø Total Cations	----	0.01	meq/L		**1.70**	**1.85**	----	----	----
EP002: Dissolved Organic Carbon (DOC)									

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Client sample ID	**LCREF**	**SCMID**	**----**	**----**	**----**
				Client sampling date / time	22-May-2019 10:00	22-May-2019 12:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**ES1915560-001**	**ES1915560-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
EP002: Dissolved Organic Carbon (DOC) - Continued									
Dissolved Organic Carbon	----	1	mg/L		**31**	**12**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1915759**	Page	: 1 of 8
Amendment	: **2**		
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Andrew Epps
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61 7 3552 8639
Project	: 2220188	Date Samples Received	: 23-May-2019 16:34
Order number	: AUTUMN 2019	Date Analysis Commenced	: 24-May-2019
C-O-C number	: ----	Issue Date	: 12-Jun-2019 13:01
Sampler	: ZOE LAGERROTH		
Site	:		
Quote number	: EN/005/18		
No. of samples received	: 10		
No. of samples analysed	: 10		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK059G: Poor spike recovery for Nitrite + Nitrate as NOx due to matrix interferences.
- ED041G: Poor spike recovery for Sulfate on sample 3 due to matrix interferences.
- ED041G: LOR raised for Sulfate on sample 5 due to sample matrix.
- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- TDS by method EA-015 may bias high for various samples samples due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- Amendment (04/06/2019): This report has been amended and re-released to add analysis for sample SKDS. All analysis results are as per the previous report.
- Amendment (12/06/2019): This report has been amended following changes to the analytical data reported. The quality system is being utilised to resolve this issue. The specific data affected includes EP003 (Total Organic Carbon) results for samples 6<->10.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	SCDS	KCDS	SKDS	SK100	CCSC1
				Client sampling date / time	23-May-2019 08:30	23-May-2019 11:00	23-May-2019 13:00	23-May-2019 13:30	23-May-2019 15:00
Compound	CAS Number	LOR	Unit		ES1915759-006	ES1915759-007	ES1915759-008	ES1915759-009	ES1915759-010
					Result	Result	Result	Result	Result
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		37.6	29.1	32.4	33.6	42.7
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		7510	4420	3830	4090	3730
Iron	7439-89-6	50	mg/kg		14400	3380	4810	3560	3820
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg		1.7	<1.0	<1.0	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Copper	7440-50-8	1.0	mg/kg		3.0	<1.0	1.1	<1.0	<1.0
Lead	7439-92-1	1.0	mg/kg		9.0	8.3	6.1	4.7	2.9
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg		20.7	8.2	8.7	7.9	12.9
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg		3.49	1.10	1.16	1.26	<1.00
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg		3.8	2.6	2.5	2.0	<1.0
Copper	7440-50-8	1.0	mg/kg		2.5	1.4	1.4	1.4	1.6
Cobalt	7440-48-4	0.5	mg/kg		0.7	<0.5	0.8	1.2	1.7
Lead	7439-92-1	1.0	mg/kg		12.0	3.0	3.9	3.8	3.1
Manganese	7439-96-5	10	mg/kg		<10	62	<10	<10	24
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	1.0	<1.0
Selenium	7782-49-2	0.1	mg/kg		2.0	0.1	0.2	0.1	0.3
Silver	7440-22-4	0.1	mg/kg		0.1	<0.1	<0.1	<0.1	0.1
Vanadium	7440-62-2	2.0	mg/kg		15.3	10.4	7.9	5.9	2.8
Zinc	7440-66-6	1.0	mg/kg		17.7	5.9	5.6	5.0	16.5
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		0.04	<0.01	<0.01	<0.01	<0.01
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	<20	<20	<20

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	SCDS	KCDS	SKDS	SK100	CCSC1
				Client sampling date / time	23-May-2019 08:30	23-May-2019 11:00	23-May-2019 13:00	23-May-2019 13:30	23-May-2019 15:00
Compound	CAS Number	LOR	Unit		ES1915759-006	ES1915759-007	ES1915759-008	ES1915759-009	ES1915759-010
					Result	Result	Result	Result	Result
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		**0.2**	<0.1	**0.4**	<0.1	<0.1
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.1**	<0.1	**0.7**	**0.2**	**0.2**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.3**	<0.1	**1.1**	**0.2**	**0.2**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**2560**	**700**	**380**	**350**	**760**
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**2560**	**700**	**380**	**350**	**760**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**76**	**54**	**40**	**54**	**84**
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**15.2**	**1.37**	**0.92**	**0.69**	**1.50**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	SCDS	KCDS	SKDS	SK100	CCSC1
			Client sampling date / time	23-May-2019 08:30	23-May-2019 11:00	23-May-2019 13:00	23-May-2019 13:30	23-May-2019 15:00
Compound	CAS Number	LOR	Unit	ES1915759-001	ES1915759-002	ES1915759-003	ES1915759-004	ES1915759-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.89	6.73	6.47	6.44	6.89
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	1.50	2.31	4.82	4.82	2.21
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	197	355	513	474	219
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	1	mg/L	168	204	295	290	188
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	128	231	333	308	142
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	21	16	13
EA045: Turbidity								
Turbidity	----	0.1	NTU	10.4	26.8	28.0	29.1	20.5
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	40	69	44	44	37
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	28	57	25	25	34
Total Alkalinity as CaCO3	----	1	mg/L	28	57	25	25	34
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	31	18	6	6	<5
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	27	59	124	141	42
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	8	11	3	3	5
Magnesium	7439-95-4	1	mg/L	5	10	9	9	6
Sodium	7440-23-5	1	mg/L	22	44	74	74	31
Potassium	7440-09-7	1	mg/L	3	2	2	2	4
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.07	0.01	0.08	0.08	0.11
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.001	<0.001	<0.001	0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SCDS	KCDS	SKDS	SK100	CCSC1
				Client sampling date / time	23-May-2019 08:30	23-May-2019 11:00	23-May-2019 13:00	23-May-2019 13:30	23-May-2019 15:00
Compound	CAS Number	LOR	Unit		ES1915759-001	ES1915759-002	ES1915759-003	ES1915759-004	ES1915759-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L		**0.024**	**0.032**	**0.025**	**0.024**	**0.018**
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	**0.0003**	<0.0001	<0.0001	**0.0001**
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.046**	**0.168**	**0.110**	**0.103**	**0.176**
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	<0.001	<0.001	**0.001**
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	**0.01**	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L		<0.005	<0.005	<0.005	<0.005	<0.005
Lithium	7439-93-2	0.001	mg/L		**0.003**	<0.001	**0.004**	**0.004**	**0.001**
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Iron	7439-89-6	0.05	mg/L		**0.58**	**0.09**	**0.55**	**0.55**	**1.10**
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.35**	**0.09**	**0.22**	**0.22**	**0.22**
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	7440-38-2	0.001	mg/L		**0.002**	<0.001	<0.001	<0.001	<0.001
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
Barium	7440-39-3	0.001	mg/L		**0.028**	**0.033**	**0.031**	**0.028**	**0.023**
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	**0.0002**	<0.0001
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		**0.002**	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L		**0.060**	**0.171**	**0.159**	**0.147**	**0.182**
Nickel	7440-02-0	0.001	mg/L		**0.002**	<0.001	<0.001	<0.001	**0.001**
Lead	7439-92-1	0.001	mg/L		**0.001**	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SCDS	KCDS	SKDS	SK100	CCSC1
				Client sampling date / time	23-May-2019 08:30	23-May-2019 11:00	23-May-2019 13:00	23-May-2019 13:30	23-May-2019 15:00
Compound	CAS Number	LOR	Unit		ES1915759-001	ES1915759-002	ES1915759-003	ES1915759-004	ES1915759-005
					Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		**0.010**	<0.005	<0.005	<0.005	<0.005
Lithium	7439-93-2	0.001	mg/L		**0.004**	<0.001	**0.005**	**0.004**	**0.001**
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Iron	7439-89-6	0.05	mg/L		**1.96**	**3.83**	**4.79**	**4.68**	**2.66**
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.1**	<0.1	**0.2**	**0.1**	**0.1**
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.03**	**0.02**	**0.02**	**0.02**	**0.05**
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.7**	**0.1**	**1.0**	**0.6**	**1.6**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.7**	**0.1**	**1.0**	**0.6**	**1.6**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.10**	**0.02**	**0.08**	**0.03**	**0.14**
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**0.01**
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**1.97**	**3.18**	**4.12**	**4.60**	**1.86**
ø Total Cations	----	0.01	meq/L		**1.84**	**3.34**	**4.16**	**4.16**	**2.19**
ø Ionic Balance	----	0.01	%		**----**	**2.44**	**0.46**	**5.04**	**----**

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Client sample ID	SCDS	KCDS	SKDS	SK100	CCSC1
				Client sampling date / time	23-May-2019 08:30	23-May-2019 11:00	23-May-2019 13:00	23-May-2019 13:30	23-May-2019 15:00
Compound	*CAS Number*	*LOR*	*Unit*		**ES1915759-001**	**ES1915759-002**	**ES1915759-003**	**ES1915759-004**	**ES1915759-005**
					Result	Result	Result	Result	Result
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**17**	**7**	**13**	**12**	**25**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1915760**	Page	: 1 of 7
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Andrew Epps
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61 7 3552 8639
Project	: 2220036	Date Samples Received	: 23-May-2019 16:36
Order number	: AUTUMN 2019 SALINE SAMPLES	Date Analysis Commenced	: 24-May-2019
C-O-C number	: ----	Issue Date	: 03-Jun-2019 21:20
Sampler	: ZOE LAGERROTH		
Site	:		
Quote number	: EN/005/18		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK059G: Poor spike recovery for Nitrite + Nitrate as NOx due to matrix interferences.
- EG093: It has been confirmed by re-digestion and re-analysis that total Manganese and Barium concentration is less than dissolved for sample ES1915760-#001. For all other samples and analytes where dissolved is greater than total, the difference is within experimental variation of the methods.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	IZ	----	----	----	----
				Client sampling date / time	23-May-2019 15:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1915760-002	--------	--------	--------	--------
					Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		**40.0**	----	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**7660**	----	----	----	----
Iron	7439-89-6	50	mg/kg		**13200**	----	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	----	----	----	----
Arsenic	7440-38-2	1.0	mg/kg		**2.0**	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		**2.3**	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg		**1.8**	----	----	----	----
Copper	7440-50-8	1.0	mg/kg		**15.1**	----	----	----	----
Lead	7439-92-1	1.0	mg/kg		**39.4**	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg		**1.4**	----	----	----	----
Silver	7440-22-4	1.0	mg/kg		<1.0	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg		**173**	----	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	----	----	----	----
Arsenic	7440-38-2	1.00	mg/kg		**9.00**	----	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		**2.4**	----	----	----	----
Chromium	7440-47-3	1.0	mg/kg		**8.2**	----	----	----	----
Copper	7440-50-8	1.0	mg/kg		**33.3**	----	----	----	----
Cobalt	7440-48-4	0.5	mg/kg		**2.1**	----	----	----	----
Lead	7439-92-1	1.0	mg/kg		**45.8**	----	----	----	----
Manganese	7439-96-5	10	mg/kg		**46**	----	----	----	----
Nickel	7440-02-0	1.0	mg/kg		**3.4**	----	----	----	----
Selenium	7782-49-2	0.1	mg/kg		**0.8**	----	----	----	----
Silver	7440-22-4	0.1	mg/kg		<0.1	----	----	----	----
Vanadium	7440-62-2	2.0	mg/kg		**24.1**	----	----	----	----
Zinc	7440-66-6	1.0	mg/kg		**220**	----	----	----	----
EG020-SDH: 1M HCl Extractable metals by ICPMS									
Selenium	7782-49-2	0.5	mg/kg		**1.8**	----	----	----	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		**0.08**	----	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	IZ	----	----	----	----
				Client sampling date / time	23-May-2019 15:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1915760-002	--------	--------	--------	--------
					Result	----	----	----	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.1**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.1**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**1360**	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ **Total Nitrogen as N**	----	20	mg/kg		**1360**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**190**	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**2.97**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IZ	----	----	----	----
				Client sampling date / time	23-May-2019 15:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1915760-001	--------	--------	--------	--------
					Result	----	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**7.99**	----	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**40200**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	1	mg/L		**27300**	----	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		**26100**	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	----	----	----	----
EA045: Turbidity									
Turbidity	----	0.1	NTU		**2.4**	----	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**4100**	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**236**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**236**	----	----	----	----
ED040F: Dissolved Major Anions									
Silicon as SiO2	14464-46-1	0.1	mg/L		**5.2**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**2040**	----	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**12800**	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**285**	----	----	----	----
Magnesium	7439-95-4	1	mg/L		**822**	----	----	----	----
Sodium	7440-23-5	1	mg/L		**6930**	----	----	----	----
Potassium	7440-09-7	1	mg/L		**245**	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.005	µg/L		<0.005	----	----	----	----
EG035T: Total Mercury by FIMS									
Mercury	7439-97-6	0.005	µg/L		**0.007**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IZ	----	----	----	----
				Client sampling date / time	23-May-2019 15:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1915760-001	--------	--------	--------	--------
					Result	----	----	----	----
EG093F: Dissolved Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		<5	----	----	----	----
Antimony	7440-36-0	0.5	µg/L		<0.5	----	----	----	----
Arsenic	7440-38-2	0.5	µg/L		**1.1**	----	----	----	----
Barium	7440-39-3	1	µg/L		**48**	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L		<0.1	----	----	----	----
Boron	7440-42-8	100	µg/L		**3540**	----	----	----	----
Cadmium	7440-43-9	0.1	µg/L		<0.1	----	----	----	----
Chromium	7440-47-3	0.5	µg/L		<0.5	----	----	----	----
Cobalt	7440-48-4	0.2	µg/L		**0.2**	----	----	----	----
Copper	7440-50-8	1	µg/L		**2**	----	----	----	----
Iron	7439-89-6	5	µg/L		**15**	----	----	----	----
Lead	7439-92-1	0.2	µg/L		<0.2	----	----	----	----
Lithium	7439-93-2	1	µg/L		**227**	----	----	----	----
Manganese	7439-96-5	0.5	µg/L		**60.8**	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L		**17.8**	----	----	----	----
Nickel	7440-02-0	0.5	µg/L		**3.6**	----	----	----	----
Selenium	7782-49-2	2	µg/L		<2	----	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	----	----	----	----
Tin	7440-31-5	5	µg/L		<5	----	----	----	----
Titanium	7440-32-6	5	µg/L		<5	----	----	----	----
Vanadium	7440-62-2	0.5	µg/L		**2.6**	----	----	----	----
Zinc	7440-66-6	5	µg/L		**8**	----	----	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS									
Aluminium	7429-90-5	5	µg/L		**95**	----	----	----	----
Antimony	7440-36-0	0.5	µg/L		<0.5	----	----	----	----
Arsenic	7440-38-2	0.5	µg/L		**1.6**	----	----	----	----
Barium	7440-39-3	1	µg/L		**28**	----	----	----	----
Beryllium	7440-41-7	0.1	µg/L		<0.1	----	----	----	----
Boron	7440-42-8	100	µg/L		**3980**	----	----	----	----
Cadmium	7440-43-9	0.2	µg/L		<0.2	----	----	----	----
Chromium	7440-47-3	0.5	µg/L		<0.5	----	----	----	----
Cobalt	7440-48-4	0.2	µg/L		<0.2	----	----	----	----
Copper	7440-50-8	1	µg/L		**3**	----	----	----	----
Iron	7439-89-6	5	µg/L		**109**	----	----	----	----
Lead	7439-92-1	0.2	µg/L		**0.4**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	IZ	----	----	----	----
				Client sampling date / time	23-May-2019 15:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1915760-001	--------	--------	--------	--------
					Result	----	----	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS - Continued									
Lithium	7439-93-2	1	µg/L		**214**	----	----	----	----
Manganese	7439-96-5	0.5	µg/L		**34.0**	----	----	----	----
Molybdenum	7439-98-7	0.1	µg/L		**17.0**	----	----	----	----
Nickel	7440-02-0	0.5	µg/L		**2.5**	----	----	----	----
Selenium	7782-49-2	2	µg/L		<2	----	----	----	----
Silver	7440-22-4	0.1	µg/L		<0.1	----	----	----	----
Tin	7440-31-5	5	µg/L		<5	----	----	----	----
Titanium	7440-32-6	5	µg/L		<5	----	----	----	----
Vanadium	7440-62-2	0.5	µg/L		**2.4**	----	----	----	----
Zinc	7440-66-6	5	µg/L		**23**	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.8**	----	----	----	----
EK055G-SW: Ammonia as N by Discrete Analyser in Sea Water									
Ammonia as N	7664-41-7	0.02	mg/L		**0.09**	----	----	----	----
EK262A: Total Nitrogen									
Total Nitrogen as N	----	0.050	mg/L		**0.358**	----	----	----	----
EK267A: Total Phosphorus (Persulfate Digestion)									
Total Phosphorus as P	----	0.005	mg/L		**0.008**	----	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**408**	----	----	----	----
ø Total Cations	----	0.01	meq/L		**390**	----	----	----	----
ø Ionic Balance	----	0.01	%		**2.34**	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**2**	----	----	----	----
EP020: Oil and Grease (O&G)									
Oil & Grease	----	5	mg/L		<5	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1933915**	Page	: 1 of 8
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Customer Services ES
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61-2-8784 8555
Project	: 22201888	Date Samples Received	: 16-Oct-2019 15:57
Order number	: SPRING 2019	Date Analysis Commenced	: 17-Oct-2019
C-O-C number	: ----	Issue Date	: 23-Oct-2019 16:12
Sampler	: JOE CAIRNS		
Site	:		
Quote number	: EN/005/19		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Poor spike recovery for (Flouride) due to matrix interferences(confirmed by re-analysis).
- EG035: Poor matrix spike recovery was obtained for Mercury on sample ES1933557 # 7. Confirmed by re-analysis.
- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EG035: Poor matrix spike recovery was obtained for Mercury on sample ES1934139 # 2. Confirmed by re-analysis.
- EK061G: Poor matrix spike for TKN due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	CCSC1	SKDS	----	----	----
				Client sampling date / time	16-Oct-2019 11:30	16-Oct-2019 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES1933915-003	ES1933915-004	--------	--------	--------
					Result	Result	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		**19.2**	**47.8**	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**2130**	**4360**	----	----	----
Iron	7439-89-6	50	mg/kg		**2050**	**3070**	----	----	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	<1.0	----	----	----
Arsenic	7440-38-2	1.0	mg/kg		<1.0	<1.0	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	----	----	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	----	----	----
Copper	7440-50-8	1.0	mg/kg		<1.0	<1.0	----	----	----
Lead	7439-92-1	1.0	mg/kg		**1.0**	**4.4**	----	----	----
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	----	----	----
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	----	----	----
Zinc	7440-66-6	1.0	mg/kg		**8.0**	**6.1**	----	----	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	<0.50	----	----	----
Arsenic	7440-38-2	1.00	mg/kg		<1.00	<1.00	----	----	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	----	----	----
Chromium	7440-47-3	1.0	mg/kg		**1.0**	**2.2**	----	----	----
Copper	7440-50-8	1.0	mg/kg		<1.0	**1.7**	----	----	----
Cobalt	7440-48-4	0.5	mg/kg		**1.2**	**0.7**	----	----	----
Lead	7439-92-1	1.0	mg/kg		**1.8**	**6.7**	----	----	----
Manganese	7439-96-5	10	mg/kg		**11**	**11**	----	----	----
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	----	----	----
Selenium	7782-49-2	0.1	mg/kg		<0.1	**0.3**	----	----	----
Silver	7440-22-4	0.1	mg/kg		<0.1	<0.1	----	----	----
Vanadium	7440-62-2	2.0	mg/kg		**2.1**	**7.0**	----	----	----
Zinc	7440-66-6	1.0	mg/kg		**21.4**	**10.6**	----	----	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		<0.01	**0.01**	----	----	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	CCSC1	SKDS	----	----	----
				Client sampling date / time	16-Oct-2019 11:30	16-Oct-2019 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES1933915-003	ES1933915-004	--------	--------	--------
					Result	Result	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.2**	**0.1**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.2**	**0.1**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**280**	**870**	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**280**	**870**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**51**	**69**	----	----	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**0.46**	**2.52**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	CCSC1	SKDS	----	----	----
			Client sampling date / time	16-Oct-2019 11:30	16-Oct-2019 14:30	----	----	----
Compound	CAS Number	LOR	Unit	ES1933915-001	ES1933915-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.73**	**6.24**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
^ Sodium Adsorption Ratio	----	0.01	-	**2.36**	**3.57**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**266**	**268**	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	1	mg/L	**200**	**203**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)								
Total Dissolved Solids (Calc.)	----	1	mg/L	**173**	**174**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	**12**	**9**	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**8.6**	**15.1**	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**35**	**21**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**33**	**16**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**33**	**16**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**12**	**6**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**57**	**61**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**4**	**2**	----	----	----
Magnesium	7439-95-4	1	mg/L	**6**	**4**	----	----	----
Sodium	7440-23-5	1	mg/L	**32**	**38**	----	----	----
Potassium	7440-09-7	1	mg/L	**5**	**2**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.23**	**0.31**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	<0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	CCSC1	SKDS	----	----	----
				Client sampling date / time	16-Oct-2019 11:30	16-Oct-2019 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES1933915-001	ES1933915-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.027**	**0.018**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.224**	**0.027**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.001**	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.005**	**0.010**	----	----	----
Lithium	7439-93-2	0.001	mg/L		<0.001	**0.002**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L		**1.44**	**1.01**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.59**	**1.08**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.002**	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.026**	**0.020**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.002**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		**0.002**	**0.001**	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.247**	**0.029**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	**0.001**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	CCSC1	SKDS	----	----	----
				Client sampling date / time	16-Oct-2019 11:30	16-Oct-2019 14:30	----	----	----
Compound	CAS Number	LOR	Unit		ES1933915-001	ES1933915-002	--------	--------	--------
					Result	Result	----	----	----
EG020T: Total Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		<0.005	**0.010**	----	----	----
Lithium	7439-93-2	0.001	mg/L		<0.001	**0.002**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L		**2.26**	**2.08**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.1**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.13**	**0.04**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.02**	**0.02**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.02**	**0.02**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**1.2**	**0.6**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**1.2**	**0.6**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.27**	**0.03**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		**0.02**	<0.01	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**2.52**	**2.16**	----	----	----
ø Total Cations	----	0.01	meq/L		**2.30**	----	----	----	----
ø Total Cations	----	0.01	meq/L		----	**2.13**	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Client sample ID	**CCSC1**	**SKDS**	**----**	**----**	**----**
				Client sampling date / time	16-Oct-2019 11:30	16-Oct-2019 14:30	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**ES1933915-001**	**ES1933915-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**24**	**22**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1934123**	Page	: 1 of 7
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Customer Services ES
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61-2-8784 8555
Project	: 2220188	Date Samples Received	: 17-Oct-2019 15:51
Order number	: SPRING 2019	Date Analysis Commenced	: 17-Oct-2019
C-O-C number	: ----	Issue Date	: 24-Oct-2019 17:59
Sampler	: JOE CAIRNS		
Site	:		
Quote number	: EN/005/19		
No. of samples received	: 8		
No. of samples analysed	: 8		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Evie Sidarta	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK057G, EK071G: LOR raised for Nitrite and Reactive Phosphorus on sample no:1 due to sample matrix.
- EG035: Poor matrix spike recovery was obtained for Mercury on sample ES1933557 # 7. Confirmed by re-analysis.
- EG020: It is recognised that total concentration is less than dissolved for some metal analytes. However, the difference is within experimental variation of the methods.
- EK061G: Poor duplicate for TKN due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- EK061G/EK067G: Poor matrix spike for TKN due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- EK059G-EK058G: LOR raised for NOx-Nitrate on sample 1 due to sample matrix.
- EG020: (Aluminium, Barium and Copper) results for samples (ES1934123 #002 and #003) confirmed by re-digestion and reanalysis.
- TDS by method EA-015 may bias high for all samples due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	LCDS	LC REF.	LC DUP	SC MID	----
				Client sampling date / time	17-Oct-2019 09:10	17-Oct-2019 10:15	17-Oct-2019 10:45	17-Oct-2019 12:30	----
Compound	CAS Number	LOR	Unit		ES1934123-005	ES1934123-006	ES1934123-007	ES1934123-008	--------
					Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		69.7	30.2	32.7	24.8	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg		3.0	<1.0	<1.0	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg		0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Copper	7440-50-8	1.0	mg/kg		9.8	<1.0	1.2	<1.0	----
Lead	7439-92-1	1.0	mg/kg		18.9	1.8	1.7	1.8	----
Nickel	7440-02-0	1.0	mg/kg		6.9	<1.0	<1.0	<1.0	----
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Zinc	7440-66-6	1.0	mg/kg		28.5	6.1	7.8	8.3	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	<0.10	<0.10	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	<20	<20	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		1.4	0.4	0.4	0.4	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		1.4	0.4	0.4	0.4	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		5050	690	1110	280	----
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		5050	690	1110	280	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		493	95	146	41	----
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		6.51	2.20	2.53	0.75	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	LCDS	LC REF	LC DUP	SC MID	----
				Client sampling date / time	17-Oct-2019 09:10	17-Oct-2019 10:15	17-Oct-2019 10:45	17-Oct-2019 12:30	----
Compound	CAS Number	LOR	Unit		ES1934123-001	ES1934123-002	ES1934123-003	ES1934123-004	--------
					Result	Result	Result	Result	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.20	6.97	6.90	6.39	----
EA006: Sodium Adsorption Ratio (SAR)									
^ Sodium Adsorption Ratio	----	0.01	-		1.05	2.09	1.95	1.29	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		287	156	155	134	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	1	mg/L		316	137	169	121	----
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		186	101	101	87	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	<5	<5	<5	----
EA045: Turbidity									
Turbidity	----	0.1	NTU		23.2	14.8	15.1	43.6	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		90	17	20	22	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		47	16	15	9	----
Total Alkalinity as CaCO3	----	1	mg/L		47	16	15	9	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		61	2	2	22	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		23	30	29	18	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		13	2	3	4	----
Magnesium	7439-95-4	1	mg/L		14	3	3	3	----
Sodium	7440-23-5	1	mg/L		23	20	20	14	----
Potassium	7440-09-7	1	mg/L		3	5	5	2	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.37	0.85	0.49	0.58	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Arsenic	7440-38-2	0.001	mg/L		0.003	<0.001	0.001	<0.001	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	LCDS	LC REF	LC DUP	SC MID	----
				Client sampling date / time	17-Oct-2019 09:10	17-Oct-2019 10:15	17-Oct-2019 10:45	17-Oct-2019 12:30	----
Compound	CAS Number	LOR	Unit		ES1934123-001	ES1934123-002	ES1934123-003	ES1934123-004	--------
					Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
Barium	7440-39-3	0.001	mg/L		**0.018**	**0.022**	**0.016**	**0.018**	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
Cobalt	7440-48-4	0.001	mg/L		**0.004**	<0.001	<0.001	<0.001	----
Chromium	7440-47-3	0.001	mg/L		**0.002**	<0.001	**0.001**	**0.001**	----
Copper	7440-50-8	0.001	mg/L		**0.003**	**0.002**	**0.001**	**0.001**	----
Manganese	7439-96-5	0.001	mg/L		**0.278**	**0.059**	**0.059**	**0.059**	----
Nickel	7440-02-0	0.001	mg/L		**0.008**	**0.002**	**0.007**	**0.002**	----
Lead	7439-92-1	0.001	mg/L		**0.002**	<0.001	<0.001	<0.001	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L		**0.010**	**0.006**	<0.005	**0.034**	----
Lithium	7439-93-2	0.001	mg/L		**0.003**	<0.001	<0.001	**0.004**	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Titanium	7440-32-6	0.01	mg/L		<0.01	**0.03**	**0.02**	**0.01**	----
Iron	7439-89-6	0.05	mg/L		**6.98**	**1.01**	**0.88**	**1.30**	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**1.21**	**1.09**	**1.10**	**2.07**	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Arsenic	7440-38-2	0.001	mg/L		**0.004**	**0.001**	**0.001**	<0.001	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
Barium	7440-39-3	0.001	mg/L		**0.021**	**0.019**	**0.018**	**0.023**	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
Cobalt	7440-48-4	0.001	mg/L		**0.006**	<0.001	<0.001	**0.001**	----
Chromium	7440-47-3	0.001	mg/L		**0.003**	**0.001**	**0.002**	**0.002**	----
Copper	7440-50-8	0.001	mg/L		**0.006**	**0.019**	**0.003**	**0.003**	----
Manganese	7439-96-5	0.001	mg/L		**0.337**	**0.075**	**0.080**	**0.061**	----
Nickel	7440-02-0	0.001	mg/L		**0.010**	**0.003**	**0.003**	**0.003**	----
Lead	7439-92-1	0.001	mg/L		**0.003**	<0.001	<0.001	**0.001**	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Vanadium	7440-62-2	0.01	mg/L		**0.01**	<0.01	<0.01	<0.01	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	LCDS	LC REF	LC DUP	SC MID	----
				Client sampling date / time	17-Oct-2019 09:10	17-Oct-2019 10:15	17-Oct-2019 10:45	17-Oct-2019 12:30	----
Compound	CAS Number	LOR	Unit		ES1934123-001	ES1934123-002	ES1934123-003	ES1934123-004	--------
					Result	Result	Result	Result	----
EG020T: Total Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		**0.015**	**0.007**	**0.014**	**0.044**	----
Lithium	7439-93-2	0.001	mg/L		**0.003**	<0.001	<0.001	**0.005**	----
Molybdenum	7439-98-7	0.001	mg/L		**0.002**	<0.001	<0.001	<0.001	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Iron	7439-89-6	0.05	mg/L		**10.3**	**1.37**	**1.38**	**3.00**	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	**0.2**	**0.2**	**0.1**	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.27**	**0.05**	**0.07**	**0.04**	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.05	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.05	**0.02**	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.05	**0.02**	<0.01	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**2.1**	**1.2**	**1.0**	**0.4**	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**2.1**	**1.2**	**1.0**	**0.4**	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.16**	**0.06**	**0.04**	**0.02**	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.02	<0.01	<0.01	<0.01	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**2.86**	**1.21**	**1.16**	**1.14**	----
ø Total Cations	----	0.01	meq/L		**2.88**	**1.34**	**1.39**	**1.11**	----
EP002: Dissolved Organic Carbon (DOC)									

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Client sample ID	**LCDS**	**LC REF**	**LC DUP**	**SC MID**	**----**
				Client sampling date / time	17-Oct-2019 09:10	17-Oct-2019 10:15	17-Oct-2019 10:45	17-Oct-2019 12:30	----
Compound	*CAS Number*	*LOR*	*Unit*		**ES1934123-001**	**ES1934123-002**	**ES1934123-003**	**ES1934123-004**	**--------**
					Result	Result	Result	Result	----
EP002: Dissolved Organic Carbon (DOC) - Continued									
Dissolved Organic Carbon	----	1	mg/L		**57**	**27**	**26**	**16**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1934266**	Page	: 1 of 8
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Customer Services ES
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61-2-8784 8555
Project	: 2220188	Date Samples Received	: 18-Oct-2019 14:18
Order number	: ----	Date Analysis Commenced	: 19-Oct-2019
C-O-C number	: ----	Issue Date	: 29-Oct-2019 14:12
Sampler	: JOE CAIRNS		
Site	:		
Quote number	: EN/005/19		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Evie Sidarta	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EK061G/EK067G: Poor matrix spike for TKN due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- EK067G: Poor duplicate for Total P due to sample heterogeneity. Confirmed by re-digestion and re-analysis.
- EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	SCDS	KCDS	SCDS <2000µm Fraction	KCDS <2000µm Fraction	----
				Client sampling date / time	18-Oct-2019 09:00	18-Oct-2019 11:45	18-Oct-2019 09:00	18-Oct-2019 11:45	----
Compound	CAS Number	LOR	Unit		ES1934266-003	ES1934266-004	ES1934266-005	ES1934266-006	--------
					Result	Result	Result	Result	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	1.0	%		**46.3**	**24.0**	----	----	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		----	----	**3350**	**4440**	----
Iron	7439-89-6	50	mg/kg		----	----	**10300**	**8980**	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		----	----	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg		----	----	**2.6**	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg		----	----	**0.1**	<0.1	----
Chromium	7440-47-3	1.0	mg/kg		----	----	<1.0	**1.6**	----
Copper	7440-50-8	1.0	mg/kg		----	----	**6.3**	**2.1**	----
Lead	7439-92-1	1.0	mg/kg		----	----	**13.2**	**3.2**	----
Nickel	7440-02-0	1.0	mg/kg		----	----	**1.1**	<1.0	----
Silver	7440-22-4	1.0	mg/kg		----	----	<1.0	<1.0	----
Zinc	7440-66-6	1.0	mg/kg		----	----	**28.8**	**4.4**	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		----	----	<0.50	<0.50	----
Arsenic	7440-38-2	1.00	mg/kg		----	----	**5.47**	**2.06**	----
Cadmium	7440-43-9	0.1	mg/kg		----	----	<0.1	<0.1	----
Chromium	7440-47-3	1.0	mg/kg		----	----	**4.0**	**3.0**	----
Copper	7440-50-8	1.0	mg/kg		----	----	**8.9**	**2.2**	----
Cobalt	7440-48-4	0.5	mg/kg		----	----	**1.2**	**0.6**	----
Lead	7439-92-1	1.0	mg/kg		----	----	**15.6**	**4.1**	----
Manganese	7439-96-5	10	mg/kg		----	----	**13**	**62**	----
Nickel	7440-02-0	1.0	mg/kg		----	----	**1.9**	<1.0	----
Selenium	7782-49-2	0.1	mg/kg		----	----	**0.7**	**0.1**	----
Silver	7440-22-4	0.1	mg/kg		----	----	<0.1	<0.1	----
Vanadium	7440-62-2	2.0	mg/kg		----	----	**14.2**	**14.9**	----
Zinc	7440-66-6	1.0	mg/kg		----	----	**36.8**	**7.0**	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		----	----	<0.10	<0.10	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		----	----	**0.04**	<0.01	----
EK055: Ammonia as N									
Ammonia as N	7664-41-7	20	mg/kg		<20	<20	----	----	----

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	SCDS	KCDS	SCDS <2000µm Fraction	KCDS <2000µm Fraction	----
				Client sampling date / time	18-Oct-2019 09:00	18-Oct-2019 11:45	18-Oct-2019 09:00	18-Oct-2019 11:45	----
Compound	CAS Number	LOR	Unit		ES1934266-003	ES1934266-004	ES1934266-005	ES1934266-006	--------
					Result	Result	Result	Result	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N (Sol.)	14797-65-0	0.1	mg/kg		**0.2**	<0.1	**----**	**----**	**----**
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N (Sol.)	14797-55-8	0.1	mg/kg		**0.4**	**0.2**	**----**	**----**	**----**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.6**	**0.2**	**----**	**----**	**----**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**1540**	**210**	**----**	**----**	**----**
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**1540**	**210**	**----**	**----**	**----**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**35**	**52**	**----**	**----**	**----**
EP003: Total Organic Carbon (TOC) in Soil									
Total Organic Carbon	----	0.02	%		**7.70**	**1.01**	**----**	**----**	**----**
GEO26: Sieving									
-2000µm	----	0.01	%		**----**	**----**	**67.1**	**57.8**	**----**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SCDS	KCDS	----	----	----
				Client sampling date / time	18-Oct-2019 09:00	18-Oct-2019 11:45	----	----	----
Compound	CAS Number	LOR	Unit		ES1934266-001	ES1934266-002	--------	--------	--------
					Result	Result	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**7.04**	**7.14**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
^ Sodium Adsorption Ratio	----	0.01	-		**1.71**	**2.17**	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**305**	**368**	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C									
Total Dissolved Solids @180°C	----	1	mg/L		**208**	**244**	----	----	----
EA016: Calculated TDS (from Electrical Conductivity)									
Total Dissolved Solids (Calc.)	----	1	mg/L		**198**	**239**	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L		<5	<5	----	----	----
EA045: Turbidity									
Turbidity	----	0.1	NTU		**43.0**	**30.6**	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**58**	**64**	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**22**	**55**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**22**	**55**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**46**	**17**	----	----	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**38**	**55**	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**10**	**11**	----	----	----
Magnesium	7439-95-4	1	mg/L		**8**	**9**	----	----	----
Sodium	7440-23-5	1	mg/L		**30**	**40**	----	----	----
Potassium	7440-09-7	1	mg/L		**3**	**2**	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.07**	**0.04**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SCDS	KCDS	----	----	----
				Client sampling date / time	18-Oct-2019 09:00	18-Oct-2019 11:45	----	----	----
Compound	CAS Number	LOR	Unit		ES1934266-001	ES1934266-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.043**	**0.033**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	**0.001**	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.008**	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.066**	**0.148**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.003**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.001**	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.070**	<0.005	----	----	----
Lithium	7439-93-2	0.001	mg/L		**0.005**	<0.001	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L		<0.01	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L		**0.42**	**0.44**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**1.34**	**0.45**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.003**	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.050**	**0.038**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.002**	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		**0.002**	**0.002**	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.009**	**0.001**	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.083**	**0.170**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.004**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.012**	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	SCDS	KCDS	----	----	----
				Client sampling date / time	18-Oct-2019 09:00	18-Oct-2019 11:45	----	----	----
Compound	CAS Number	LOR	Unit		ES1934266-001	ES1934266-002	--------	--------	--------
					Result	Result	----	----	----
EG020T: Total Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		**0.105**	<0.005	----	----	----
Lithium	7439-93-2	0.001	mg/L		**0.006**	**0.001**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		<0.001	<0.001	----	----	----
Silver	7440-22-4	0.001	mg/L		<0.001	<0.001	----	----	----
Tin	7440-31-5	0.001	mg/L		<0.001	<0.001	----	----	----
Titanium	7440-32-6	0.01	mg/L		**0.01**	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L		**2.38**	**3.41**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.1**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.05**	**0.05**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.04**	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.04**	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.4**	**0.2**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**0.4**	**0.2**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.21**	**0.04**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		**0.01**	<0.01	----	----	----
EN055: Ionic Balance									
ø Total Anions	----	0.01	meq/L		**2.47**	**3.00**	----	----	----
ø Total Cations	----	0.01	meq/L		**2.54**	**3.08**	----	----	----
ø Ionic Balance	----	0.01	%		**----**	**1.25**	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Client sample ID	**SCDS**	**KCDS**	**----**	**----**	**----**
				Client sampling date / time	18-Oct-2019 09:00	18-Oct-2019 11:45	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**ES1934266-001**	**ES1934266-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
EP002: Dissolved Organic Carbon (DOC)									
Dissolved Organic Carbon	----	1	mg/L		**11**	**10**	**----**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1934910**	Page	: 1 of 4
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: MR JOE CAIRNS	Contact	: Customer Services ES
Address	: PO BOX 5403 NEWCASTLE WEST NSW, AUSTRALIA 2302	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 02 6393 6400	Telephone	: +61-2-8784 8555
Project	: 2220036	Date Samples Received	: 15-Oct-2019 17:00
Order number	:	Date Analysis Commenced	: 28-Oct-2019
C-O-C number	: ----	Issue Date	: 08-Nov-2019 12:58
Sampler	: JOE CAIRNS		
Site	:		
Quote number	: EN/005/19		
No. of samples received	: 9		
No. of samples analysed	: 9		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020-SD (Total Metals in Sediments by ICP-MS): Sample ES1934910-001(PCMH) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- EG005 SDH (1M HCl Extractable Metals): Sample ES1934910-001 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection
- EG035-SDH (1M HCl Extractable Mercury) Sample ES1934910-002 (IZ) shows poor matrix spike recovery due to sample heterogeneity. Confirmed by re-extraction and re-analysis.

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	PCMH <2000µm Fraction	IZ <2000µm Fraction	SCCIZ <2000µm Fraction	CCSC1 <2000µm Fraction	SKDS <2000µm Fraction
				Client sampling date / time	15-Oct-2019 00:00	16-Oct-2019 00:00	16-Oct-2019 00:00	16-Oct-2019 00:00	16-Oct-2019 00:00
Compound	CAS Number	LOR	Unit		ES1934910-001	ES1934910-002	ES1934910-003	ES1934910-004	ES1934910-005
					Result	Result	Result	Result	Result
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		2090	2800	2540	990	1200
Iron	7439-89-6	50	mg/kg		4920	5860	6440	2190	1640
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic	7440-38-2	1.0	mg/kg		1.4	2.3	1.7	<1.0	<1.0
Cadmium	7440-43-9	0.1	mg/kg		0.4	1.4	1.0	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg		<1.0	1.1	<1.0	<1.0	<1.0
Copper	7440-50-8	1.0	mg/kg		4.5	18.1	11.5	1.1	<1.0
Lead	7439-92-1	1.0	mg/kg		6.8	23.4	18.6	1.9	3.3
Nickel	7440-02-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	<1.0
Zinc	7440-66-6	1.0	mg/kg		67.9	93.7	80.9	10.1	3.8
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	<0.50	<0.50	<0.50	<0.50
Arsenic	7440-38-2	1.00	mg/kg		2.41	5.14	4.78	<1.00	<1.00
Cadmium	7440-43-9	0.1	mg/kg		0.3	1.4	1.3	<0.1	<0.1
Chromium	7440-47-3	1.0	mg/kg		2.8	4.1	4.3	<1.0	<1.0
Copper	7440-50-8	1.0	mg/kg		15.5	26.6	22.1	1.4	1.6
Cobalt	7440-48-4	0.5	mg/kg		0.8	1.1	1.4	2.0	<0.5
Lead	7439-92-1	1.0	mg/kg		8.0	26.1	34.2	1.7	4.2
Manganese	7439-96-5	10	mg/kg		19	28	42	20	<10
Nickel	7440-02-0	1.0	mg/kg		1.7	2.2	3.5	1.7	<1.0
Selenium	7782-49-2	0.1	mg/kg		0.6	0.4	0.6	<0.1	<0.1
Silver	7440-22-4	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	2.0	mg/kg		7.9	10.0	9.5	2.2	3.7
Zinc	7440-66-6	1.0	mg/kg		64.6	114	104	12.7	5.0
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	<0.10	<0.10	<0.10
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		0.12	0.05	0.03	<0.01	<0.01
GEO26: Sieving									
-2000µm	----	0.01	%		90.9	87.1	47.0	39.8	88.9

Analytical Results

Sub-Matrix: SEDIMENT (Matrix: SOIL)				Client sample ID	LCDS <2000µm Fraction	LC REF <2000µm Fraction	LC DUP <2000µm Fraction	SC MID <2000µm Fraction	----
				Client sampling date / time	17-Oct-2019 00:00	17-Oct-2019 00:00	17-Oct-2019 00:00	17-Oct-2019 00:00	----
Compound	CAS Number	LOR	Unit		ES1934910-006	ES1934910-007	ES1934910-008	ES1934910-009	--------
					Result	Result	Result	Result	----
EG005(ED093)-SD: Total Metals in Sediments by ICP-AES									
Aluminium	7429-90-5	50	mg/kg		**2820**	**1330**	**1280**	**1560**	----
Iron	7439-89-6	50	mg/kg		**3750**	**1270**	**1240**	**5000**	----
EG005(ED093)-SDH: 1M HCl-Extractable Metals by ICPAES									
Antimony	7440-36-0	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Arsenic	7440-38-2	1.0	mg/kg		**1.5**	<1.0	<1.0	<1.0	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Copper	7440-50-8	1.0	mg/kg		**4.0**	**1.4**	**2.0**	<1.0	----
Lead	7439-92-1	1.0	mg/kg		**6.4**	**1.8**	**4.8**	**1.5**	----
Nickel	7440-02-0	1.0	mg/kg		**2.8**	<1.0	<1.0	<1.0	----
Silver	7440-22-4	1.0	mg/kg		<1.0	<1.0	<1.0	<1.0	----
Zinc	7440-66-6	1.0	mg/kg		**10.3**	**7.1**	**8.0**	**7.1**	----
EG020-SD: Total Metals in Sediments by ICPMS									
Antimony	7440-36-0	0.50	mg/kg		<0.50	<0.50	<0.50	<0.50	----
Arsenic	7440-38-2	1.00	mg/kg		**1.98**	<1.00	<1.00	**1.88**	----
Cadmium	7440-43-9	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
Chromium	7440-47-3	1.0	mg/kg		**3.1**	<1.0	<1.0	**2.3**	----
Copper	7440-50-8	1.0	mg/kg		**5.6**	**1.6**	**1.7**	**2.3**	----
Cobalt	7440-48-4	0.5	mg/kg		**1.0**	<0.5	<0.5	**0.6**	----
Lead	7439-92-1	1.0	mg/kg		**7.2**	**1.9**	**1.9**	**2.5**	----
Manganese	7439-96-5	10	mg/kg		**22**	**17**	**20**	**14**	----
Nickel	7440-02-0	1.0	mg/kg		**3.4**	<1.0	<1.0	**1.5**	----
Selenium	7782-49-2	0.1	mg/kg		**0.4**	<0.1	**0.1**	<0.1	----
Silver	7440-22-4	0.1	mg/kg		<0.1	<0.1	<0.1	<0.1	----
Vanadium	7440-62-2	2.0	mg/kg		**7.9**	**2.5**	**2.5**	**13.2**	----
Zinc	7440-66-6	1.0	mg/kg		**12.1**	**6.4**	**6.6**	**16.4**	----
EG035-SDH: 1M HCl extractable Mercury by FIMS									
Mercury	7439-97-6	0.10	mg/kg		<0.10	<0.10	<0.10	<0.10	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.01	mg/kg		**0.03**	<0.01	<0.01	<0.01	----
GEO26: Sieving									
-2000µm	----	0.01	%		**54.2**	**88.9**	**85.4**	**41.3**	----

Appendix C – Raw macroinvertebrate results

Autumn 2019 – freshwater sites

Class/Order	Lowest Taxon	SIGNAL-2 Family	CCSC1 E1	CCSC1 E2	LCRef E1	LCRef E2	KCDS E1	KCDS E2	SCMid E1	SCMid E2	SCDS E1	SCDS E2	SKDS E1	SKDS E2	WMP27 m	SP6 m	SP5 m
Acarina	Acarina sp.	6	3	1	3	3	2	1	1	3	3	1	2	2	3	2	
Bivalvia	Sphaeriidae	5	3														
Coleoptera	Dytiscidae	2	3	1	3	1	2	1	3	4	1	2			5	7	
Coleoptera	Haliplidae	2				1											
Coleoptera	Hydraenidae	3	5		5	1	1	1	1		1		1	1		1	
Coleoptera	Hydrochidae	4										1			5		
Coleoptera	Hydrophilidae	2			3	7				2					3	3	
Coleoptera	Scirtidae	6	4	3	3	1			1	1	1				4	1	1
Decapoda	Atyidae	3	1	2	1	1					1	1				1	2
Decapoda	Parastacidae	4								1					2		1
Diptera	Athericidae	8														1	
Diptera	Ceratopogonidae	4		1				1									1
Diptera	Chaoboridae	2	5	1	1	3									3		
Diptera	Chironominae	3	10	16	16	8	13	18	14	7	9	3	9	20	7	11	3
Diptera	Culicidae	1	1				1	1				1			1	1	1
Diptera	Dixidae	7															1
Diptera	Ephydridae	2	3		1	1						1					
Diptera	Orthocladiinae	4									1			2			
Diptera	Stratiomyidae	2														1	5
Diptera	Tabanidae	3														2	
Diptera	Tanypodinae	4					23	13				4	3	3		1	3
Diptera	Tipulidae	5											1	1			
Ephemeroptera	Baetidae	5															6
Ephemeroptera	Caenidae	4										1					
Ephemeroptera	Leptophlebiidae	8		1	3	2	4		1	2	4	2			3	3	
Gastropoda	Ancylidae	4				1					1					1	
Gastropoda	Lymnaeidae	1	1			2											
Gastropoda	Planorbidae	2			1		1	5					2	2			
Hemiptera	Gelastocoridae	5	1												2	2	1

Class/Order	Lowest Taxon	SIGNAL-2 Family	CCSC 1 E1	CCSC 1 E2	LCRef E1	LCRef E2	KCDS E1	KCDS E2	SCMid E1	SCMid E2	SCDS E1	SCDS E2	SKDS E1	SKDS E2	WMP 27 E	SP6 E	SP5 E
Hemiptera	Gerridae	4	1				1						1				1
Hemiptera	Hydrometridae	3	1		2	1	2	1	1	1		1			2	2	1
Hemiptera	Mesoveliidae	2	1		2		1		2	1						3	
Hemiptera	Corixidae	2	2	2													
Hemiptera	Naucoridae	2	1														
Hemiptera	Notonectidae	1			2		1		1	2						1	2
Hemiptera	Pleidae	2	3	1													
Hemiptera	Veliidae	3	1	2			2	1		2	1	2	1		5	1	
Hirudinea	Glossiphoniidae	1		2				2									
Odonata	Aeshnidae	4			1	3		1	4	2					4	3	5
Odonata	Argiolestidae	5			1		1	2	4	3	1	2			1	1	2
Odonata	Coenagrionidae	2	3	2		1	1	2			3	2	1	2			3
Odonata	Cordulephyidae	5					4	2					1				
Odonata	Corduliidae	5	1								1		1	2			3
Odonata	Gomphidae	5									1	1					
Odonata	Isostictidae	3									1						
Odonata	Lestidae	1														1	
Odonata	Libellulidae	4	1	1		1								1			
Odonata	Platycnemidae	4		1													
Oligochaeta	Oligochaeta sp.	2	7	16			6	22	3	1	6	2		3			5
Trichoptera	Ecnomidae	4															18
Trichoptera	Hydroptilidae	4							1								
Trichoptera	Leptoceridae	6	4	5	5	3	7	4	6	4	5	3	3	3		5	2
Turbellaria	Dugesiidae	2		1	1	1									2	1	

Autumn 2019 – LT Creek sites

Class/Order	Lowest Taxon	SIGNAL-2 Family	By-Wash	By-Wash	WMP03	WMP03	SP004	SP004
			E1	E2	E1	E2	E1	E2
Acarina	Acarina sp.	6	9	3		1		
Coleoptera	Dytiscidae	2	1	3	1		4	1
Coleoptera	Haliplidae	2			3		1	
Coleoptera	Scirtidae	6				2	4	4
Diptera	Ceratopogonidae	4	2	3			1	3
Diptera	Chironominae	3	9	10	14	8	3	3
Diptera	Culicidae	1	7	3		1		
Diptera	Ephydridae	2	1					
Diptera	Orthocladiinae	4	1	3				3
Diptera	Simuliidae	5	1		1		1	1
Diptera	Stratiomyidae	2	1	1			2	
Diptera	Tanypodinae	4		1	5	3	4	1
Diptera	Tipulidae	5					1	1
Ephemeroptera	Baetidae	5	1	4		1		
Ephemeroptera	Caenidae	4	5	3	4	3	1	2
Gastropoda	Hydrobiidae	4	1	4				
Gastropoda	Lymnaeidae	1					1	5
Gastropoda	Planorbidae	2	4	4				
Hemiptera	Gerridae	4	1	3	1		1	
Hemiptera	Hebridae	3			1			
Hemiptera	Mesoveliidae	2	4	1		1		
Hemiptera	Nepidae	3		1				
Hemiptera	Notonectidae	1	3	1				
Hemiptera	Pleidae	2	5	3		2		
Hemiptera	Veliidae	3	2	3	1	4	1	1
Hydrazoa	Hydridae	2						2
Lepidoptera	Crambidae	3	1					
Odonata	Aeshnidae	4	3	1		1		
Odonata	Coenagrionidae	2	4	6	3	2		
Odonata	Corduliidae	5	1	2	1	2		1
Odonata	Gomphidae	5			2			1
Odonata	Libellulidae	4	6	4	7	5	6	5
Odonata	Lindeniidae	3			4	5	3	2
Oligochaeta	Oligochaeta sp.	2	4	3				
Trichoptera	Calamoceratidae	7						3
Trichoptera	Ecnomidae	4	2		1	4	2	2
Trichoptera	Hydroptilidae	4	1	3	1	1		
Trichoptera	Leptoceridae	6	5	1	5	8	4	3
Turbellaria	Dugesiidae	2	2					

Autumn 2019 – estuarine sites

Phylum	Class/Order	Family	PCMH	PCMH	PCMH	IZ	IZ	IZ	SCCIZ	SCCIZ	SCCIZ
			Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
Annelida	Polychaeta	Capitellidae	4	1		43		1		20	
Annelida	Polychaeta	Eunicidae								2	
Annelida	Polychaeta	Ophellidae	1			15	2				1
Annelida	Polychaeta	Spionidae				3					1
Annelida	Polychaeta	Polychaeta (Immature/Damaged)			1		1	1			1
Crustacea	Amphipoda	Melitidae				5		1			

Spring 2019 – freshwater sites

Class/Order	Lowest Taxon	SIGNAL-2 Family	CCSC1	CCSC1	LCRef	LCRef	KCDS	KCDS	SCMid	SCMid	SCDS	SCDS	SKDS	SKDS
			E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
Acarina	Acarina sp.	6	3	3	3	2	2	2	2	1	2	1	3	5
Bivalvia	Sphaeriidae	5	3	1								3		
Coleoptera	Dytiscidae	2	7	1	2	1	5	2	5	5	3	2	2	
Coleoptera	Hydraenidae	3			1	3								
Coleoptera	Hydrophilidae	2	3	1	9	3	1	1	3	1	1	1		
Coleoptera	Scirtidae	6	2	1	2		1	1	1	1	1			
Decapoda	Atyidae	3	2								1	2		
Diptera	Ceratopogonidae	4		1			2	1			1	1	3	4
Diptera	Chaoboridae	2								1				
Diptera	Chironominae	3	16	13	23	18	8	18	7	6	15	13	1	7
Diptera	Culicidae	1	3				1		1	1		1		
Diptera	Ephydridae	2	2	1										
Diptera	Orthocladiinae	4						1	1	1	1			
Diptera	Tanypodinae	4					8	15	2	1	3	4	5	5
Ephemeroptera	Leptophlebiidae	8	4	3	2	3	3	1	2	1	2	2		
Gastropoda	Ancylidae	4									1	1		
Gastropoda	Lymnaeidae	1	1	1										
Gastropoda	Planorbidae	2		2				2					1	1
Hemiptera	Belostomatidae	1		1										
Hemiptera	Gelastocoridae	5					2	1	1	2				
Hemiptera	Gerridae	4						1						
Hemiptera	Hydrometridae	3	1		1		2	1	2	1	1			
Hemiptera	Corixidae	2			1						1			
Hemiptera	Notonectidae	1	2		1		1		1					
Hemiptera	Pleidae	2	2	1									1	
Hemiptera	Veliidae	3	2			1	6	2	2	3	2	1		
Hirudinea	Glossiphoniidae	1		3										
Odonata	Aeshnidae	4							1	2				
Odonata	Argiolestidae	5	1				3	3	1	2	2			

Class/Order	Lowest Taxon	SIGNAL-2 Family	CCSC1	CCSC1	LCRef	LCRef	KCDS	KCDS	SCMid	SCMid	SCDS	SCDS	SKDS	SKDS
			E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
Odonata	Coenagrionidae	2		1			4	1			1	1	3	3
Odonata	Cordulephyidae	5					4	1	1		2	3	2	1
Odonata	Corduliidae	5		1				1						
Odonata	Gomphidae	5					1				1			
Odonata	Isostictidae	3	1	1								2		
Odonata	Libellulidae	4	3											
Oligochaeta	Oligochaeta sp.	2	7	4	2		2		3	2		1	2	2
Trichoptera	Atriplectididae	7										1		
Trichoptera	Leptoceridae	6	3	5	4	2	4	4	4	6	4	4	1	4
Trichoptera	Odontoceridae	7						1						
Turbellaria	Dugesiidae	2	3	2					3	2				

Spring 2019 – freshwater sites

Class/Order	Lowest Taxon	SIGNAL-2 Family	WMP20	WMP20	WMP38	WMP38	By-Wash	By-Wash	WMP03	WMP03	SP004	SP004	WMP27	SP6	SP5
			E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E	E	E
Acarina	Acarina sp.	6	1	1	1	2	4	3		2				2	
Amphipoda	Talitridae	3		1											
Coleoptera	Dytiscidae	2	2	5	4	4	8	3		3			7	7	1
Coleoptera	Gyrinidae	4													1
Coleoptera	Hydraenidae	3	2	1		1									
Coleoptera	Hydrochidae	4											4		
Coleoptera	Hydrophilidae	2	4	4	3	4	1				1		2	1	1
Coleoptera	Scirtidae	6	1			4			1	1	2	4	1	2	
Decapoda	Atyidae	3					2								2
Decapoda	Parastacidae	4			1	1							1		1
Diptera	Ceratopogonidae	4					3	5	2			4			3
Diptera	Chaoboridae	2			3	4							1	1	
Diptera	Chironominae	3		10	9	13	10	13	27	11	1	1	10	11	24
Diptera	Culicidae	1	2				2	3		3				1	
Diptera	Dixidae	7													1
Diptera	Orthocladiinae	4	2	1				1	4	4	2		1	1	1
Diptera	Simuliidae	5							4		4	3			
Diptera	Stratiomyidae	2	1				5	3	1	1	4	3			4
Diptera	Tanypodinae	4					8	2	12	7	3	2		2	
Diptera	Tipulidae	5									1	1			
Ephemeroptera	Baetidae	5					1	1		3				2	
Ephemeroptera	Caenidae	4					6	5	5	2					
Ephemeroptera	Leptophlebiidae	8			1								2	2	2
Gastropoda	Ancylidae	4												3	
Gastropoda	Hydrobiidae	4					2		2		2	3			
Gastropoda	Lymnaeidae	1					1								
Gastropoda	Planorbidae	2			2	2	7	1	1						1
Hemiptera	Belostomatidae	1								1					
Hemiptera	Gelastocoridae	5				1					1		1	2	

Class/Order	Lowest Taxon	SIGNAL-2 Family	WMP20	WMP20	WMP38	WMP38	By-Wash	By-Wash	WMP03	WMP03	SP004	SP004	WMP27	SP6	SP5
			E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E	E	E
Hemiptera	Gerridae	4						1		2	1	1		1	3
Hemiptera	Hydrometridae	3											2	1	1
Hemiptera	Mesoveliidae	2					2			1				3	4
Hemiptera	Corixidae	2											1		1
Hemiptera	Nepidae	3					1	1		1					
Hemiptera	Notonectidae	1					4	5						1	3
Hemiptera	Pleidae	2					1	2	3	1					
Hemiptera	Veliidae	3	1	1			2	4	2	2	2		5	2	2
Megaloptera	Corydalidae	7							1						
Odonata	Aeshnidae	4	2	3	2	2	5	3		1			1	1	2
Odonata	Argiolestidae	5							1					1	
Odonata	Coenagrionidae	2					1	4	1	2	1			3	
Odonata	Corduliidae	5					1	1						3	2
Odonata	Gomphidae	5								1					
Odonata	Lestidae	1			1									1	
Odonata	Libellulidae	4					3	2	9	3	5	6			
Odonata	Lindeniidae	3					2	2							
Oligochaeta	Oligochaeta sp.	2		2										1	
Trichoptera	Calamoceratidae	7							2	3		2			
Trichoptera	Ecnomidae	4									1	1			5
Trichoptera	Hydropsychidae	6							1						
Trichoptera	Hydroptilidae	4					4		2						
Trichoptera	Leptoceridae	6				1	2	3	4	2	5	6		4	1
Turbellaria	Dugesiidae	2	1		1								1		

Spring 2019 – estuarine sites

Phylum	Class/Order	Family	PCMH	PCMH	PCMH	IZ	IZ	IZ	SCCIZ	SCCIZ	SCCIZ
			Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
Annelida	Polychaeta	Capitellidae		1	2	2	1			11	3
Annelida	Polychaeta	Eunicidae		1		1	1				
Annelida	Polychaeta	Nereidae		1							
Annelida	Polychaeta	Ophellidae		5	5	1	2			7	9
Annelida	Polychaeta	Sabellidae		5			2	2	1		
Annelida	Polychaeta	Spionidae		1							
Annelida	Polychaeta	Polychaeta (Immature/Damaged)	1	12					2		2
Crustacea	Amphipoda	Corophiidae			3	3	6				
Crustacea	Amphipoda	Hyalellidae				1					
Crustacea	Amphipoda	Melitidae			1		3	1		2	3
Crustacea	Amphipoda	Talitridae		1							
Crustacea	Amphipoda	Amphipoda (Immature/Damaged)		1							

Appendix D – Water quality QA

Autumn 2019

Analyte	Units	LOR	SKDS	Duplicate
			23/05/2019	23/05/2019
Physicochemical parameters				
TDS	mg/L	1	295	290
TSS	mg/L	5	21	16
Turbidity	NTU	0.1	28	29.1
Total Hardness as CaCO3	mg/L	1	44	44
Major ions				
Bicarbonate Alkalinity as CaCO3	mg/L	1	25	25
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	25	25
Chloride	mg/L	1	124	141
Sulfate as SO4 - Turbidimetric	mg/L	1	6	6
Calcium	mg/L	1	3	3
Magnesium	mg/L	1	9	9
Sodium	mg/L	1	74	74
Potassium	mg/L	1	2	2
Dissolved metals				
Aluminium	mg/L	0.01	0.08	0.08
Antimony	mg/L	0.001	<0.001	<0.001
Arsenic	mg/L	0.001	<0.001	<0.001
Barium	mg/L	0.001	0.025	0.024
Beryllium	mg/L	0.001	<0.001	<0.001
Boron	mg/L	0.05	<0.05	<0.05
Cadmium	mg/L	0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001
Cobalt	mg/L	0.001	<0.001	<0.001
Copper	mg/L	0.001	<0.001	<0.001
Iron	mg/L	0.05	0.55	0.55
Lead	mg/L	0.001	<0.001	<0.001
Lithium	mg/L	0.001	0.004	0.004
Manganese	mg/L	0.001	0.11	0.103
Mercury	mg/L	0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	<0.001	<0.001
Nickel	mg/L	0.001	<0.001	<0.001
Selenium	mg/L	0.01	<0.01	<0.01
Silver	mg/L	0.001	<0.001	<0.001
Tin	mg/L	0.001	<0.001	<0.001
Titanium	mg/L	0.01	<0.01	<0.01
Vanadium	mg/L	0.01	<0.01	<0.01
Zinc	mg/L	0.005	<0.005	<0.005

Analyte	Units	LOR	SKDS	Duplicate
			23/05/2019	23/05/2019
Nutrients				
Ammonia as N	mg/L	0.01	0.02	0.02
Nitrite as N	mg/L	0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	1	0.6
Total Nitrogen as N	mg/L	0.1	1	0.6
Total Phosphorus as P	mg/L	0.01	0.08	0.03
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01
Other parameters				
Dissolved Organic Carbon	mg/L	1	13	12

Spring 2019

Analyte	Unit	LOR	LCRef	Duplicate
			17/10/2019	17/10/2019
Physicochemical parameters				
TDS	mg/L	1	137	169
TSS	mg/L	5	<5	<5
Turbidity	NTU	0.1	14.8	15.1
Total Hardness as CaCO3	mg/L	1	17	20
Major ions				
Bicarbonate Alkalinity as CaCO3	mg/L	1	16	15
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	16	15
Chloride	mg/L	1	30	29
Sulfate as SO4 - Turbidimetric	mg/L	1	2	2
Calcium	mg/L	1	2	3
Magnesium	mg/L	1	3	3
Sodium	mg/L	1	20	20
Potassium	mg/L	1	5	5
Dissolved metals				
Aluminium	mg/L	0.01	0.85	0.49
Antimony	mg/L	0.001	<0.001	<0.001
Arsenic	mg/L	0.001	<0.001	0.001
Beryllium	mg/L	0.001	<0.001	<0.001
Barium	mg/L	0.001	0.022	0.016
Boron	mg/L	0.05	<0.05	<0.05
Cadmium	mg/L	0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	0.001
Cobalt	mg/L	0.001	<0.001	<0.001
Copper	mg/L	0.001	0.002	0.001
Iron	mg/L	0.05	1.01	0.88
Lead	mg/L	0.001	<0.001	<0.001
Lithium	mg/L	0.001	<0.001	<0.001

Analyte	Unit	LOR	LCRef	Duplicate
			17/10/2019	17/10/2019
Manganese	mg/L	0.001	0.059	0.059
Mercury	mg/L	0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	<0.001	<0.001
Nickel	mg/L	0.001	0.002	0.007
Selenium	mg/L	0.01	<0.01	<0.01
Silver	mg/L	0.001	<0.001	<0.001
Tin	mg/L	0.001	<0.001	<0.001
Titanium	mg/L	0.01	0.03	0.02
Vanadium	mg/L	0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.006	<0.005
Nutrients				
Ammonia as N	mg/L	0.01	0.05	0.07
Nitrite as N	mg/L	0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.02	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.02	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	1.2	1
Total Nitrogen as N	mg/L	0.1	1.2	1
Total Phosphorus as P	mg/L	0.01	0.06	0.04
Reactive Phosphorus as P	mg/L	0.01	<0.01	<0.01
Other parameters				
Dissolved Organic Carbon	mg/L	1	27	26

Appendix E – Sediment quality QA

Autumn 2019

Analyte	Units	LOR	SKDS	SK100
1M HCl-extractable metals				
Antimony	mg/kg	1	<1.0	<1.0
Arsenic	mg/kg	1	<1.0	<1.0
Cadmium	mg/kg	0.1	<0.1	<0.1
Chromium	mg/kg	1	<1.0	<1.0
Copper	mg/kg	1	1.1	<1.0
Lead	mg/kg	1	6.1	4.7
Mercury	mg/kg	0.1	<0.10	<0.10
Nickel	mg/kg	1	<1.0	<1.0
Silver	mg/kg	1	<1.0	<1.0
Zinc	mg/kg	1	8.7	7.9
Nutrients				
Ammonia as N	mg/kg	20	<20	<20
Nitrite as N (Sol.)	mg/kg	0.1	0.4	<0.1
Nitrate as N (Sol.)	mg/kg	0.1	0.7	0.2
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	1.1	0.2
Total Kjeldahl Nitrogen as N	mg/kg	20	380	350
Total Nitrogen as N	mg/kg	20	380	350
Total Phosphorus as P	mg/kg	2	40	54
Other parameters				
Total Organic Carbon	%	0.02	6.52	7.64

Spring 2019

Analyte	Unit	LOR	LCRef	Duplicate
1M HCl-extractable metals				
Antimony	mg/kg	1	<1.0	<1.0
Arsenic	mg/kg	1	<1.0	<1.0
Cadmium	mg/kg	0.1	<0.1	<0.1
Chromium	mg/kg	1	<1.0	<1.0
Copper	mg/kg	1	<1.0	1.2
Lead	mg/kg	1	1.8	1.7
Mercury	mg/kg	0.1	<0.10	<0.10
Nickel	mg/kg	1	<1.0	<1.0
Silver	mg/kg	1	<1.0	<1.0
Zinc	mg/kg	1	6.1	7.8
Nutrients				
Ammonia as N	mg/kg	20	<20	<20
Nitrite as N (Sol.)	mg/kg	0.1	<0.1	<0.1
Nitrate as N (Sol.)	mg/kg	0.1	0.4	0.4
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	0.4	0.4
Total Kjeldahl Nitrogen as N	mg/kg	20	690	1110
Total Nitrogen as N	mg/kg	20	690	1110
Total Phosphorus as P	mg/kg	2	95	146
Other parameters				
Total Organic Carbon	%	0.02	2.2	2.53

Appendix F – Macroinvertebrate QA

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: CA Processing Date: 15.7.19

Project #: 2220036 LIMS/Sample #: 1141514 Sample Code: 113ByWashP

Site Name: By Wash Site Code: ByWash

Collection Date: 21.5.19 Method/Habitat: Sweep Collected By: ZL + TH

Taxonomic Id Level: Family Pass/Fail Rate: 95% QA/QC By: ZB

Incorrect Identification	Correct Identification	Error Code

Number of Taxa (species/families): 30

Number Identified Incorrectly: 0

Percentage Correct: 100%

Pass or Fail: Pass

Training Received For Incorrect Taxa? (Yes/No) QA Date: 29.7.19

Senior Taxonomist Identifier: ZR

Notes:
Please refer to .\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount*
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

* These are NOT included in error rate calculations

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: CA Processing Date: 16.7.19

Project #: 2220188 LIMS/Sample #: 114531 Sample Code: 113KCDSP

Site Name: Site Code: KCDSP

Collection Date: 23.5.19 Method/Habitat: Swamp Collected By: JC + TH

Taxonomic Id Level: Family Pass/Fail Rate: 95% QA/QC By: ZB

Incorrect Identification	Correct Identification	Error Code
	Gerridae	6

Number of Taxa (species/families): 21

Number Identified Incorrectly: 1

Percentage Correct: 95%

Pass or Fail: Pass

Training Received For Incorrect Taxa? (Yes/(No)) QA Date: 29.7.19

Senior Taxonomist Identifier: ZA

Notes:
Please refer to .\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount*
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

* These are NOT included in error rate calculations

Macroinvertebrate Data Sheet

Project No.: 2220036 | LIMS #: 114633 | Sample Code: 114 By - Wash P
Waterway: | Site Code: By - Wash
Collection Date: 14.10.19 | Sample Method: Sweep | Habitat: Edge
Sorted By: JS | Date Sorted: | Collected By: JC + TH
No. of Vials: 1 | Number of Slides: 0 | Time Taken: 1
Sub-Sampled? Yes / | Percentage sub-sampled: –
Data Entry by: | Validated By: | Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Chironomidae	𝍸 𝍸	10		✓	
		Notonectidae	𝍸	4		✓	
		Cladocera	II	2		✓	
		Asellidae	𝍸	5		✓	
		Hydrophilidae	I	1		✓	
		Caenidae	𝍸 I	6		✓	
		Veliidae	II	2		✓	
		Planorbidae	𝍸 II	7		✓	
		Hydrobiidae	II	2		✓	
		Cyclidae	II	2		✓	
		Lymnaeidae	I	1		✓	
		Sphaeriidae	𝍸	5		✓	
		Corduliidae	I	1		✓	
		Tanypodinae	𝍸 III	8		✓	
		Leptoceridae	II	2		✓	
		Megapodagrionidae	II	2		✓	
		Naucoridae	I	1		✓	
		Dytiscidae	𝍸 II	8		✓	
		Limnephilidae	II	2		✓	
		Atyidae	II	2		✓	
		Libellulidae	III	3		✓	
		Hydroptilidae	IIII	4		✓	
		Ostracoda	II	2		✓	
		Mites	IIII	4		✓	
		Ceratopogonidae	III	3		✓	
		Pleidae	I	1		✓	
		Coenagrionidae	I	1		✓	
		Baetidae	I	1		✓	

Macroinvertebrate Data Sheet

QA/QC

Project No.: 2220036 LIMS #: 114633 Sample Code: 114By-WashP
Waterway: By-Wash Dam Site Code: ByWash
Collection Date: 14.10.19 Sample Method: Sweep Habitat: Edge
Sorted By: ZB Date Sorted: QA 7/11/19 Collected By: JC PTH
No. of Vials: 1 Number of Slides: / Time Taken: 12-12.45 1:30-2
Sub-Sampled? Yes / (No) Percentage sub-sampled: /
Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
✓		Hydridae	II	2			
✓		Mites	IIII	4			
✓		Nepidae	I	1			
✓		Leptoceridae	II	2			
✓		Hydroptilidae	IIII	4			
✓		Aeshnidae	HHT	5			
✓		Stratiomyidae	HHT	5			
✓		Hydrobiidae	II	2			
✓		Ceratopogonidae	III	3			
✓		Lymnaeidae	I	1			
✓		Caenidae	HHT(	6			
✓		Planorbidae	HHT II	7			
✓		Notonectidae	IIII	4			
✓		Limnephilidae	II	2			
✓		Physidae	I	1			
✓		Tubificidae	III	3			
✓		Mesoveliidae	II	2			
✓		Corduliidae	I	1			
✓		Veliidae	II	2			
✓		Cladocera	II	2			
✓		Hydrophilidae (L)	I	1			
✓		Ostracoda	II	2			
✓		Culicidae	II	2			
✓		Baetidae	I	1			
✓		Dytiscidae (A)	HHI	6			
✓		Dytiscidae (L)	II	2			
✓		Tanypodinae	HH III	8			
✓		Chironominae	HH HH	10			
✓		Coenagrionidae	I	1			

Macroinvertebrate Identification QA/QC Data Sheet

Identifier: Zac Billingham Processing Date: QA! 7/11/19

Project #: 2220036 LIMS/Sample #: 114633 Sample Code: 114By-Wash

Site Name: By-Wash Dam Site Code: By-Wash

Collection Date: 14.10.19 Method/Habitat: Edge Collected By: JC + TH

Taxonomic Id Level: Family Pass/Fail Rate: QA/QC By: LB

Incorrect Identification	Correct Identification	Error Code

Number of Taxa (species/families): 28

Number Identified Incorrectly: 0

Percentage Correct: 100%

Pass or Fail: PASS

Training Received For Incorrect Taxa? (Yes/No) QA Date: NA

Senior Taxonomist Identifier

Notes:
Please refer to .\General\Ecology Files\Quality Assurance\Quality Assurance for the Victorian River Health Program.pdf for an explanation of how rates are calculated.

Error Codes:

1. ID adult/larvae not identified
2. Complete misidentification
3. Could *reasonably* be identified to a finer taxonomic resolution
4. Identification has been taken too far based on specimen condition (small or damaged)*
5. Miscount*
6. Taxon not recorded on the data sheet
7. Inappropriate Identification based on larval exuviae, shells or if the specimen was obviously dead when collected

* These are NOT included in error rate calculations

Macroinvertebrate Data Sheet

Project No.: 2220026 | LIMS #: 114634 | Sample Code: 114By-Wash P1
Waterway: | Site Code: By-Wash
Collection Date: 14-10-19 | Sample Method: Sweep | Habitat: Edge
Sorted By: ZS | Date Sorted: | Collected By: JC + TH
No. of Vials: 1 | Number of Slides: 0 | Time Taken: 1
Sub-Sampled? Yes / No | Percentage sub-sampled: -
Data Entry by: | Validated By: | Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data validated
		Culicidae	III	3		✓	
		Tanypodinae	II	2		✓	
		Mites	III	3		✓	
		Notonectidae	IIII	4		✓	
		Gerridae	I	1		✓	
		Chironomidae	HH HH III	13		✓	
		Caenidae	HH	5		✓	
		Notonectidae	HH	5		✓	
		Centropyxidae	HH	5		✓	
		Pleidae	II	2		✓	
		Leptoceridae	III	3		✓	
		Corixidae	IIII	4		✓	
		Libellulidae	II	2		✓	
		Cladocera	I	1		✓	
		Limnesiidae	II	2		✓	
		Orthocladiinae	I	1		✓	
		Strationyidae	III	3		✓	
		Nepidae	I	1		✓	
		Aeshnidae	III	3		✓	
		Dytiscidae	III	3		✓	
		Corduliidae	I	1		✓	
		Planorbidae	I	1		✓	
		Baetidae	I	1		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 114635 Sample Code: 114WMP38P
Waterway: Site Code: WMP38
Collection Date: 15-10-19 Sample Method: Sweep Habitat: Edge
Sorted By: ZS Date Sorted: Collected By: JC + TH
No. of Vials: 1 Number of Slides: 0 Time Taken: 05
Sub-Sampled? Yes / No Percentage sub-sampled: —
Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Mites	I	1		✓	
		Cladocera	III	3		✓	
		Ostracoda	II	2		✓	
		Chironomidae	IIII III	9		✓	
		Dytiscidae	IIII	4		✓	
		Hydroptilidae	III	3		✓	
		Aeshnidae	II	2		✓	
		Leptoceridae	I	1		✓	
		Leptophlebiidae	I	1		✓	
		Chaoboridae	III	3		✓	
		Parastacidae	I	1		✓	
		Dugesiidae	I	1		✓	
		Planorbidae	II	2		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 114636 Sample Code: 114LWMP38P1

Waterway: Site Code: WMP38

Collection Date: 15·10·19 Sample Method: Sweep Habitat: Edge

Sorted By: ZB Date Sorted: Collected By: JC + TH

No. of Vials: 1 Number of Slides: 0 Time Taken: 75

Sub-Sampled? Yes / (NO) Percentage sub-sampled: —

Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Ostracoda	III	3		✓	
		Chironomidae	IIII IIII III	13		✓	
		Chaoboridae	IIII	4		✓	
		Mites	II	2		✓	
		Hydrophilidae	IIII	4		✓	
		Clathrocera	III	3		✓	
		Scirtidae	IIII	4		✓	
		Hydrachnidae	I	1		✓	
		Planorbidae	II	2		✓	
		Dytiscidae	IIII	4		✓	
		Leptoceridae	I	1		✓	
		Psephenidae	I	1		✓	
		Gelastocoridae	I	1		✓	
		Aeshnidae	II	2		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 111637 Sample Code: 111WMP20P

Waterway: Site Code: WMP20

Collection Date: 15·10·19 Sample Method: Sweep Habitat: Edge

Sorted By: JS Date Sorted: Collected By: JC + TH

No. of Vials: 1 Number of Slides: 0 Time Taken: 05

Sub-Sampled? Yes / (No) Percentage sub-sampled: –

Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Cladocera	IIII	4		✓	
		Hydracarina	II	2		✓	
		Dugesiidae	I	1		✓	
		Deltacyclidae	II	2		✓	
		Hydroptilidae	IIII	4		✓	
		Coloidea	II	2		✓	
		Staphylinidae	I	1		✓	
		Dytiscidae	II	2		✓	
		Aeshnidae	II	2		✓	
		Ostracoda	III	3		✓	
		Copepoda	I	1		✓	
		Scirtidae	I	1		✓	
		Veliidae	I	1		✓	
		Mites	I	1		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 114638 Sample Code: 114WMP2021

Waterway: Site Code: WMP20

Collection Date: 15·10·19 Sample Method: Sweep Habitat: Edge

Sorted By: JB Date Sorted: Collected By: JC + TH

No. of Vials: 1 Number of Slides: 0 Time Taken: ~5

Sub-Sampled? Yes / (No) Percentage sub-sampled: –

Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Cladocera	III	3		✓	
		Hydrodictyidae	IIII	4		✓	
		Chironomidae	++++ ++++	10		✓	
		Talitridae	I	1		✓	
		Dytiscidae	++++	5		✓	
		Mites	I	1		✓	
		Orthocladiinae	I	1		✓	
		Oligochaeta	II	2		✓	
		Acarina	III	3		✓	
		Copepoda	I	1		✓	
		Hydrozoa	I	1		✓	
		Vertidae	I	1		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 114639 Sample Code: 114WMP03P
Waterway: Site Code: WMP03
Collection Date: 14-10-19 Sample Method: Sweep Habitat: Edge
Sorted By: ZB Date Sorted: Collected By: JC + TH
No. of Vials: 1 Number of Slides: 0 Time Taken: 1
Sub-Sampled? Yes / Percentage sub-sampled: —
Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Tanypodinae	𝍸 𝍸 ||	12		✓	
		chironomini	𝍸 𝍸 𝍸 𝍸 ||	27		✓	
		Veliidae	||	2		✓	
		cladocera	|	1		✓	
		Simuliidae	|||	4		✓	
		Hydroptilidae	||	2		✓	
		Leptoceridae	|||	4		✓	
		Pleidae	||	3		✓	
		Hydrobiidae	||	2		✓	
		Orthocladiinae	|||	4		✓	
		Caecidae	𝍸	5		✓	
		Planorbidae	|	1		✓	
		Hydropsychidae	|	1		✓	
		Coenagrionidae	|	1		✓	
		Argiolestidae	|	1		✓	
		Coenagrionidae	|	1		✓	
		Calamoceratidae	||	2		✓	
		Scirtidae	|	1		✓	
		Ceratopogonidae	||	2		✓	
		Stratiomyidae	|	1		✓	
		Libellulidae	𝍸 |||	9		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 1116140 Sample Code: 111WMP03P1
Waterway: Site Code: WMP03
Collection Date: 14-10-19 Sample Method: Sweep Habitat: Edge
Sorted By: JC Date Sorted: Collected By: JC + TH
No. of Vials: 1 Number of Slides: 0 Time Taken: 1
Sub-Sampled? Yes / (No) Percentage sub-sampled: —
Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Chironomidae	𝍸 𝍸 I	11		✓	
		Culicidae	III	3		✓	
		Cladocera	𝍸 I	6		✓	
		Stationygidae	I	1		✓	
		Oligochaeta	III	3		✓	
		Pleidae	I	1		✓	
		Tanypodinae	𝍸 II	7		✓	
		Veliidae	II	2		✓	
		Orthocladiinae	IIII	4		✓	
		Naucoridae	I	1		✓	
		Ceratopogonidae	II	2		✓	
		Baetidae	III	3		✓	
		Mesoveliidae	I	1		✓	
		Acarina	I	1		✓	
		Mites	II	2		✓	
		Ostracoda	I	1		✓	
		Sciaridae	I	1		✓	
		Calamoceratidae	III	3		✓	
		Pleidae	I	1		✓	
		Gerridae	II	2		✓	
		Libellulidae	III	3		✓	
		Gomphidae	I	1		✓	
		Leptoceridae	II	2		✓	
		Coenagrionidae	II	2		✓	

Macroinvertebrate Data Sheet

Project No.: 2220036 | LIMS #: 114641 | Sample Code: 114 SPool1P
Waterway: | Site Code: SPool1
Collection Date: 14·10·19 | Sample Method: Sweep | Habitat: Edge
Sorted By: ZS | Date Sorted: | Collected By: SC + T
No. of Vials: 1 | Number of Slides: 0 | Time Taken: ·5
Sub-Sampled? Yes / (No) | Percentage sub-sampled: —
Data Entry by: | Validated By: | Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data Validated
		Leptoceridae	𝍸	5		✓	
		Simuliidae	𝍸 |	4		✓	
		Orthocladiinae	||	2		✓	
		Tanypodinae	||	3		✓	
		Hydrachnidiae	|	1		✓	
		Stratiomyidae	||	4		✓	
		Ceratopogonidae	|	1		✓	
		Limoniidae	𝍸	5		✓	
		Calamoceratidae	|	1		✓	
		Coenagrionidae	|	1		✓	
		Chironomini	|	1		✓	
		Hydrobiidae	|\	2		✓	
			|	1		✓	
		Ecnomidae	|				
				2		✓	
		Veliidae	|\				
				2		✓	
		Sciomyzidae	|\				
				1		✓	
*Retained 25		Tipulidae	1				

Macroinvertebrate Data Sheet

Project No.: 2220036 LIMS #: 1141612 Sample Code: 1141 SP004 P1
Waterway: Site Code: SP004
Collection Date: 14.10.19 Sample Method: Sweep Habitat: Edge
Sorted By: ZB Date Sorted: Collected By: JC + TL
No. of Vials: 1 Number of Slides: 0 Time Taken: ~5
Sub-Sampled? Yes / No Percentage sub-sampled: —
Data Entry by: Validated By: Certified Complete:

ID check	Voucher Code	Taxon	Count	Total	Corrected Total	Data Entered	Data validated
		Chironomidae	1	1		✓	
		Leptoceridae	𝍸 1	6		✓	
		Hydrobiidae	111	3		✓	
		Stratiomyidae	111	3		✓	
		Tanypodinae	11	2		✓	
		Ceratopogonidae	1111	4		✓	
		Scirtidae	1111	4		✓	
		Libellulidae	𝍸 1	6		✓	
		Simuliidae	111	3		✓	
		Calamoceratidae	11	2		✓	
		Gerridae	1	1		✓	
		Copepoda	1	1		✓	
*Retained ZB		Tipulidae	1	1		✓	
		Ecnomidae	1	1		✓	

Appendix G – PMST report

Australian Government
Department of the Environment and Energy

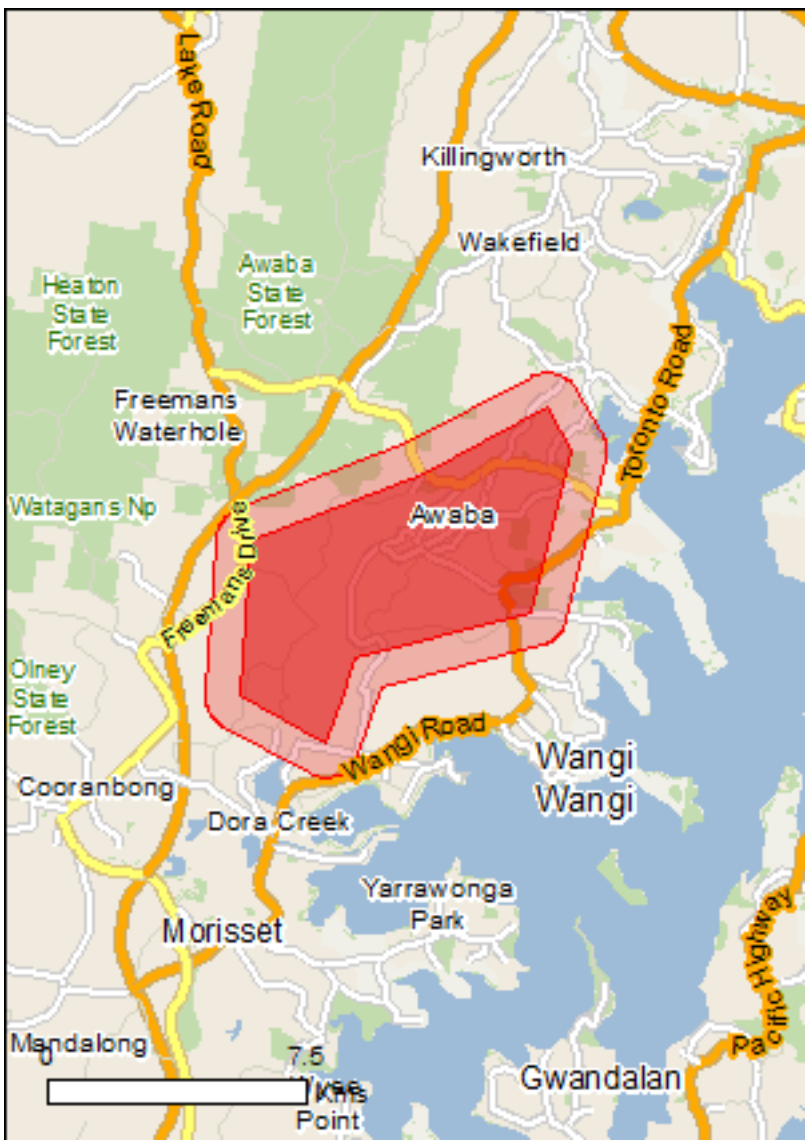
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

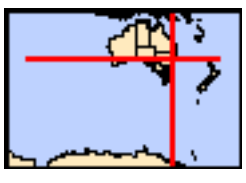
Report created: 02/10/19 09:44:01



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	64
Listed Migratory Species:	47

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	53
Whales and Other Cetaceans:	1
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	2
Regional Forest Agreements:	1
Invasive Species:	48
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Species or species habitat known to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat likely to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Dasyornis brachypterus Eastern Bristlebird [533]	Endangered	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis rubricollis Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat may occur within area
Fish		
Epinephelus daemelii Black Rockcod, Black Cod, Saddled Rockcod [68449]	Vulnerable	Species or species habitat likely to occur within area
Frogs		
Heleioporus australiacus Giant Burrowing Frog [1973]	Vulnerable	Species or species habitat may occur within area
Litoria aurea Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat known to occur within area
Litoria littlejohni Littlejohn's Tree Frog, Heath Frog [64733]	Vulnerable	Species or species habitat may occur within area
Mixophyes iteratus Giant Barred Frog, Southern Barred Frog [1944]	Endangered	Species or species habitat may occur within area
Insects		
Synemon plana Golden Sun Moth [25234]	Critically Endangered	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat known to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat likely to occur within area
Petrogale penicillata Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Plants		
Acacia bynoeana Bynoe's Wattle, Tiny Wattle [8575]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence within area
Angophora inopina Charmhaven Apple [64832]	Vulnerable	Species or species habitat known to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat likely to occur within area
Cryptostylis hunteriana Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat known to occur within area
Cynanchum elegans White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
Grevillea parviflora subsp. parviflora Small-flower Grevillea [64910]	Vulnerable	Species or species habitat known to occur within area
Melaleuca biconvexa Biconvex Paperbark [5583]	Vulnerable	Species or species habitat known to occur within area
Persicaria elatior Knotweed, Tall Knotweed [5831]	Vulnerable	Species or species habitat likely to occur within area
Persoonia hirsuta Hairy Geebung, Hairy Persoonia [19006]	Endangered	Species or species habitat may occur within area
Pterostylis gibbosa Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood [4562]	Endangered	Species or species habitat may occur within area
Rutidosis heterogama Heath Wrinklewort [13132]	Vulnerable	Species or species habitat likely to occur within area
Syzygium paniculatum Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry [20307]	Vulnerable	Species or species habitat likely to occur within area
Tetratheca juncea Black-eyed Susan [21407]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur

Name	Status	Type of Presence within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Dugong dugon Dugong [28]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species

Name	Threatened	Type of Presence
		habitat likely to occur within area
[Ardea alba](#) Great Egret, White Egret [59541]		Breeding known to occur within area
[Ardea ibis](#) Cattle Egret [59542]		Breeding likely to occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
[Calidris canutus](#) Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
[Calonectris leucomelas](#) Streaked Shearwater [1077]		Species or species habitat known to occur within area
[Diomedea antipodensis](#) Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea epomophora](#) Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea exulans](#) Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Diomedea gibsoni](#) Gibson's Albatross [64466]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Diomedea sanfordi](#) Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
[Fregata ariel](#) Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
[Fregata minor](#) Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat likely to occur within area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
[Hirundapus caudacutus](#) White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
[Lathamus discolor](#) Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat likely to occur within area
Puffinus griseus Sooty Shearwater [1024]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Species or species habitat may occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
[Thalassarche impavida](#) Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
[Thalassarche melanophris](#) Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
[Thalassarche salvini](#) Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
[Thalassarche sp. nov.](#) Pacific Albatross [66511]	Vulnerable*	Species or species habitat may occur within area
[Thalassarche steadi](#) White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
[Thinornis rubricollis](#) Hooded Plover [59510]		Species or species habitat may occur within area
[Thinornis rubricollis rubricollis](#) Hooded Plover (eastern) [66726]	Vulnerable	Species or species habitat may occur within area
[Tringa nebularia](#) Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Mammals		
[Dugong dugon](#) Dugong [28]		Species or species habitat may occur within area
Reptiles		
[Caretta caretta](#) Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
[Chelonia mydas](#) Green Turtle [1765]	Vulnerable	Species or species habitat known to occur within area
[Dermochelys coriacea](#) Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
[Eretmochelys imbricata](#) Hawksbill Turtle [1766]	Vulnerable	Species or species habitat known to occur within area
[Natator depressus](#) Flatback Turtle [59257]	Vulnerable	Species or species habitat known to occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
[Sousa chinensis](#) Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
LNE Special Management Zone No1	NSW
Sugarloaf	NSW

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
North East NSW RFA	New South Wales

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Alauda arvensis Skylark [656]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Pycnonotus jocosus Red-whiskered Bulbul [631]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Alternanthera philoxeroides Alligator Weed [11620]		Species or species habitat likely to occur within area
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Asparagus scandens Asparagus Fern, Climbing Asparagus Fern [23255]		Species or species habitat likely to occur within area
Cabomba caroliniana Cabomba, Fanwort, Carolina Watershield, Fish Grass, Washington Grass, Watershield, Carolina Fanwort, Common Cabomba [5171]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera subsp. rotundata Bitou Bush [16332]		Species or species habitat likely to occur within area
Cytisus scoparius Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Nassella neesiana Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Ulex europaeus Gorse, Furze [7693]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.064553 151.514808,-33.054421 151.492566,-33.020758 151.495254,-33.005989 151.540184,-32.991592 151.572277,-33.00048 151.578546,-33.036152 151.568395,-33.046038 151.52257,-33.064553 151.514808,-33.064553 151.514808,-33.064553 151.514808

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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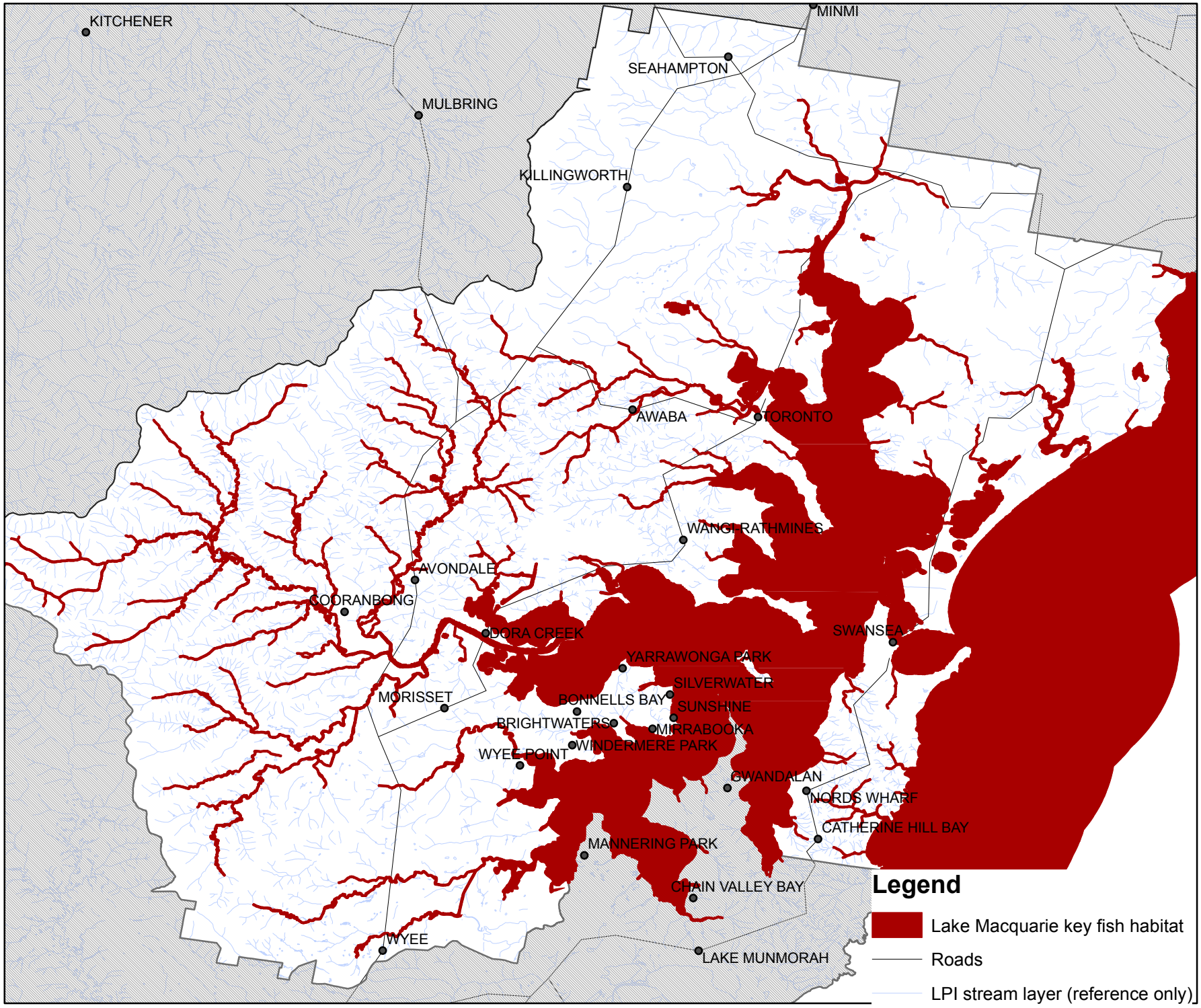
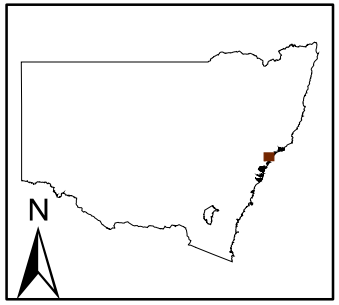
Appendix H – Key Fish Habitat map



Key Fish Habitat

LAKE MACQUARIE LGA



Source: data from the Australian Geoscience, NSW DPI, NSW DECC and NSW LPI
Datum: Geocentric Datum of Australia (GDA)
Grid: Mapping Grid of Australia (MGA94)

Prepared by GIS section, Fisheries Ecosystems Branch, Division of Agriculture & Fisheries, NSW DPI.

0 1.25 2.5 5

Kilometres

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Appendix I – Historical water quality results summary statistics

Freshwater sites

Site	Unit	Lords Creek		Kilaben Creek		Stony Creek			
		CCSC1		WMP27		WMP20		WMP38	
		Count	Median	Count	Median	Count	Median	Count	Median
Dissolved aluminium	mg/L	4	0.09	7	0.32	7	0.27	5	0.06
Dissolved arsenic	mg/L	4	0.001	7	0.001	7	0.001	5	0.002
Dissolved barium	mg/L	4	0.028	7	0.022	7	0.044	5	0.024
Dissolved cadmium	mg/L	4	0.0001	7	0.0001	7	0.0001	5	0.0001
Dissolved cobalt	mg/L	4	0.001	7	0.001	7	0.001	5	0.002
Dissolved copper	mg/L	3	0.001	7	0.001	7	0.004	5	0.003
Dissolved iron	mg/L	4	1.25	7	0.51	7	0.6	5	0.27
Dissolved lead	mg/L	3	0.001	7	0.001	7	0.001	5	0.001
Dissolved manganese	mg/L	4	0.207	7	0.017	7	0.093	5	0.749
Dissolved nickel	mg/L	4	0.0015	7	0.001	7	0.004	5	0.01
Dissolved zinc	mg/L	4	0.0085	7	0.006	7	0.033	5	0.012
Bicarbonate alkalinity	mg/L	4	33.5	7	6	7	26	5	48
Calcium	mg/L	4	4.5	7	1	7	6	5	8
Chloride	mg/L	4	67	7	33	7	25	5	28
Magnesium	mg/L	4	6	7	3	7	4	5	6
Potassium	mg/L	4	4	7	2	7	3	5	4
Sodium	mg/L	4	38.5	7	21	7	23	5	29
Sulfate	mg/L	4	8.5	7	2	7	19	5	50
pH	pH unit	4	6.545	7	5.8	7	6.75	5	6.8
NOx	mg/L	4	0.03	7	0.01	7	0.02	5	0.01
TKN	mg/L	4	1	7	0.3	7	0.9	5	1.1
TP	mg/L	4	0.09	7	0.01	7	0.04	5	0.06
Season first sampled		Spring 2013		Spring 2015		Autumn 2014		Autumn 2015	

Freshwater sites

Site	Unit	LT Creek						Unnamed tributary of Muddy Lake			
		By-Wash		WMP03		SP004		SP6		SP5	
		Count	Median	Count	Median	Count	Median	Count	Median	Count	Median
Dissolved aluminium	mg/L	12	0.01	12	0.01	12	0.01	12	0.09	13	0.01
Dissolved arsenic	mg/L	12	0.001	12	0.001	12	0.001	12	0.001	13	0.001
Dissolved barium	mg/L	12	0.092	12	0.095	12	0.0925	12	0.0275	11	0.022
Dissolved cadmium	mg/L	12	0.0001	12	0.0001	12	0.0001	11	0.0001	13	0.0001
Dissolved cobalt	mg/L	12	0.001	12	0.001	12	0.001	12	0.001	13	0.004
Dissolved copper	mg/L	12	0.001	12	0.001	12	0.001	11	0.001	13	0.001
Dissolved iron	mg/L	12	0.05	12	0.05	12	0.05	12	0.665	13	0.18
Dissolved lead	mg/L	12	0.001	12	0.001	12	0.001	11	0.001	13	0.001
Dissolved manganese	mg/L	12	0.0035	12	0.005	12	0.008	12	0.0425	13	0.514
Dissolved nickel	mg/L	12	0.008	12	0.007	12	0.0075	12	0.001	13	0.009
Dissolved zinc	mg/L	12	0.005	12	0.005	12	0.005	12	0.005	13	0.005
Bicarbonate alkalinity	mg/L	12	528.5	12	507	12	511	12	83	13	300
Calcium	mg/L	12	23	12	23	12	23	12	18.5	13	153
Chloride	mg/L	12	352	12	378.5	12	387.5	12	161	13	626
Magnesium	mg/L	12	11	12	11	12	10.5	12	24	13	199
Potassium	mg/L	12	4	12	4	12	4	12	4.5	13	14
Sodium	mg/L	12	459.5	12	467	12	462.5	12	108	13	488
Sulfate	mg/L	12	101	12	101.5	12	94	12	82.5	13	991
pH	pH unit	12	8.41	12	8.39	12	8.42	12	6.95	13	7.44
NOx	mg/L	12	0.03	12	0.025	12	0.025	12	0.01	12	0.03
TKN	mg/L	12	0.15	12	0.1	12	0.1	12	0.45	13	0.1
TP	mg/L	11	0.01	12	0.01	12	0.01	12	0.01	13	0.01
Season first sampled		Autumn 2014		Autumn 2014		Autumn 2014		Autumn 2014		Winter 2012	

Estuarine sites

Site	Unit	Pourmalong Creek		LT Creek		Stony Creek	
		PCMH		IZ		SCCIZ	
		Count	Median	Count	Median	Count	Median
Dissolved aluminium	mg/L	9	0.016	12	0.0245	12	0.0605
Dissolved arsenic	mg/L	9	0.0017	12	0.00195	12	0.0061
Dissolved barium	mg/L	9	0.014	12	0.0285	12	0.014
Dissolved cadmium	mg/L	9	0.0002	12	0.00025	12	0.00065
Dissolved cobalt	mg/L	9	0.0002	12	0.0007	12	0.00515
Dissolved copper	mg/L	9	0.001	12	0.006	12	0.006
Dissolved iron	mg/L	9	0.018	12	0.054	12	0.1
Dissolved lead	mg/L	9	0.0002	12	0.0006	12	0.0051
Dissolved manganese	mg/L	9	0.0079	12	0.03565	12	0.0181
Dissolved nickel	mg/L	9	0.0007	12	0.00365	12	0.00535
Dissolved zinc	mg/L	9	0.005	12	0.014	12	0.036
Calcium	mg/L	9	414	12	326	12	365
Chloride	mg/L	9	17700	12	14050	12	15600
Magnesium	mg/L	9	1240	12	969	12	1090
NOx	mg/L	8	0.008	11	0.022	11	0.02
pH	pH unit	9	7.94	12	7.895	12	7.735
Potassium	mg/L	9	368	12	280.5	12	330
Sodium	mg/L	9	10700	12	8430	12	9550
Sulfate	mg/L	9	2800	12	2005	12	2300
TKN	mg/L	8	0.387	11	0.323	11	0.4
TP	mg/L	9	0.02	12	0.039	12	0.04
Bicarbonate alkalinity	mg/L	9	109	12	199	12	111.5
Season first sampled		Spring 2015		Autumn 2014		Autumn 2014	

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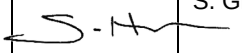
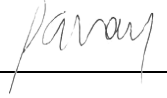
Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	J. Cairns T. Hopwood Z. Lagerroth	S. Harrow		S. Gray		24/01/2020

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