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Report

Carmichael Coal Mine and Rail Project Surface Water Monitoring Program

AUSTRALIA

Carmichael Coal Surface Water Monitoring Program

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Adani Mining Pty Ltd

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ABBREVIATIONS

Abbreviation	Description
ANZECC	Australian and New Zealand Environment and Conservation Council
AS/NZS	Australian Standard/New Zealand Standard
AusRivAS	Australian Rivers Assessment System
CoC	Chain of Custody
CV/FIMS	Cold Vapour/Flow Injection Mercury System
DEHP	Department of Environment and Heritage Protection
EA	Environmental Authority
EIS	Environmental Impact Statement
EPC	Exploration Permit for Coal
EP Act	Environmental Protection Act
EPP	Environmental Protection (Water) Policy
EVs	Environmental Values
HD	Highly Disturbed
HEV	High Ecological/Conservation Value
HSE	Health, Safety and Environment
ISQG	Interim Sediment Quality Guideline
MAW	Mine Affected Water
NATA	National Association of Testing Authorities
NRHP	National River Health Program
QA/QC	Quality Assurance/Quality Control
QWQG	Queensland Water Quality Guidelines
SEIS	Supplementary Environmental Impact Statement
SMD	Slightly to Moderately Disturbed
WQOs	Water Quality Objectives

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1 INTRODUCTION

1.1 Project Background

The Carmichael Coal Mine and Rail Project (the project) is a 60 million tonne per annum thermal coal mine proposed to be developed by Adani Mining Pty Ltd (Adani). The project is located in the north Galilee Basin, approximately 160 kilometres north-west of Clermont (refer to Figure 1-1). The project comprises two main components, as follows:

- A greenfield coal mine over Exploration Permit for Coal (EPC) 1690 and the eastern portion of EPC 1080 which includes both open cut and underground mining, on-mine infrastructure and associated mine processing facilities (refer to Figure 1-2). Offsite mine infrastructure includes a workers accommodation village and associated facilities, a permanent airport site and water supply infrastructure.
- A greenfield rail line connecting to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point. Features include:
  - A 120 kilometre dual gauge rail line from the mine site running wet to east to Diamond Creek;
  - A 69 kilometre narrow gauge rail line running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah; and,
  - Quarry material is to be extracted from five quarries in the region and will be used for upgrade and maintenance works on existing infrastructure and the construction of new infrastructure.

1.2 Purpose of Monitoring Program

The purpose of this monitoring program is to develop a baseline surface water quality dataset across the project site. The monitoring program builds upon previous water quality monitoring completed as part of the development of the Environmental Impact Statement (EIS) and Supplementary EIS (SEIS) for the project. Further baseline surface water and sediment quality monitoring has also been undertaken more recently by 4T Consultants as part of an ongoing monitoring program (4T Consultants Pty Ltd, 2013b). Baseline monitoring undertaken to date (2011 - 2014) has been limited mainly to low flow conditions. As a result, enough data has been collected to calculate low-flow water quality objectives (WQOs) for the site, as per the Queensland Water Quality Guidelines (QWQG), 2009 (refer to Section 1.6.2 for more detail).

The data set collected as a result of monitoring undertaken as part of this program combined with previous results will enable the finalisation of WQOs and associated conditions under the Mine Environmental Authority (EA).

Major components of the monitoring program include:

1. A short-term stream/river monitoring program (undertaken over two wet seasons) to provide information relating to water quality during medium to high flow conditions. This will ensure that a representative and statistically robust baseline water quality dataset is collected pre-construction for medium to high-flow conditions. This data will be used to finalise the local WQOs for the project (which have been developed using the results of

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monitoring undertaken to date) under both stream baseflow and high flow conditions, in order to underpin mine water discharges into the Carmichael River.
2. Flow measurements of the Carmichael River during periods of medium and high flow.
3. A short-term monitoring program for macroinvertebrate and spring water quality in order to provide additional information relating to the baseline quality of the aquatic environment within and adjacent to the project area.
4. A short-term monitoring program associated with the rail component of the project to be implemented during the construction phase.
5. A description of the relationship between the baseline surface water monitoring program and proposed Environmental Authority (EA) conditions for the Carmichael Coal project.

This monitoring program supersedes programs developed as part of the EIS and SEIS process, including those set out in the following documents:

- GHD (2012a). Carmichael Coal Mine and Rail Project: Mine Technical Report. Mine Water Quality 25215-D-RP-005. Prepared for Adani Mining Pty Ltd, 15 November 2012 (Revision 2).
- GHD (2012b). Mine Aquatic Ecology Report 2344-D-RP-0025. Prepared for Adani Mining Pty Ltd, 16 November 2012 (Revision 1).
- GHD (2013a). Carmichael Coal Mine and Rail Project SEIS Surface Water Quality Monitoring Plan. Prepared for Adani Mining Pty Ltd, July 2013.
- 4T Consultants Pty Ltd (2013).Carmichael Coal Mine Environmental Monitoring: Surface water and sediment quality. Final Report prepared for Adani Mining Pty Ltd, November 2013.

1.3 Surface Water Environment

The study area is located in the Burdekin Basin, defined as part of the central coast region in the Queensland QWQG (DEHP, 2009a). The water types within and in the vicinity of the project area include upland streams, (greater than 150 m elevation above sea level), spring complexes and farm dams.

The Carmichael River, designated as a fifth order stream, is the major surface water resource potentially affected by the mine aspect of the project. The river discharges to the Belyando River approximately 20 km to the east of the site. The Belyando Catchment is approximately 35,411 km^2 in size and is one of the largest in the Burdekin Basin.

The flow regime of the Carmichael River is subject to seasonal variability as overland flow drains from the catchment in the wet season. Late in the dry season, the Carmichael River is reduced to a low flow environment, interspersed with deeper pools. The Carmichael River was characterised by a well-established riparian zone that provided extensive shading of the water. Conversely, the farm dam sites and Cabbage Tree Creek all had limited riparian zones, resulting in increased exposure to direct radiance from the sun.

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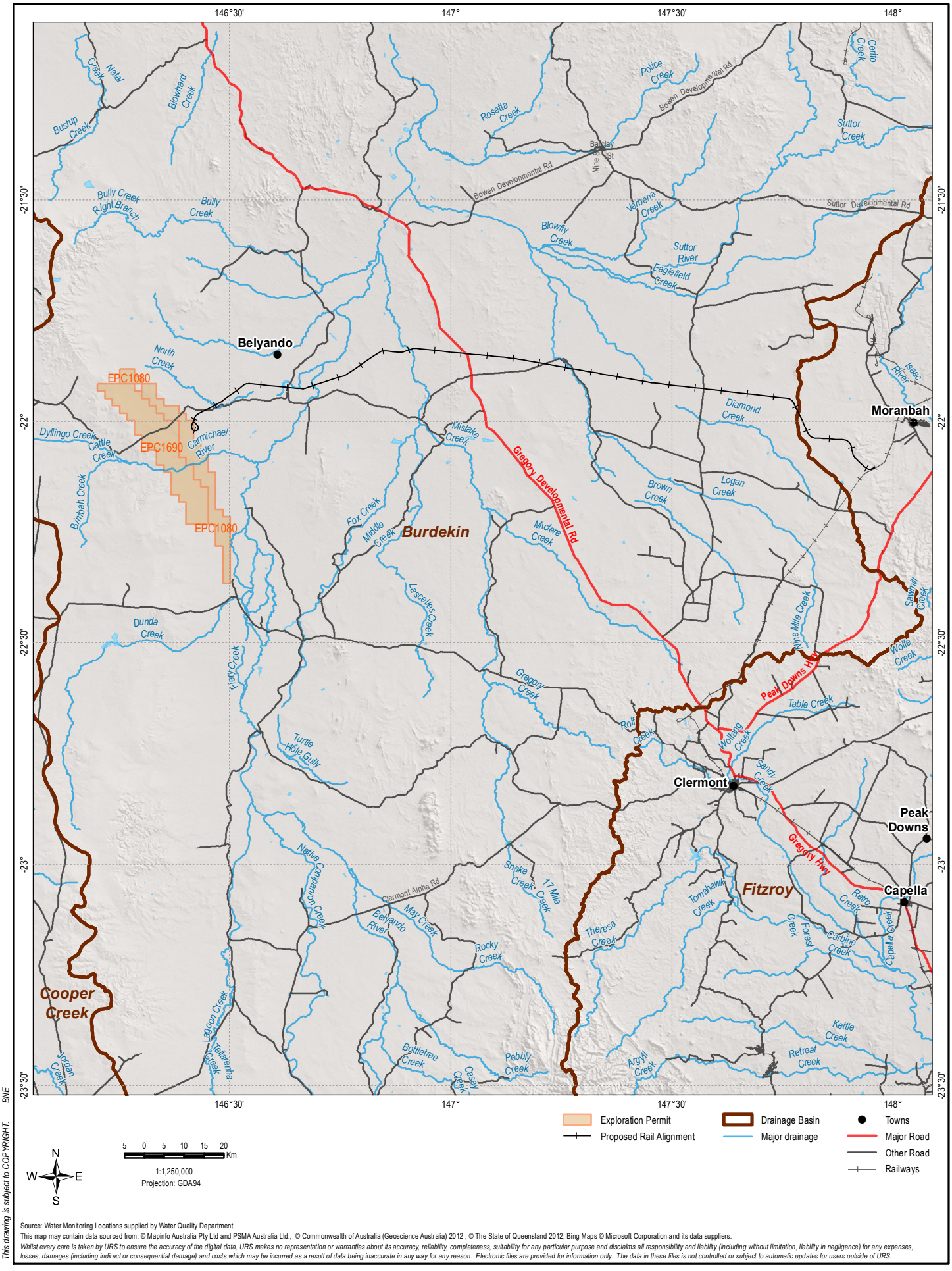

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CARMICHAEL COAL MINE EA SUPPORT

PROJECT LOCATION

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SURFACE WATER MONITORING PROGRAM

Figure: **1-1**

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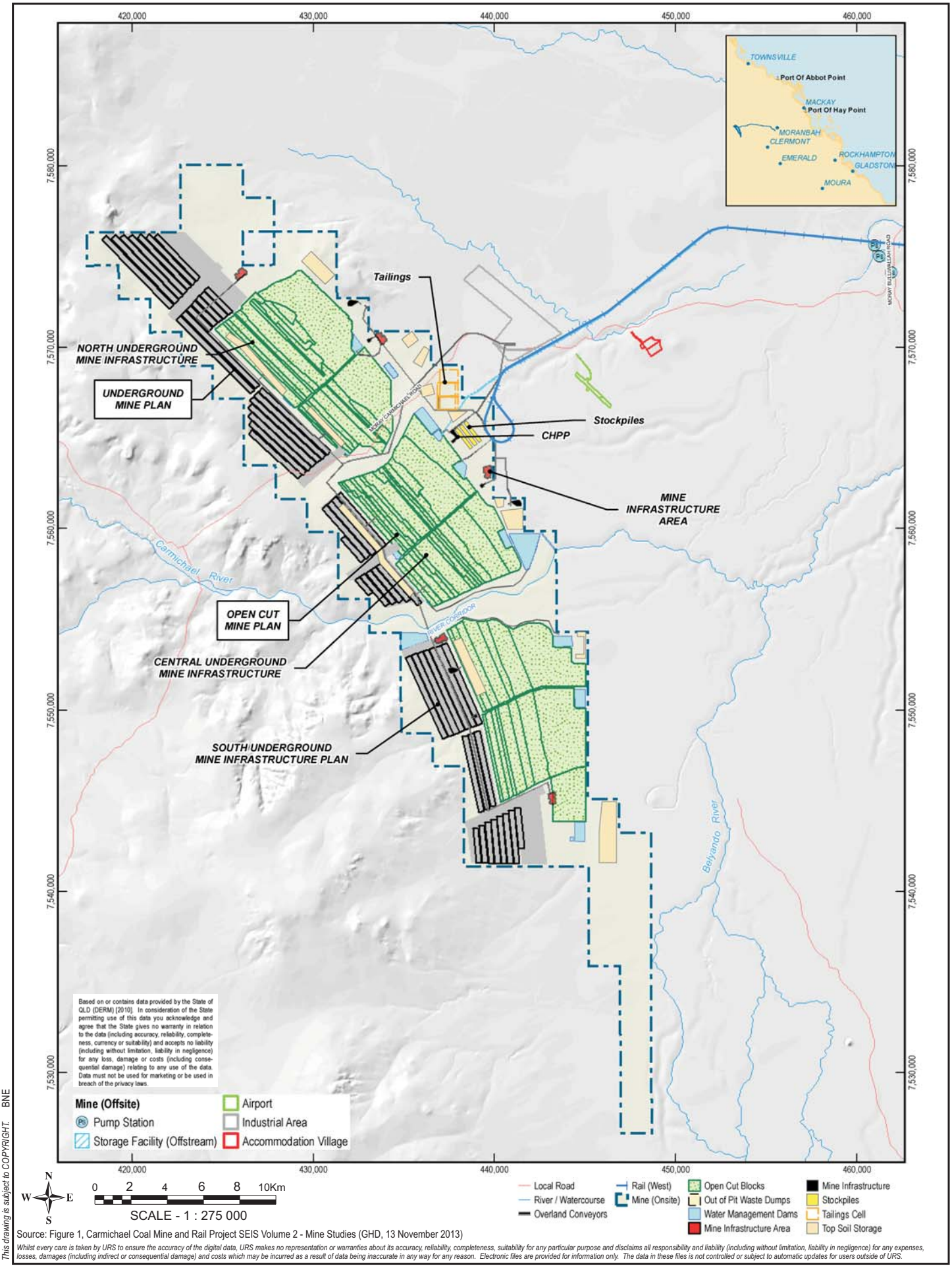

Source: Figure 1, Carmichael Coal Mine and Rail Project SEIS Volume 2 - Mine Studies (GHD, 13 November 2013)

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CARMICHAEL COAL MINE EA SUPPORT

PROJECT MINE LAYOUT

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SURFACE WATER MONITORING PROGRAM

Figure: **1-2**

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Tributaries within the Carmichael River catchment include:

- Cattle Creek
- Dyllingo Creek
- Surprise Creek
- Carmichael Creek
- Dingo Creek
- Dooyne Creek.

Cattle Creek, Dyllingo Creek and Surprise Creek converge into the Carmichael River upstream of the project area boundary. The river also receives discharge from the Doongmabulla Springs complex, which is also located to the west of the project area.

Information on observed surface water flows, groundwater levels and a comparison of groundwater and surface water quality data for the Carmichael River suggests that flows and/or water levels are at least partly supported by direct groundwater flow from the underlying units and/or by discharge from the Doongmabulla Springs (GHD, 2013b). As flow and water depth increase with rainfall during the summer period, water quality within the Carmichael River becomes less influenced by groundwater conditions. There are two springs complexes located in the vicinity of the project area. The Doongmabulla Springs complex is located 8 km to the west of the project, and contributes flow to the Carmichael River. The complex is recognised as an endangered threatened ecological community under the Environment Protection and Biodiversity Conservation Act 1999. The Mellaluka Springs complex is located on the south eastern edge of the project area. All of the springs associated with this complex are discrete environments that are not located within or near to any riverine waterways (GHD, 2013c).

1.4 Project Activities that may Impact Surface Water

The key proposed project infrastructure/activities with the potential to influence surface water comprises of the following:

- Creek diversions (Construction phase)
- Flood protection levees (Construction phase)
- Mine water management infrastructure including mine water dams (Construction phase)
- Other mine and rail project construction activities
- Controlled releases of mine affected water into receiving environment (Operations)

Volume 4 Appendix K4 (Flood Mitigation and Creek Diversion Design) of the SEIS (GHD, 2013d) depicts proposed levees and other flood mitigation infrastructure.

1.4.1 Creek Diversions

Multiple minor ephemeral creeks which currently flow during heavy rainfall events were found to intersect the mine area from the western boundary. Where these waterways intersect the proposed open cut mining areas, it is proposed that they be diverted using drains (and/or levees) sized to convey the peak 100 year Annual Return Interval (ARI) flow around the

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protected area to either the Carmichael River or an existing local waterway. Existing watercourses will be maintained where possible and drainage outflow points will be designed to closely mimic existing drainage paths and maintain flows where practical to waterways to the east of the mine area.

1.4.2 Flood Protection Levees

Levee banks are proposed to reduce the risk of flood waters entering pits and to assist with the separation of mine affected areas, therefore reducing the amount of mine affected water (MAW) (GHD, 2013a). The proposed levees include:

- Levees located either side of the Carmichael River and extending to wrap around active open cut pits and out-of-pit waste rock dump areas to reduce the risk of Carmichael River flood waters from entering the pits;
- Bunds around pit areas to prevent flooding due to runoff from local mine runoff;
- Minor levees either side of Eight Mile Creek so as to safely pass the existing waterway between out-of-pit waste rock dump areas;
- Minor levees around active pit areas to protect from flooding of local minor waterways; and,
- Other levees to protect underground mine access areas from either local or regional flooding.

Levees will be designed to provide 1000 year ARI flood immunity to the open cut pits and a minimum of 100 year ARI immunity to the waste dump areas.

1.4.3 Mine Water Management System

The drain diversion system will manage the movement of clean water away from mine workings, releasing this water back in to the environment without interaction with mine workings. MAW dam sediment basins will receive all raw water and MAW from operational pits, via the internal diversion drains. The design of these pits is underpinned by the requirement for discharge waters to meet relevant water quality objectives.

Discharge control measures include:

- Raw water will be delivered and temporarily stored in a raw water dam(s).
- MAW is to be retained on site and stored in facilities that are designed and managed in accordance with the draft guideline '*Regulated Dams in Environmentally Relevant Activities (Regulated Dams Guideline) Managing Dams Containing Hazardous Wastes'* (DERM, 2010).
- All water entering in the pit or underground working areas is considered MAW.
- Runoff from disturbed catchments areas has to be treated to a sufficient level before being released into the natural environment or is considered MAW.
- Clean water runoff from undisturbed catchments areas is diverted around any mine workings or disturbed areas and released downstream.

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- If there is water in sediment basins available with sufficient settlement time (5 days) then this water will be used for dust suppression.
- In case of Acidic Mine Drainage (AMD), water will be treated through neutralization. The nature of exact treatment will depend upon the water quality.
- Each spoil area will contain sedimentation basins.
- When spoil areas are rehabilitated in the later mine stages, the associated sediment basins are assumed to remain operational for a nominal minimum period of 10 years until vegetation cover is sufficient to mimic the pre-existing natural conditions.

1.5 Relevant Legislation

Legislation relevant to the surface water monitoring program includes the following:

- *Environmental Protection Act 1994* (EP Act); and,
- Queensland Environment Protection (Water) Policy 2009 (EPP Water).

1.5.1 Environmental Protection Act 1994

In particular, the EP Act provides for the regulation of surface water management with its requirement for the development of an Environmental Management Plan (EM Plan) and EA conditions. A Level 1 EA (Mining Activities) is applicable to the Project. The EA conditions provide specific requirements for monitoring receiving waters and any discharges from the Site to surface water, and reporting on water quality.

1.5.2 Queensland Environmental Protection (Water) Policy (EPP Water) 2009

The EPP Water (DERM, 2009) is subordinate legislation under the EP Act that functions to establish environmental values (EVs) associated with water, and ensuring that broad environmental protection measures are defined for protecting these EVs. The schedules of the EPP Water include prescribed EVs for some parts of Queensland. The Project site is not in area where EVs are currently defined by the EPP Water. Consequently the Project has identified preliminary EVs based on the findings of the EIS studies (refer to Section 1.8).

1.6 Relevant Guidelines

Guidelines relevant to the surface water monitoring program include the following:

- Australian and New Zealand Environment and Conservation Council (ANZECC) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
- Department of Environment and Heritage Protection (DEHP) (2009a). *Queensland Water Quality Guidelines (QWQG), Version 3 2009.*

1.6.1 ANZECC Guidelines for Fresh and Marine Water Quality

The ANZECC 2000 Guidelines provide guideline values (numbers) or descriptive statements for different indicators to protect aquatic ecosystems and human uses of waters (e.g. primary recreation, human drinking water, agriculture, stock watering). Although the ANZECC 2000 Guidelines provide extensive default guideline values for aquatic ecosystems, they strongly

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emphasise the need to develop more locally relevant guidelines (DEHP, 2009a). The ANZECC guidelines state: 'It is not possible to develop a universal set of specific guidelines that apply equally to the wide range of ecosystems in Australia and New Zealand. A framework is provided that allows the user to move beyond single-number, necessarily conservative values, to guidelines that can be refined according to local environmental conditions. This is the key message of the Guidelines.'

1.6.2 QWQG 2009

The QWQG (DEHP, 2009a) is a set of technical guidelines, primarily for the protection of Queensland aquatic ecosystems. The guidelines include locally and regionally relevant guideline values for fresh, estuarine and marine waters and are intended to address the need identified in the ANZECC 2000 Guidelines (see Section 1.6.1) by:

- Providing guideline values (numbers) that are tailored to Queensland regions and water types; and,
- Providing a process/framework for deriving and applying more locally specific guidelines for waters in Queensland.

The guidelines outline a methodology to develop site-specific water quality objectives. This methodology was adopted in order to develop site-specific water quality objectives for this project (refer to Section 2.1 for more detail).

1.7 Relevant Standards

Australian Standards relevant to the surface water monitoring program include the following:

- Australian Standard/New Zealand Standard (AS/NZS) 5667.1:1998. Water Quality – Sampling. Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.
- AS/NZS 5667.6:1998. Water Quality – Sampling. Guidance on sampling of rivers and streams.
- AS/NZS 5667.12:1999. Water Quality – Sampling. Guidance on sampling of bottom sediments.

1.8 Environmental Values

EVs for the project area are not specified in Schedule 1 of the EPP Water. Instead, EVs for receiving waters in the project area were derived from a desktop assessment of available information on the watercourses and their uses, based on the suite of EVs provided in the QWQG. EVs for receiving waters within and around the project area are presented in Table 1-1 below.

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Table 1-1 Environmental Values Applicable to the Project

Environmental Value	QWQG Definition (DEHP, 2009a)	Relevant to Project	Comment
Aquatic Ecosystems – Level 1: High Ecological Conservation Value (HEV) Ecosystem	Effectively unmodified or other highly valued systems, typically occurring in national parks, conservation reserves or in remote or inaccessible locations. The ecological integrity of HEV systems is regarded as intact.	✘	The catchment of the study area is considered to be slightly to moderately disturbed (SMD) (see below).
Aquatic Ecosystems – Level 2: Slightly to Moderately Disturbed (SMD) Ecosystem	Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation. Slightly to moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism.	✓	The catchment of the study area is considered to be SMD as the water resources receive runoff from land disturbed by grazing. Watercourses are accessed by stock for watering and dams are artificial habitat.
Aquatic Ecosystems – Level 3: Highly Disturbed (HD) Ecosystem	These are measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be rural streams receiving runoff from intensive horticulture.	✘	The catchment of the study area is considered to be SMD (see above).
Primary Industries Irrigation	Suitability of water supply for irrigation	✓	Some downstream crop irrigation occurs. The site drains to the Burdekin Falls dam, which supplies a number of irrigation areas.
Primary Industries Farm Water Supply	Suitability of domestic farm water supply other than drinking water.	✘	Farm dams used for stock watering only (see below).

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Environmental Value	QWQG Definition (DEHP, 2009a)	Relevant to Project	Comment
Primary Industries Stock Watering	Suitability of water supply for production of healthy livestock.	✓	Water resources within and downstream of the study area are used for stock watering.
Primary Industries Aquaculture	Health of aquaculture species and humans consuming aquatic foods from commercial ventures.	✗	No aquaculture occurs within or immediately downstream of the study area. The ephemeral nature of the streams makes it unlikely that aquaculture will be introduced to the area.
Primary Industries Human Consumers of Aquatic Foods	Health of humans consuming aquatic foods from natural waterways.	✗	No aquaculture or recreational fisheries occurs within or immediately downstream of the study area.
Recreation and Aesthetics Primary Recreation	Health of humans during recreation which involves direct contact and a high probability of water being swallowed.	✗	No water-based recreation activities occur within or immediately downstream of the study area. The ephemeral nature of watercourses would generally preclude primary recreation.
Recreation and Aesthetics Secondary Recreation	Health of humans during recreation which involves direct contact and a low probability of water being swallowed.	✗	No water-based recreation activities occur within or immediately downstream of the study area. The ephemeral nature of watercourses would generally preclude primary recreation
Recreation and Aesthetics Visual Recreation	Amenity of waterways for recreation which does not involve any contact with water.	✗	No water-based recreation activities occur within or immediately downstream of the study area due to a lack of public access and distance from settlements.
Drinking Water	Suitability of raw drinking water supply. This assumes minimal treatment of water is required.	✗	Farm dams used for stock watering only.
Industrial Uses	Suitability of water supply for industrial use.	✗	Farm dams used for stock watering only.
Cultural and Spiritual Values	Indigenous and non-indigenous cultural heritage.	✓	Traditional owners of the study area are the Wangan and Jagalingou people. The project is of relevance to these groups.

Source: Adapted from GHD, 2012

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2 BASELINE SURFACE WATER MONITORING PROGRAM

2.1 Water and Sediment Quality Objectives

2.1.1 Rationale

The ANZECC (2000) guidelines suggest that in order to protect and improve water resources a three tiered approach, comprising national, state (or territory) and regional or catchment is required. When determining water quality objectives (WQOs), locally derived objectives can be determined using processes set out in the QWQG (DEHP, 2009a) if sufficient data is available. If local data is not available, regional or catchment based WQOs are then relied on. If no such objectives exist or objectives are not set for a certain variable, then reference is made to the Queensland and then national water quality guidelines. Thus, locally derived water quality objectives take precedence over regional or catchment objectives, which in turn take precedence over state and national water quality objectives.

The study area is located in the Burkedin Basin. WQOs for this basin are yet to be scheduled in the EPP (Water). Draft WQOs are proposed in the Burdekin Water Quality Improvement Plan (Dight, 2009). These are consistent with the WQOs contained in the QWQG (DEHP, 2009a) and the ANZECC (2000) guidelines for slightly to moderately disturbed systems.

In order to derive local WQOs the QWQG recommends that percentile estimates at a reference site should be based on a minimum of 18 samples collected at each site over at least 12 and preferably 24 months (in order to capture two complete annual cycles). Given that such large data sets are rarely available outside government agencies, percentile estimates based on eight or more samples could be used to derive interim guidelines on the understanding that further data would be collected and guideline values updated accordingly (DEHP, 2010).

The QWQG indicate that in more ephemeral streams, there is often significant variability in quality (as a result of the fluctuating flow regime) and that this natural variability should be assessed. As sampling for the Carmichael coal project has been undertaken only during low-flow conditions (refer to Section 2.1.2 below for more detail), further sampling during high flow conditions is required before local WQOs can be derived.

2.1.2 Sampling Undertaken to Date

Water (both watercourse and spring), aquatic sediment and macroinvertebrate quality sampling in and around the project area was undertaken as part of the EIS, SEIS, as well as a separate sampling program. Results are presented in the following documents:

- GHD (2012a). *Carmichael Coal Mine and Rail Project: Mine Technical Report. Mine Water Quality 25215-D-RP-0005.* Prepared for Adani Mining Pty Ltd, 15 November 2012 (Revision 2).
- GHD (2012b). *Mine Aquatic Ecology Report 23244-D-RP-0025.* Prepared for Adani Mining Pty Ltd, 16 November 2012 (Revision 1).
- GHD (2013a). *Carmichael Coal Mine and Rail Project SEIS. Report for Mine Water Quality*. Prepared for Adani Mining Pty Ltd, 24 October 2013.

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- 4T Consultants Pty Ltd (2013). *Carmichael Coal Mine Environmental Monitoring. Surface Water and Sediment Quality.* Final Report, November 2013.

Basic stream water quality parameters have been assessed (during low-flow conditions) on 23 occasions over almost two years from April 2011 until February 2014 (results of sampling undertaken in October, November, December 2013 and January and February 2014 have not yet been published in a report). A broader analytical suite (including parameters such as hydrocarbons and metals) was assessed for 20 of the 23 events during this period.

Stream sediment quality has been assessed on six occasions (July 2011, December 2012, March 2013, June 2013, September 2013 and December 2013).

A summary of sampling undertaken to date is presented in Figure 2-1 and Figure 2-2 below. A summary of the number of samples collected to date (up to and including February 2014) is included in Table 2-1 and Table 2-2. It should be noted that minor amendments to the water quality parameters analysed were made after September 2011, therefore results are presented in separate tables.

Water quality for the Doongmabulla and Mellaluka Springs complex has been assessed on one occasion (May/June 2012 and April 2013 respectively). Samples were collected from 14 locations within the Doongmabulla complex in May/June 2012 (GHD, 2012a) and 11 locations within the Mellaluka complex (including both spring and groundwater bore sampling points) in April 2013 (GHD, 2013c).

Macroinvertebrate sampling was undertaken at three locations in May 2011 (post wet season) and November 2011 (pre wet season).

A number of surface water, sediment and macroinvertebrate sampling sites previously sampled as part of the EIS, SEIS and ongoing monitoring program have been selected for additional monitoring as part of this baseline surface water monitoring program (refer to Section 2.2 below for more detail).

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Figure 2-1 Summary of Stream Water and Sediment Sampling Undertaken to April 2013 (GHD 2013a)

	Event 1 13-14 April 2011	Event 2 4-5 May 2011	Event 3 21-22 June 2011	Event 4 26-27 July 2011	Event 5 23-24 Aug 2011	Event 6 20-21 Sept 2011
Site 1	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 2	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 3	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 4	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 5	● ●	Site not accessible	● ●	Site not accessible	● ●	● ● ●
Site 6	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 7	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 8	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 9	● ●	● ● ●	● ●	● ● ● ●	● ●	● ● ●
Site 10	No water	No water	No water	● ●	No water	No water
Site 11	No water	No water	No water	● ●	No water	No water
Site 12	No water	No water	No water	● ●	No water	No water

KEY: ● In-situ water suite ● Basic analytical suite (water) ● Broad analytical suite (water) ● Sediment sampling suite ● DI leach suite

	Event 7 31 October 2012	Event 8 29 November 2012	Event 9 19 December 2012	Event 10 10 January 2013	Event 11 20 February 2013	Event 12 14 March 2013	Event 13 10 April 2013
Site 1			No flow	Low flow	No flow	No Flow	
Site 2			No Flow				
Site 3							
Site 4							
Site 5							
Site 13				No Flow			
Site 14			No Flow			No Flow	
Site 15							
Site 16		No Flow		No Flow			

KEY: In-situ water suite; Basic analytical suite (water); Broad analytical suite (water)

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Figure 2-2 Summary of Stream Water and Sediment Sampling Undertaken To Date (4T Consultants 2013)

Site	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Events
BEL01	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
BEL02								●	● ●	●	●	● ●	●
CAR01	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
CAR02	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
CCK01	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
CT01	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
DCK01	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
ECK02	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●
NCK01	●	●	● ●	●	●	● ●	●	●	● ●	●	●	● ●	●

● **Water Quality Samples** ● **Sediment Quality Samples**

Note: Additional water quality monitoring has also been undertaken in October, November and December 2013 and January and February 2014, and additional sediment sampling undertaken in December 2013 (J. El Khoury, personal communication, 4 March 2014). EC and flow data for this period is presented in Section 3. Other analytical results for this period are not yet available.

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Table 2-1 Number of Stream Water Quality Samples Collected from April 2011 to September 2011

Analyte Group	Number of Background Low-Flow Samples
In-situ physio chemical water quality parameters: - Turbidity - Dissolved Oxygen - pH - Temperature - Electrical conductivity	52
Basic analytical suite: - Nutrients - Chlorophyll a - Faecal coliforms - Total dissolved solids - Total suspended solids	52
Broad analytical suite: - Major cations and anions - Total hardness - Total petroleum hydrocarbons - Polycyclic aromatic hydrocarbons - Total and dissolved metals - Dissolved silicon - Fluoride	25

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Table 2-2 Number of Stream Water Quality Samples Collected from October 2012 to February 2014

Analyte Group	Number of Background Low-Flow Samples
In-situ physio chemical water quality parameters: - Turbidity - Dissolved Oxygen - pH - Electrical conductivity	143
Physical parameters: - Major anions - Major cations - Total dissolved solids - Total suspended solids	143
Nutrients: - Total Nitrogen - Ammonia - Nitrite - Nitrate - Total Kjeldahl Nitrogen - Total phosphorus	143
Total and dissolved metals	143
Total petroleum hydrocarbons	143

Note: Assumes that samples were able to be collected from all nine monitoring locations in October, November and December 2013 and January and February 2014.

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2.1.3 Local WQOs (Low Flow Conditions) and Sediment Quality Objectives

Locally derived low-flow water quality objectives adopted for this assessment are provided in Table 2-3 below. Further detail regarding the derivation of local water quality objectives for low flow conditions can be found in Table 14 of the report entitled '*Report for Mine Water Quality'* (GHD, 2013a); all surface water samples undertaken as part of the EIS and SEIS were collected during periods of no flow/ low flow and therefore can only be considered as WQO's for the Carmichael River during periods of low flow. Given the probable influence of groundwater and spring water, which is likely to be far greater during the dry season (GHD, 2013a) it is highly probable that the surface water quality during periods of low and no flow is significantly different compared with that during high flow conditions. The derivation of WQOs for high flow conditions is important for the protection of downstream EVs during the wet season. It is anticipated that following the collection of samples during periods of high flow conditions over two wet seasons (periods of high flow), sufficient data will have been accumulated to derive WQO's of baseline surface water quality conditions for the Carmichael River under high flow conditions.

Sufficient information has now been collected by 4T Consulting Pty Ltd (from gauges around the project area) to calculate WQOs for EC under medium and high flow conditions. Results are presented in Section 3.

Table 2-3 Local Water Quality Objectives for the Carmichael River[1]

Parameter	Unit	Selected WQO	Source of WQO
Physico Chemical			
pH	pH units	6.5 – 8.5	QWQG (DEHP, 2009a)
Electrical Conductivity (EC)	µS/cm	168	Belyando Suttor subcatchment WQO[D]
Turbidity	NTU	17[A]	Carmichael River 80th percentile
Total Suspended Solids	mg/L	54[A]	Carmichael River 80th percentile
Total Dissolved Solids	mg/L	818[A]	Carmichael River 80th percentile
Nutrients			
Ammonia-N	µg/L	90[A]	Carmichael River 80th percentile

[1] The data in this table may change following a review of raw data and calculations (which may result in revisions to 80th percentile values).

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Parameter	Unit	Selected WQO	Source of WQO
Nitrate	µg/L	78[A]	Carmichael River 80th percentile
Organic N	µg/L	470[B]	Carmichael River 80th percentile
Total N	µg/L	960[A]	Carmichael River 80th percentile
Filterable reactive phosphorus	µg/L	15	QWQG (DEHP, 2009a)
Total Phosphorus	µg/L	120[A]	Carmichael River 80th percentile
Sulphate	mg/L	13[A]	Carmichael River 80th percentile
Hardness	Insufficient data		
Dissolved Metals			
Aluminium	µg/L	55	DEHP Model Conditions[C]
Arsenic	µg/L	13	ANZECC, 2000 (SMD Guideline)
Boron	µg/L	370	ANZECC, 2000 (SMD Guideline)
Cadmium	µg/L	0.2	ANZECC, 2000 (SMD Guideline)
Copper	µg/L	4[A]	Carmichael River 80th percentile
Chromium (III+IV)	µg/L	2[A]	Carmichael River 80th percentile
Iron	µg/L	300	DEHP Model Conditions[C]
Lead	µg/L	4	ANZECC, 2000 (SMD Guideline)
Manganese	µg/L	1900	ANZECC, 2000 (SMD Guideline)
Mercury	µg/L	0.06	ANZECC, 2000 (SMD Guideline)

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Parameter	Unit	Selected WQO	Source of WQO
Nickel	µg/L	11	ANZECC, 2000 (SMD Guideline)
Zinc	µg/L	30[A]	Carmichael River 80th percentile

[A] Calculated using data collected from April 2011 to September 2013.

[B] Calculated using data collected from April 2011 to April 2013.

[C] DEHP Guideline for Model Mining Conditions (EM944, Version 4) and DEHP Guideline for Model Water Conditions for Coal Mines in the Fitzroy Basin (EM288, Version 3).

[D] Although EC values for the Carmichael River are elevated at very low flows, (see Section 3), releases would not occur during such conditions, therefore the Belyando Suttor subcatchment WQO was adopted for EC.

Source: Adapted from GHD, 2013a and 4T Consultants Pty Ltd, 2013

ANZECC (2000) Interim Sediment Quality Guidelines (ISQG) have been adopted as sediment quality objectives for the project (refer to GHD, 2013a for further detail). These objectives are presented in Table 2-4. The results of sediment sampling undertaken as part of the EIS and SEIS were assessed against these objectives.

Table 2-4 Proposed Sediment Quality Objectives

Parameter	Sediment Quality Objective (ANZECC ISQG-Low)	Sediment Quality Objective (ANZECC ISQG-High)
Metals and Metalloids (mg/kg dry wt)		
Arsenic	20	70
Cadmium	1.5	10
Chromium (III+IV)	80	370
Copper	65	270
Lead	50	220
Mercury	0.15	1
Nickel	21	52
Silver	1	3.7
Zinc	200	410
Organics (µg/kg dry wt)		

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Parameter	Sediment Quality Objective (ANZECC ISQG-Low)	Sediment Quality Objective (ANZECC ISQG-High)
Acenaphthene	16	0.5
Anthracene	85	1.1
Benz(a)anthacene	261	1.6
Benzo(a)pyrene	430	1.6
Chrysene	384	2.8
Dibenz(a,h)anthracene	63	0.26
Fluoranthene	600	5.1
Fluorene	19	0.54
Napthalene	160	2.1
Phenanthrene	240	1.5
Pyrene	665	2.6

Source: GHD, 2013a

2.2 Proposed Locations and Frequencies of Sampling

2.2.1 Mine Project Stream Water Quality

Baseline Monitoring under High-Flow Conditions

The proposed baseline high-flow water sampling schedule associated with the mine project is presented in Table 2-5 and Figure 2-3 below. Sampling will be undertaken following rainfall events that generate sufficient runoff (see Section 3) to cause stream flow with the minimum time between sampling events being weekly. Due to safety considerations samples will be collected following the recession of floodwaters. The minimum number of samples to be collected at each site is twelve over the next two wet seasons as per DEHP guidelines (Table 4.2.2).

Table 2-5 Baseline High-Flow Surface Water Monitoring Schedule

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency	
CAR04	Carmichael River upstream gauging	-22.1087960	+146.3527180	–	Following major rainfall events for full laboratory analysis*

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Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
	station			– Continuous monitoring of flow and EC
DCK01	Dyllingo Creek at Carmichael/Moray Rd	-22.0888320	+146.2606000	– Following major rainfall events for full laboratory analysis* – Continuous monitoring of flow and EC
CAR01	Carmichael River downstream of mining lease	-22.0740740	+146.4675990	– Following major rainfall events for full laboratory analysis* – Continuous monitoring of flow and EC
CAR02	Carmichael River at Mid GS	-22.0975750	+146.4055550	– Following major rainfall events for full laboratory analysis*
CAR03	Carmichael River at Main Crossing	-22.1071410	+146.3957890	– Following major rainfall events for full laboratory analysis*
BEL01	Belyando River at Carmichael/Moray Rd	-21.9594600	+146.6568190	– Following major rainfall events for full laboratory analysis* – Continuous monitoring of flow and EC

*Sampling to be undertaken following major rainfall events where flow is sufficient and access to monitoring locations is available. The minimum elapsed time between sampling events is weekly. A minimum of twelve samples should be collected at each site over two wet seasons.

Construction Phase Mine Water Monitoring

The proposed water sampling schedule associated with the construction phase of the mine project is presented in Table 2-6 below. Due to the ephemeral nature of the surface water bodies in the project area, sampling will be undertaken following rainfall events that generate sufficient runoff to cause stream flow. Due to safety considerations samples will be collected following the recession of floodwaters. Sampling shall continue for the duration of the mine construction period.

Table 2-6 Mine Construction Period Surface Water Monitoring Schedule

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
CAR04	Carmichael River upstream gauging station	-22.1087960	+146.3527180	– Following major rainfall events for full laboratory analysis*

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Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
				– Continuous monitoring of flow and EC
DCK01	Dyllingo Creek at Carmichael/Moray Rd	-22.0888320	+146.2606000	– Following major rainfall events for full laboratory analysis* – Continuous monitoring of flow and EC
CAR01	Carmichael River downstream of mining lease	-22.0740740	+146.4675990	– Following major rainfall events for full laboratory analysis* – Continuous monitoring of flow and EC
CAR02	Carmichael River at Mid GS	-22.0975750	+146.4055550	– Following major rainfall events for full laboratory analysis*
CAR03	Carmichael River at Main Crossing	-22.1071410	+146.3957890	– Following major rainfall events for full laboratory analysis*
BEL01	Belyando River at Carmichael/Moray Rd	-21.9594600	+146.6568190	– Following major rainfall events for full laboratory analysis* – Continuous monitoring of flow and EC
BEL02	Belyando River at Bygana Waterhole (upstream of Carmichael River and mine)	-22.1620320	+146.5285470	– Following major rainfall events for full laboratory analysis*
CCK01	Cattle Creek upstream of Dyllingo confluence at Moses Springs	-22.0906570	+146.2562410	– Following major rainfall events for full laboratory analysis*
CT01	Cabbage Tree Creek approximately 2.5 km downstream of Carmichael River confluence	-22.1067830	+146.4139080	– Following major rainfall events for full laboratory analysis*
NCK01	North Creek at Carmichael/Moray Road	-21.9661140	+146.4865360	– Following major rainfall events for full laboratory analysis*
ECK02	Eight Mile Creek at Carmichael/Moray Road	-21.9691720	+146.3987390	– Following major rainfall events for full laboratory analysis*

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*Sampling to be undertaken following major rainfall events where flow is sufficient and access to monitoring locations is available, for the duration of the mine construction period.

Operational Phase Mine Water Monitoring

Monitoring of water quality during the operational phase of the mine project will be undertaken using the locations and frequencies outlined in Table 2-7 below.

Table 2-7 Operational Phase Mine Water Monitoring Schedule

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
Upstream Background Monitoring Points				
CAR04	Carmichael River upstream gauging station	-22.1087960	+146.3527180	– Daily during the release – Continuous monitoring of flow and EC
BEL02	Belyando River at Bygana Waterhole	-22.1620320	+146.5285470	– Daily during the release – Continuous monitoring of flow and EC
Downstream Monitoring Points				
CAR01	Carmichael River downstream of mining lease	-22.0740740	+146.4675990	– Daily during the release – Continuous monitoring of flow and EC
BEL01	Belyando River at Carmichael/Moray Rd	-21.9594600	+146.6568190	– Daily during the release – Continuous monitoring of flow and EC

2.2.2 Rail Project Stream Water Quality - Construction Period

Stream/river monitoring locations associated with the rail component of the project are presented in Table 2-8 below. Water sampling is to be undertaken at these locations monthly during construction of the rail project. Samples are to be analysed for the parameters presented in Table 2-3 above.

Table 2-8 Rail Surface Water Monitoring Schedule

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
BEL01	Belyando River at Carmichael/Moray Rd (upstream of rail line)	-21.9594600	+146.6568190	– Monthly during construction of the rail project
BEL03	Belyando River downstream of rail line	-21.889250	+146.706395	– Monthly during construction of the rail project

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2.2.3 Stream Macroinvertebrate Monitoring Locations

Stream macroinvertebrate monitoring locations are presented in Table 2-9 below. Macroinvertebrate sampling is to be undertaken twice (in Autumn and Spring, as per AusRivAS protocols) for one more year.

Table 2-9 Macroinvertebrate Monitoring Schedule

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
CAR04	Carmichael River upstream gauging station	-22.1087960	+146.3527180	– Autumn and Spring
DCK01	Dyllingo Creek at Carmichael/Moray Rd	-22.0888320	+146.2606000	– Autumn and Spring
CAR01	Carmichael River downstream of mining lease	-22.0740740	+146.4675990	– Autumn and Spring
BEL01	Belyando River at Carmichael/Moray Rd	-21.9594600	+146.6568190	– Autumn and Spring

2.2.4 Spring Monitoring Locations

Spring monitoring locations are presented in Table 2-10 below. Three representative monitoring locations within the Doongmabulla Springs complex were selected based on descriptions provided in the previous assessment of spring water quality (GHD, 2013a). Only sites with observed water flow were selected. Sampling points within the Mellaluka Spring complex were selected based on sites proposed in the Groundwater Dependent Ecosystems Management Plan (GHD, 2014).

Spring water sampling is to be undertaken monthly until data for two wet seasons has been obtained. Sampling is to include the water quality parameters presented in Table 2-3. Macroinvertebrate sampling is to be conducted twice in the next year (Autumn and Spring).

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Table 2-10 Spring Monitoring Schedule

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
DS1	Doon Spring 1 (Little Moses Spring group)	-22.091048	+146.269163	– Monthly for water quality and level* – Twice for macroinvertebrates (Autumn and Spring)
DS4	Doon Spring 4 (Moses Spring group)	-22.086698	+146.239912	– Monthly for water quality and level* – Twice for macroinvertebrates (Autumn and Spring)
DS10	Doon Spring 10 (Joshua Spring)	-22.069449	+146.23513	– Monthly for water quality and level* – Twice for macroinvertebrates (Autumn and Spring)
MS01	Mellaluka Spring	-22.318086	+146.48369	– Monthly for water quality and level* – Twice for macroinvertebrates (Autumn and Spring)
MS02	Stories Spring (Mellaluka Complex)	-22.296555	+146.481523	– Monthly for water quality and level* – Twice for macroinvertebrates (Autumn and Spring)
MS03	Lignum Spring	-22.26406	+146.47457	– Monthly for water quality and level* – Twice for macroinvertebrates (Autumn and Spring)

*Sampling to continue until data for two wet seasons is obtained.

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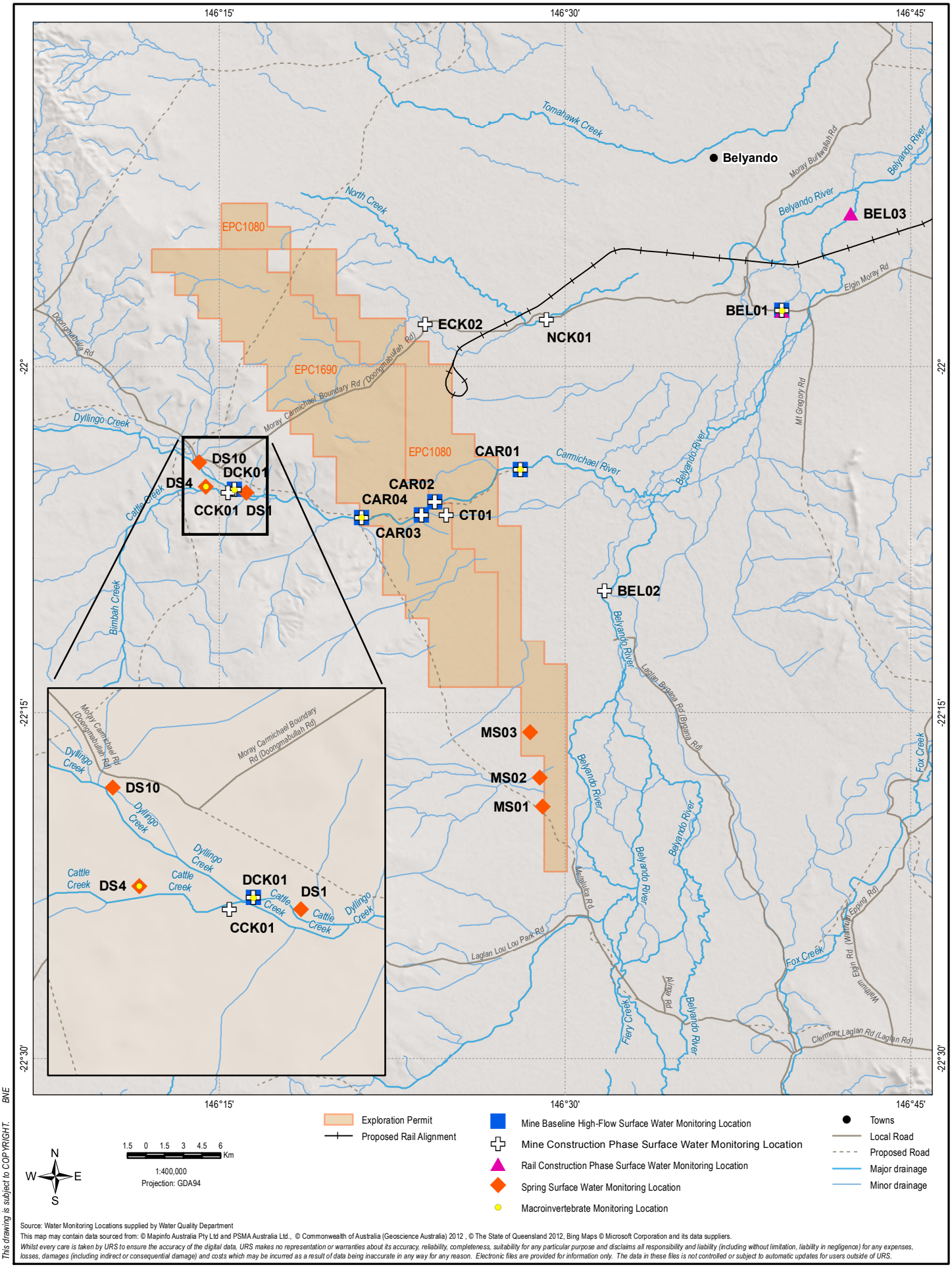

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BASELINE MONITORING LOCATIONS AND TYPES

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SURFACE WATER MONITORING PROGRAM

Figure: 2-3

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3 ASSESSMENT OF HIGH FLOW WATER QUALITY

3.1 Introduction

The proposed discharges of MAW requires the robust characterisation of the receiving environment's water quality objectives (WQOs), during both the baseflow (dry season) and high flows (wet season). Substantial baseflow water quality data was gathered by the proponent between 2011 and 2013 and presented in the EIS and SEIS (GHD 2012, GHD 2013a and GHD 2013b) as well as in a separate report post SEIS (4T Consultants Pty Ltd 2013). This has allowed for the baseflow (low flow) WQOs for the Carmichael River to be derived.

As part of their ongoing monitoring of the baseline condition of the Carmichael River, the proponent has installed a number of stream gauges to collect flow and water quality (pH, electrical conductivity, turbidity, temperature and dissolved oxygen) data during periods of high flow in the river.

3.2 Carmichael River Hydrograph (October 2013 to December 2013)

Stream flow data from the Carmichael River upstream gauge (CAR04) for stream flow, turbidity and EC levels for the period from October 2013 to 3 February 2014 was gathered and assessed for flow relationships with EC and turbidity for the Carmichael River. Assessment of the flow data indicated that the most significant flow event during this period occurred between 13 October to 18 October 2013, during which time the river experienced three high flow events, peaking on the 18 November, 23 November and 24 November 2013. The peak flows for these events were measured at 55.7, 34.7 and 25.1 m^3/sec, respectively (Figure 3-1). Other flow events occurred on the 8 January, 27 January and 3 February 2014 when flows peaked at 10, 23.2 and 10.7 m^3/s, respectively (Figure 3-2).

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Figure 3-1 Stream flow, EC and Turbidity of the Carmichael River for period October to December 2013

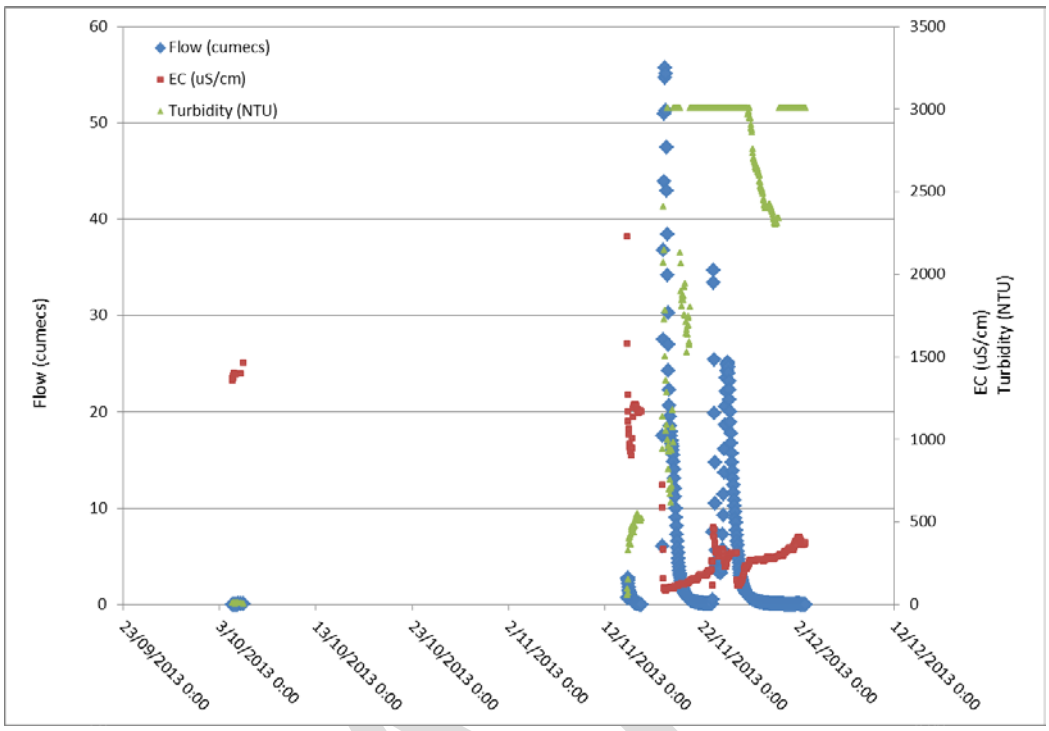
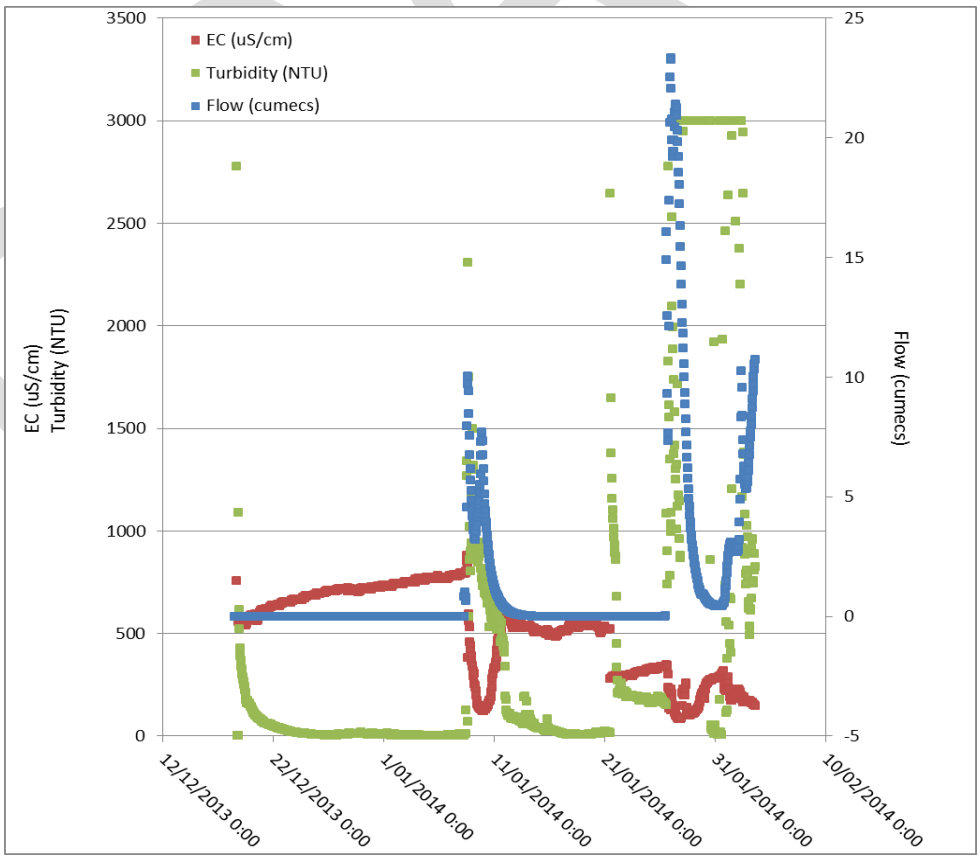


Figure 3-2 Stream flow, EC and Turbidity of the Carmichael River for the period December 2013 to February 2014



The hydrographs clearly indicate that flushes of water through the Carmichael River recede rapidly, and that the water quality in terms of EC and turbidity are strongly dependent on stream flow.

3.3 Characterisation of Relationship between EC and Flow in the Carmichael River

Accurate assessment of the relationship between EC and stream flow using the full range of CAR04 stream gauge data was difficult given the high degree of data "noise"; it was therefore decided that the period containing the most significant flow event, from 15 November to 22 November 2013, be used to characterise the low and medium flows of the Carmichael River. Levels of EC were plotted against stream flow for this period and the results are shown in Figure 3-3 and Figure 3-4; data for this period was selected to include only measurements taken for the main flush event specifically for the recessionary or falling limb of the hydrograph, after the groundwater influence had been removed.

The plot identifies three separate hydrological phases for the Carmichael River as follows;

- Where on the scatter plot the trend exceeded the WQO for the Belyando Suttor sub-catchment of 168 µS/cm, this was identified as the low flow trigger. A baseflow (low flow) phase is characterised by flows less than 0.2 m^3/sec (17.3ML/day).
- A medium flow was characterised by the point on the scatter plot where the EC levels starts to markedly increase. This occurred at a flow of 1 m^3/sec and a corresponding EC level of 125 µS/cm.
- A high flow phase was characterised by stream flow greater than 10m^3/sec with a stable EC level of approximately 100-110 µS/cm. This level represents the 80th percentile of flows for the period 14 November to 22 November 2013

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Figure 3-3 Correlation between EC and stream flow (at low and medium flows) for the Carmichael River

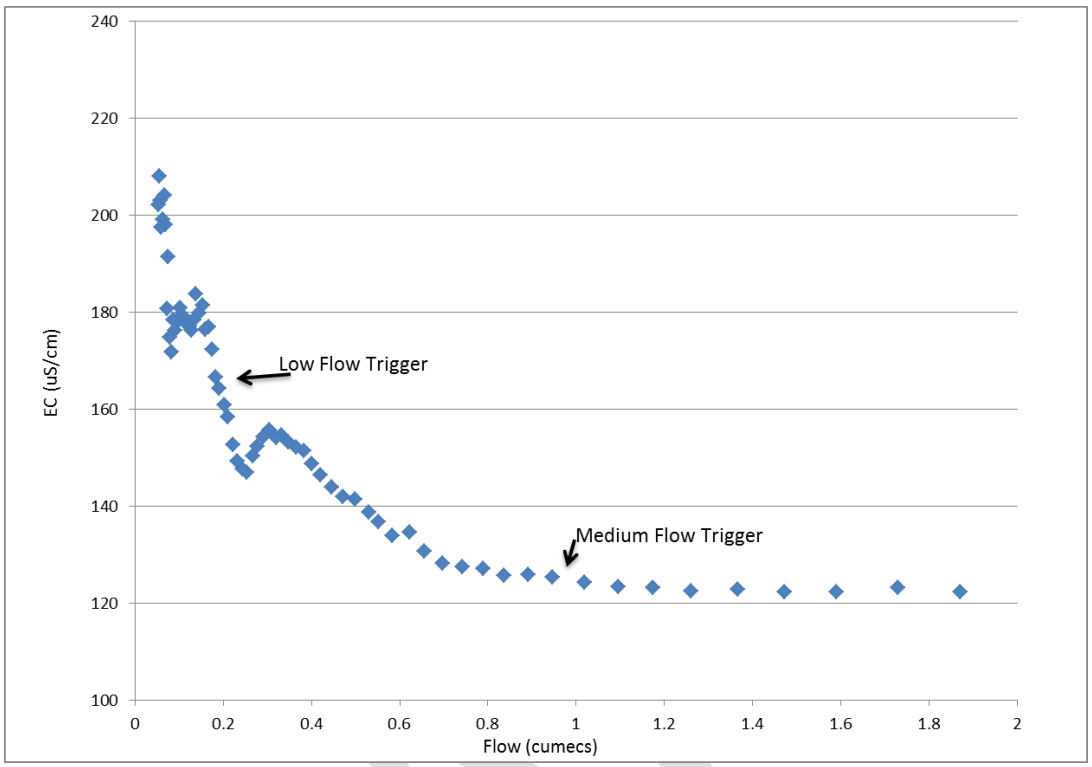

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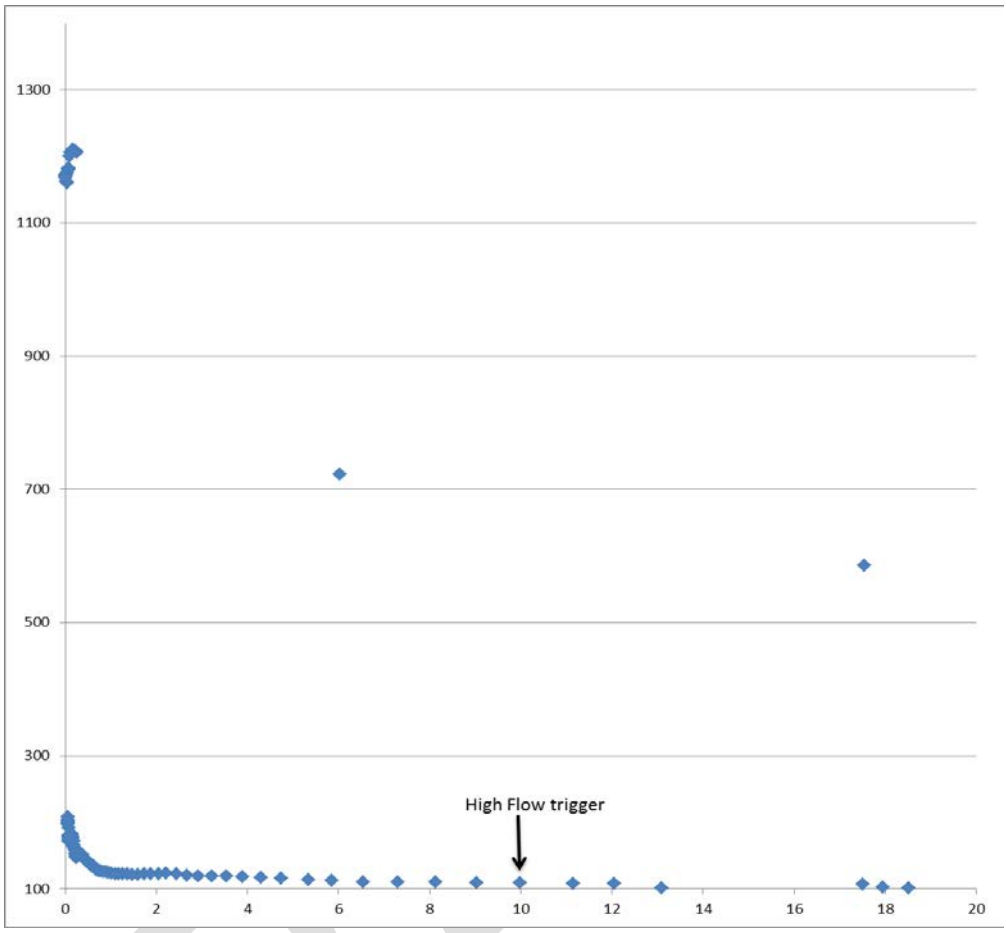
Figure 3-4 Correlation between EC and stream flow for the Carmichael River showing high flows



3.4 Characterisation of relationship between turbidity and flow

Assessment of the relationship between stream flow and turbidity levels of the Carmichael River using the data from the upstream stream gauge (CAR04) for the period 18 December 2013 to 3 February 2014 also appears to vary greatly in its turbidity levels as a function of stream flow (Figure 3-5). Assessment of water turbidity levels as a function of stream flows identified the following general relationships:

- At baseflow (<0.2 m^3/sec) the Carmichael River had low but variable turbidity levels ranging from 2 to 500 Nephalometric Turbidity Units (NTU).
- At medium flows (1-10 m^3/sec) and high flows (>10 m^3/sec) the turbidity of the water varied greatly from approximately 500 NTU to 3000 NTU.

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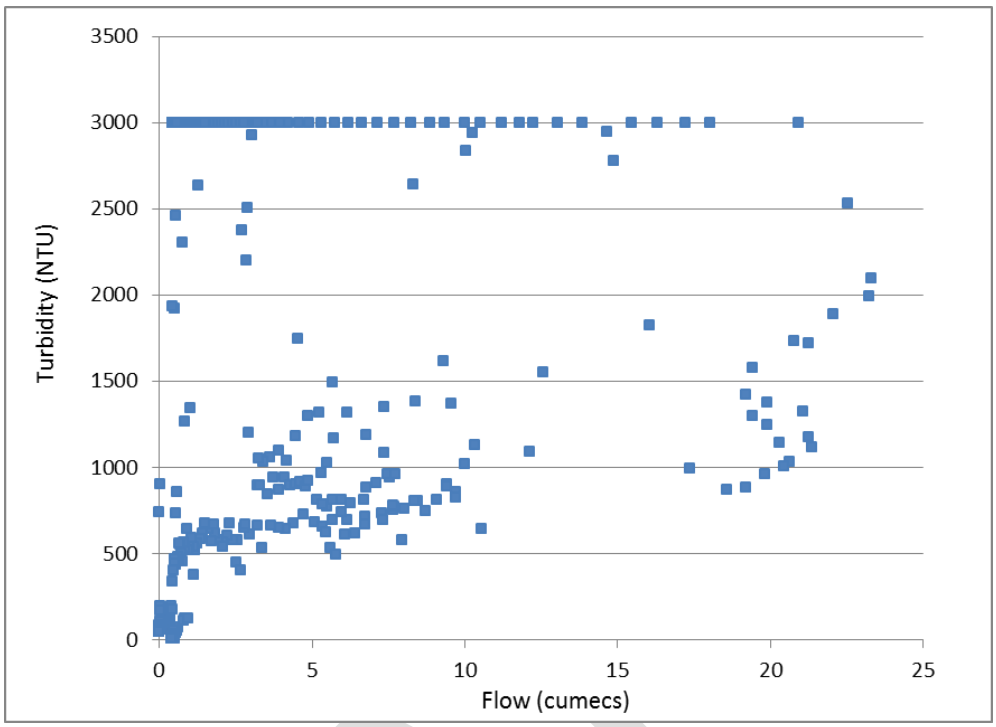
Figure 3-5 Flow and Turbidity Relationship for the Carmichael River



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4 RELATIONSHIP BETWEEN BASELINE SURFACE WATER MONITORING AND PROPOSED ENVIRONMENTAL AUTHORITY CONDITIONS

4.1 Introduction

As discussed earlier, a key purpose of the baseline monitoring program is to accumulate sufficient data to complete an assessment of baseline surface water conditions and to develop site-specific water quality objectives for the site. It is planned that the baseline data would be used to inform the development of contaminant trigger investigation levels applicable to proposed mine water releases, and receiving water contaminant trigger levels downstream of the mine to assess impacts from the operation of the mine.

Additionally, release points and operational surface water quality monitoring locations have been identified based on the proposed Environmental Authority (EA) conditions. These are discussed below.

4.2 Proposed Release Points

It is proposed that controlled releases will occur from two mine water dams for the Carmichael coal mine. Controlled releases will occur through a release point for each of the mine water dams. Details are presented in Table 4-1 below. Release limits for mine affected waters are presented in Table 4-2. Release limits during flow events are presented in Table 4-3. These releases apply to the gauging station situated at site CAR01, which is required to be recorded continuously.

Table 4-1 Mine Affected Water Release Points

Release Point	Latitude	Longitude	Contaminant Source and Location	Monitoring Point	Receiving Water Description
RP1 – Central MAW North	-22.073	146.435	Mine Affected Water Dam Central - North	Outlet works to Carmichael River	Carmichael River
RP2 – Central MAW South	-22.118	146.375	Mine Affected Water Dam Central – South	Outlet works to Carmichael River	Carmichael River

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Table 4-2 Mine Affected Water Release Limits

Quality Characteristic	Release Limit	Monitoring Frequency
Electrical conductivity (µS/cm)	Low flow <0.2 m^3/s: 168 Medium flow > 1 m^3/s: 840 Medium flow > 5 m^3/s: 1,850 High flow: 3500	Continuously
pH (pH Unit)	6.5 (minimum) 9.0 (maximum)	Continuously
Turbidity (NTU)	For all flows, downstream levels to be no greater than upstream levels	Monitoring to be commenced within 2 hours of commencement of the release, and then daily during the duration of the release.
Sulphate (SO42-) (mg/L)	Low flow <0.2 m^3/s: 250 Medium flow > 1 m^3/s: 1,000 Medium flow > 5 m^3/s: 2,500 High flow: 5,250	Monitoring to be commenced within 2 hours of commencement of the release, and then daily during the duration of the release.

Table 4-3 Mine Affected Water Release Limits during Flow Events

Receiving water flow criteria for discharge (m3/s)	Maximum release rate	Electrical conductivity and sulphate release limits
Low flow <0.2 m^3/s for a period of 28 days after natural flow events that exceed 0.2 m3/s	< 0.05 m^3/s	Electrical conductivity: 168 µS/cm Sulphate (SO_4^{2-}): 250 mg/L
Medium flow >1 m^3/s	< 0.25 m^3/s	Electrical conductivity: 840 µS/cm Sulphate (SO_4^{2-}): 1,000 mg/L
Medium flow >5 m^3/s	< 0.5 m^3/s	Electrical conductivity: 1,850 µS/cm Sulphate (SO_4^{2-}): 2,500 mg/L
High flow > 10 m^3/s	< 0.5 m^3/s	Electrical conductivity (µS/cm): 3,500 µS/cm Sulphate (SO_4^{2-}) (mg/L): 5,250 mg/L

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4.3 Interim Contaminant Trigger Investigation Levels for Mine Water Releases

Interim contaminant trigger investigation levels for mine water releases (see Table 4-1 for release point locations) are presented in Table 4-4. Monitoring is to be commenced within 2 hours of the commencement of the release, then at 24 hour intervals thereafter. Interim receiving water contaminant limits are presented in Table 4-5.

Table 4-4 Interim Contaminant Trigger Investigation Levels for Mine Water Releases

Quality Characteristic	Trigger Level	Source of Trigger Level
Aluminium[1]	55	*DEHP model conditions*[2]
Arsenic[1]	13	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*
Cadmium[1]	0.2	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*
Chromium[1]	2	*Carmichael River 80th percentile*
Copper[1]	4	*Carmichael River 80th percentile*
Iron[1]	300	*DEHP model conditions*[2]
Lead[1]	4	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*
Mercury[1]	0.2	*For aquatic ecosystem protection, based on LOR for CV FIMS*
Nickel[1]	11	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*
Zinc[1]	30	*Carmichael River 80th percentile*
Boron[1]	370	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*
Cobalt[1]	90	*DEHP model conditions*[2]
Manganese[1]	1900	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*
Molybdenum[1]	34	*DEHP model conditions*[2]
Selenium[1]	10	*DEHP model conditions*[2]
Silver[1]	1	*DEHP model conditions*[2]
Uranium[1]	1	*DEHP model conditions*[2]
Vanadium[1]	10	*DEHP model conditions*[2]
Ammonia as N[1]	900	*For aquatic ecosystem protection, based on SMD guideline, ANZECC 2000 guidelines*

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Quality Characteristic	Trigger Level	Source of Trigger Level
Nitrate as NO_3[1]	1100	*For aquatic ecosystem protection, based on ambient Qld WQ Guidelines (2006) for TN*
Phosphorus as FRP	15	*QWQG (DEHP 2009)*
Petroleum hydrocarbons (C6-C9)	20	
Petroleum hydrocarbons (C10-C36)	100	
Fluoride (total)	2000	*Protection of livestock and short term irrigation guideline*
Sodium[1]	232,000	*Carmichael River 80th percentile*
Suspended Solids	Limit to be determined based on receiving water reference data and achievable best practice sedimentation control and treatment*	
Sulphate (SO_4^{2-}) (mg/L)	Limit to be determined based on receiving water reference data and achievable best practice sedimentation control and treatment*	*Drinking water environmental values from NHMRC 2006 guidelines OR ANZECC*

[1]All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/ metalloids apply if dissolved results exceed trigger.

[2]DEHP Guideline for Model Mining Conditions (EM944, Version 4) and DEHP Guideline for Model Water Conditions for Coal Mines in the Fitzroy Basin (EM288, Version 3).

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Table 4-5 Interim Receiving Water Contaminant Trigger Levels

Monitoring Point	Latitude	Longitude	Quality Characteristic	Limit	Monitoring Frequency
Upstream (US)					
CAR04	-22.1087960	+146.3527180	Electrical conductivity (µS/cm)	168	Continuously
BEL02	-22.1620320	+146.5285470	Electrical conductivity (µS/cm)	168	Continuously
Downstream (DS)					
CAR01	-22.0740740	+146.4675990	Electrical conductivity (µS/cm)	168	Continuously
BEL01	-21.9594600	+146.6568190	Electrical conductivity (µS/cm)	168	Continuously

*This will be derived from high-flow EC data.

4.4 Operational Water Quality Monitoring Locations

The monitoring locations for the proposed operational monitoring program will be a subset of the sites which have been sampled for the baseline monitoring program. Sampling sites have been separated into those sites which are upstream of the proposed releases and those which are downstream of proposed releases. The location details for the operational monitoring sites are provided in Table 4-6.

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Table 4-6 Operational Surface Water Monitoring Locations

Monitoring Location	Description	Latitude	Longitude	Monitoring Frequency
Upstream Background Monitoring Points				
CAR04	Carmichael River upstream gauging station	-22.1087960	+146.3527180	– Daily during the release – Continuous monitoring of flow and EC
BEL02	Belyando River at Bygana Waterhole	-22.1620320	+146.5285470	– Daily during the release – Continuous monitoring of flow and EC
Downstream Monitoring Points				
CAR01	Carmichael River downstream of mining lease	-22.0740740	+146.4675990	– Daily during the release – Continuous monitoring of flow and EC
BEL01	Belyando River at Carmichael/Moray Rd	-21.9594600	+146.6568190	– Daily during the release – Continuous monitoring of flow and EC

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5 SAMPLING METHODOLOGY

5.1 Sampling Protocol

5.1.1 Landholder Access Approval

Prior to undertaking site visits, landowner access approval should be obtained via Adani.

5.1.2 Water Quality Sampling

Sampling is to be undertaken in accordance with the Monitoring and Sampling Manual 2009 (DEHP, 2013) and AS/NZS 5667.6:1998. A summary of the steps to be undertaken is as follows:

1. Label all sample containers (using a Xylene-free, fine-tip permanent marker pen) with the appropriate sample identification, date, time and field sampler's name.

2. Select a safe and easily accessed sampling location in the vicinity of the GPS coordinates provided.

3. Take photographs of the sampling location and record GPS co-ordinates.

4. Wearing nitrile gloves, collect samples directly into the sample container using a sampling pole. Bottles that contain preservative should not be used directly to collect samples. Instead, use a non-preserved container and pour the sample into the preserved container, filling to the top but taking care not to over-top (which will result in loss of preservative). A new set of gloves should be worn at each sampling location and for the duplicate sample. Be aware of bottle preservatives (typically hydrochloric acid, nitric acid or sulphuric acid) which can burn and/or stain skin and clothing.

5. Samples should be collected from the centre of the channel, where the velocity is highest. Hold the mouth of the sampling container well above the base of the channel, to avoid disturbing and picking up any settled solids. Where possible, avoid sampling from riffles/rapids (water is typically over-oxygenated in those locations). If the water depth permits, the mouth of the sample container should be held approximately 10 cm below the water surface.

6. Samples for dissolved metals analysis must be filtered in the field. To filter a sample, pour the sample directly into the top chamber of a Stericup® filter unit, and replace the plastic lid. Attach a handheld vaccum pump to the Stericup® nozzle, and pump to 15 psi. The sample will filter into the bottom chamber. Pour the filtered sample into one of the 60mL plastic sampling containers. Filter units can only be used once.

7. Ensure containers are tightly sealed, then pack upright in an esky with ice (samples should be stored as close to 4°C as possible).

8. Take field measurements for pH, electrical conductivity, turbidity, temperature and dissolved oxygen. Water quality meters should be calibrated as per manufacturer's instructions, and a calibration sheet completed each time. Record field

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measurements and other relevant observations such as flow rate, water depth, colour, weather etc. on a field sheet (example supplied in Appendix A). Decontaminate probes between sampling locations using demineralised water and a surface active cleaning agent such as Decon 90.

9. At the end of each day, complete the Chain of Custody (CoC) form (example provided in Appendix B). A copy of the CoC must be placed inside a sealed ziplock bag, in each esky.

10. Seal esky lids using packing tape and laboratory provided security seals.

11. Dispatch samples daily (via same-day or overnight courier) to a selected National Association of Testing Authorities (NATA) accredited laboratory.

5.1.3 Sediment Sampling

Sediment sampling should comply with the requirements of AS/NZS 5667.12:1999. Samples should be composites, consisting of three separate grab samples per site. Composite samples should be prepared as follows (AS/NZS 5667.12:1999):

1. The individual single samples should be homogenised;

2. Equal volumes of each sample should be taken, combined and homogenised.

It is recommended that samples be obtained using a Ponar style self-tripping grab sampler, similar to that pictured in Plate 5-1. The Ponar type grab sampler features centre hinged jaws, a spring loaded pin that releases when the sampler makes impact with the bottom and an under-lip attachment that cleans gravel from the jaws to prevent lateral loss of sample. The top is covered with a stainless steel screen with neoprene rubber flaps, which allows water to flow through for a controlled descent and less interference with the sample (Rickly Hydrological Company, 2013).

Plate 5-1 Ponar Style Grab Sampler

Source: http://www.rickly.com/as/bottomgrab.htm

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Samples should be taken from the top 10 cm of sediment to represent the sediment fraction that is most bio-active, and collected in unpreserved plastic jars obtained from the analytical laboratory. Sediment sampling equipment should be decontaminated between sampling locations using demineralised water and a surface active cleaning agent such as Decon 90. Observations regarding sediment substrate type, water depth etc. should be recorded for each sampling event. Ensure containers are tightly sealed, then pack upright in an esky with ice (samples should be stored as close to 4°C as possible). Samples should be accompanied by a CoC and dispatched to the analytical laboratory.

5.1.4 Macroinvertebrate Sampling

Macroinvertebrate sampling should be undertaken in accordance with the procedure outlined in the Queensland Department of Natural Resources and Mines document entitled '*Queensland Australiand River Assessment System (AusRivAS) Sampling and Processing Manual*' (DNRM, 2001). This protocol is considered to be a standard method that permits direct temporal and spatial comparisons of data and allow sites to be compared with existing reference and test sites. Use of this protocol will also allow the results to be run in the Australian Rivers Assessment System (AusRivAS) model.

AusRivAS is a rapid prediction system used to assess the biological health of rivers in Australia. It was developed by the Federal Government under the National River Health Program (NRHP). The model presents site-specific predictions of the macroinvertebrate fauna expected to be present based on the site location. Physical and chemical data collected at a site (environmental or predictor variables) are used to determine the predicted ('Expected') composition of the macroinvertebrate fauna if the site is in an undisturbed or reference condition. An AusRivAS assessment, therefore, represents a comparison of the macroinvertebrates collected at a site ('Observed') to those predicted to occur ('Expected') if the site is in an undisturbed or reference condition. Model outputs are classified in different bands that reflect the general health of the macroinvertebrate community.

All macroinvertebrate samples should be collected with a standard 250 µm mesh dip net. Recommended dimensions are triangular 250 mm x 250 mm x 250 mm opening, 50-75 cm depth and with a 1-1.5 m aluminium handle. The net should be checked for damage prior to each sampling trip and washed thoroughly after sampling each habitat to remove animals left from previous sampling. Sample a total distance of 10 m, covering a variety of velocities, if possible, and different examples of the habitat. Macroinvertebrates should be live-counted in the field and preserved in 70% methanol for subsequent sorting and identification.

Sampling details should be recorded on an appropriate field sheet such as the example provided in Appendix C.

5.2 Quality Assurance/Quality Control

Standard Quality Assurance/Quality Control (QA/QC) procedures should be followed when undertaking this monitoring program. These include:

1. Collect, preserve and transport samples in accordance with the Monitoring and Sampling Manual 2009 (DERM, 2009) and AS/NZS 5667.6:1998.

2. Collecting appropriate quality control samples. It is recommended that at least one duplicate, one trip blank, one field blank and one rinsate sample be collected and

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analysed for every 20 primary samples. AS/NZS 5667.1:1998 provides further detail relating to quality control samples

3. Take comprehensive field notes, including the sampler's name, time, date, field water quality measurements and other environmental conditions.
4. Keep a record of calibration for equipment such as water quality meters.
5. Use a NATA accredited laboratory for analysis of water and sediment samples.
6. Use appropriate CoC documentation.

5.3 Health, Safety and Environment

Prior to commencement of this sampling program, a detailed Health, Safety and Environment (HSE) plan specific to the program should be developed and implemented.

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6 ANNUAL REPORTING

A monitoring report will be prepared annually and must record at a minimum, the following information:

1. The date on which the sample was taken;
2. The time at which the sample was taken;
3. The monitoring point at which the sample was taken;
4. The measured or estimated daily quantity of mine affected water released from all release points;
5. The release flow rate at the time of sampling for each release point;
6. The results of all monitoring and details of any exceedances of the conditions of the EA; and,
7. Water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.

Adani will also consider options for making the groundwater data collected throughout the monitoring life available for the public through posting data on a webpage dedicated to sharing monitoring information in its website.

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7 REFERENCES

4T Consultants Pty Ltd (2013). *Carmichael Coal Mine Environmental Monitoring. Surface Water and Sediment Quality.* Final Report, November 2013.

Australian and New Zealand Environment and Conservation Council (ANZECC) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. ISBN 09572845 0 5.

AS/NZS 5667.1:1998. *Water Quality – Sampling. Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.*

AS/NZS 5667.6:1998. *Water Quality – Sampling. Guidance on sampling of rivers and streams.*

AS/NZS 5667.12:1999. *Water Quality – Sampling. Guidance on sampling of bottom sediments.*

Department of Environment and Heritage Protection (2009a). *Queensland Water Quality Guidelines.* Version 3, July 2013.

Department of Environment and Heritage Protection (2013). *Monitoring and Sampling Manual 2009 Environmental Protection (Water) Policy 2009.* Version 2, July 2013.

Department of Environment and Heritage Protection (2013). *Guideline – Model Mining Conditions.*

Department of Natural Resources and Mine (2001). *Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual.* August 2001.

Department of Natural Resources and Mine (2010). *Regulated Dams in Environmentally Relevant Activities (Regulated Dams Guideline) Managing Dams Containing Hazardous Wastes.'*

Dight, I. (2009). *Burdekin Water Quality Improvement Plan.* Northern Queensland Dry Tropics, Townsville.

GHD (2012a). *Carmichael Coal Mine and Rail Project: Mine Technical Report. Mine Water Quality 25215-D-RP-005.* Prepared for Adani Mining Pty Ltd, 15 November 2012 (Revision 2).

GHD (2012b). *Mine Aquatic Ecology Report 2344-D-RP-0025.* Prepared for Adani Mining Pty Ltd, 16 November 2012 (Revision 1).

GHD (2013a). *Carmichael Coal Mine and Rail Project SEIS. Report for Mine Water Quality.* Prepared for Adani Mining Pty Ltd, 24 October 2013.

GHD (2013b). *Carmichael Coal Mine and Rail Project SEIS. Report for Update Mine Hydrology.* Prepared for Adani Mining Pty Ltd, 14 November 2013

GHD (2013c). *Carmichael Coal Mine and Rail Project SEIS. Report for Doongmabulla and Mellaluka Springs.* Prepared for Adani Mining Pty Ltd, 17 October 2013.

GHD (2013d). *Carmichael Coal Mine and Rail Project SEIS. Report for Preliminary Flood Mitigation and Creek Diversion Design.* Prepared for Adani Mining Pty Ltd, 21 October 2013.

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GHD (2014). *Carmichael Coal Mine and Rail Project. Groundwater Dependent Ecosystems Management Plan.* Prepared for Adani Mining Pty Ltd, 23 January 2014.

Rickley Hydrological Company, http://www.rickly.com/as/bottomgrab.htm, "Bottom Grab Samplers," accessed 25 June 2013.

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8 LIMITATIONS

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Adani Mining Pty Ltd and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the contract dated 11 December 2013.

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Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

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APPENDIX A WATER QUALITY SAMPLING FIELD SHEET EXAMPLE

Source: Queensland Department of Natural Resources and Mines, 2001

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WATER QUALITY SAMPLING FIELD SHEET

NATURAL RESOURCES Queensland Government

* *Site Number*
* *Date*
* *Time* EST
* *Project Name*
* *Collecting Authority*
* *Sample Source*

Site Name _____
Gauge No.
Party *and*

Analysis No.

TYPE *Submitted* / *Received*

A	B	C	D	E	F	G	H	I	J	K	L	M	N

Parameter	Value	Quality	Variable
Gauge Height m			100.
Air Temperature ^0C			2065.5
Water Temperature ^0C			2080.5
Conductivity $\mu S/cm@25^0$			2010.5
pH			2100.5
Dissolved O_2 mg/l			2351.5
Turbidity NTU			2030.5
Phenol. Alkalinity mg/l			2114.5
Total Alkalinity mg/l			2113.5
Transparency (secchi) m			2046.5
Velocity m/s			240.
Discharge m^3/s			140.
Discharge Method: measured [ ] estimated [ ] rating curve [ ]			

Observations at Water Sampling Site

Rain in past week:	Yes [ ]	No [ ]			
Weather:	No rain [ ]	Showers [ ]	Heavy rain [ ]		
	Sunny [ ]	Some Cloud [ ]	Over cast [ ]		
	Calm [ ]	Breeze [ ]	Strong Wind [ ]		
Water Odour:	None [ ]	Effluent [ ]	Anoxic [ ]	Algae [ ]	
Water Foaming:	None [ ]	Detergent [ ]	Surf. Spot [ ]	Scum [ ]	
Algae: } ON SUBSTRATE:	None [ ]	Little [ ]	Moderate [ ]	Lot [ ]	
} IN WATER COLUMN:	None [ ]	Little [ ]	Moderate [ ]	Lot [ ]	
Macrophytes: } EMERGENT:	None [ ]	Little [ ]	Moderate [ ]	Lot [ ]	
} SUBMERGED:	None [ ]	Little [ ]	Moderate [ ]	Lot [ ]	
} FLOATING:	None [ ]	Little [ ]	Moderate [ ]	Lot [ ]	

Presence of Pastoral Animals [ ] *Presence of Non-Pastoral Animals* [ ]

Any Human Activity . . . . . .

Plant Types (aquatic only) . . . . . .

Animal Life (eg fish, prawn) . . . . . .

Comments: . . . . . .

. . . . . .

. . . . . .

(Office use only) ENTERED INTO HYDSYS ON / / BY . . . . . .

CHECKED ON / / BY . . . . . .

DU107339.P65 (LM3883) 20/8//98

* Compulsory Fields

Reach Observations

Water odours: 1. normal 2. sewage 3. petroleum 4. chemical 5. none [ ]

Water oils: 1. slick 2. sheen 3. globs 4. flecks 5. none [ ]

Turbidity: 1. clear 2. slight 3. turbid 4. opaque [ ]

Plume: 1. little 2. some 3. lots [ ]
(amount of fine sediment generated when kick sampling)

Sediment oils: 1. absent 2. light 3. moderate 4. profuse [ ]

Sediment odours: 1. normal 2. sewage 3. petroleum 4. chemical
5. anaerobic 6. none 7. other ..... [ ]

Flow level: (relative to 'watermark' i.e. normal inundation level shown by limit of terrestrial grasses, or by eroded area, or boundary in bank sediment types).
1. no flow (dry/isolated) 2. low (<water mark) 3. moderate (=) 4. high (>water mark) 5. flood [ ]

Bare ground above water mark: area in riparian zone expected to be vegetated but bare. left bank . . . . . %
right bank . . . . . %

Bank erosion: 1. extreme 2. extensive 3. moderate 4. limited 5. none [ ]

Are the undersides of stones, which are not deeply embedded, black? 1. yes 2. no [ ]

Sediment deposits: 1. none 2. sludge 3. sawdust 4. paper fibre
5. sand 6. relict shells 7. other ..... [ ]

Local catchment erosion: 1. none 2. some 3. moderate 4. heavy [ ]

Local non-point source pollution: 1. no evidence 2. potential . . . . . 3. obvious . . . . . [ ]

Local point source pollution: 1. no evidence 2. potential . . . . . 3. obvious . . . . . [ ]

Dams/barriers: 1. absent 2. present upstream/downstream [ ]
discharge: >natural flow/<natural flow [ ]

Hydrologic deviation: 1. none 2. some extraction 3. minor dams, weirs etc
4. extensive extraction 5. major dams 6. other . . . . . [ ]

Site position in catchment: 1. upland 2. midland 3. lowland [ ]

Site classification (of the reach): 1. steep valley 2. broad valley 3. wetland/bog 4. heath
5. levees present 6. stream bars 7. natural riparian meadow [ ]

Adjacent landuse: 1. urban 2. semi-urban 3. irrigated cropping
(indicate L &/or R bank if different) 4. non-irrigated cropping 5. light grazing 6. moderate grazing
7. heavy grazing 8. forestry 9. native forest 10. other . . . . . [ ]

Upstream catchment development: 1. >75% 2. 50-75% 3. 25-50% 4. 0-25% 5. none [ ]

Bars: (bed surface protruding from normal water level & forming a bar) . . . . . %

Macrophytes

Indicate whether the following common taxa are present in the reach:

NATIVE

Azolla . . . . .
Duckweed . . . . .
Hornwort *(Ceratophyllum)* . . . . .
Stoneworts (*Chara or Nitella*) . . . . .
Hydrilla . . . . .
Water Milfoil (*Myriophyllum*) . . . . .
Pondweeds (*Potamogeton*) . . . . .
Ribbonweed (*Vallisneria*) . . . . .
Water Ribbon (*Triglochin*) . . . . .
Water Lettuce (*Pistia statiotes*) . . . . .
Water Primrose (*Ludwigia*) . . . . .
Sedge (*Cyperus*) . . . . .
Common Rush (*Juncus*) . . . . .
Typha/Cumbungi . . . . .
Slender Knotweed (*Persicaria*) . . . . .
Other . . . . .
. . . . .
. . . . .

EXOTIC

Water Hyacinth *(Eichhornia)* . . . . .
Salvinia . . . . .
Alligator Weed *(Alternanthera)* . . . . .
Egeria . . . . .
Elodea . . . . .
Para Grass (*Urochloa*) . . . . .
Other . . . . .
. . . . .
. . . . .
. . . . .
. . . . .

APPENDIX B EXAMPLE CHAIN OF CUSTODY FORM (ALS LABORATORY)

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CHAIN OF CUSTODY DOCUMENTATION

Australian Laboratory Services Pty Ltd

CLIENT:	SAMPLER:
ADDRESS / OFFICE:	MOBILE:
PROJECT MANAGER (PM):	PHONE
PROJECT ID:	EMAIL REPORT TO:
SITE: P.O. NO.:	EMAIL INVOICE TO:
RESULTS REQUIRED (**Date**): QUOTE NO.:	**ANALYSIS REQUIRED including SUITES** (note - suite codes must be listed to attract suite prices)

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DIPOSAL:

Notes: e.g. Highly contaminated samples, Extra volume for QC or trace LORs etc.

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total containers	

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name:	Date:	Name:	Date:	Con' Note No:
Of:	Time:	Of:	Time:	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserveed Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bad for Acid Sulphate Soils; B = Unpreserved Bag.

ALS Environmental

APPENDIX C MACROINVERTEBRATE SAMPLING FIELD SHEET EXAMPLE

Source: Queensland Department of Natural Resources and Mines, 2001

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River Bioassessment Program

MACROINVERTEBRATE SAMPLING FIELD SHEET

NATURAL RESOURCES Queensland Government

SITE NUMBER: [| | | | | |] **SITE NAME:** _____

Project Name: _____ **Date:** ___/___/___ **Time (24 hrs):** [| | |] **GPS:** _____

EDGE/BACKWATER: Y [ ] N [ ] Collected by: [| |] Picked By: [| |] No. vials: [ ]

Velocity (m/sec): max [| • | |] min [| • | |]

Mean Depth: [| • | |] m

Mean Channel Width: [| | | • |] m

Method: 10 m sweep [ ]
60 min random pick [ ]
Other _____ [ ]

Canopy Cover: [| |] %

Width of Riparian Zone: LB [| |] m RB [| |] m

Composition of Riparian Zone:
Native [| |] % Exotic [| |] %

***Riparian Vegetation:**
Grass [| |] % Trees <10 m high [| |] %
Shrubs [| |] % Trees >10 m high [| |] %

Substrate Description:

Bedrock	[| |] %	Gravel (4 - 16 mm)	[| |] %
Boulder (> 256 mm)	[| |] %	Sand (1 - 4 mm)	[| |] %
Cobble (64 - 256 mm)	[| |] %	Silt/Clay (< 1mm)	[| |] %
Pebble (16 - 64 mm)	[| |] %		

Substrate Cover:

Periphyton	0	1	2	3	4
Moss	0	1	2	3	4
Filamentous algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Detritus	0	1	2	3	4

0 = <10% 1 = 10-35% 2 = 35-65% 3 = 65-90% 4 = >90%

Bank Overhang Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

Trailing Bank Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

BED: Y [ ] N [ ] Collected by: [| |] Picked By: [| |] No. vials: [ ]
TYPE: Riffle [ ] Rocky/Gravel Bed [ ] Sandy/Silty [ ]

Velocity (m/sec): max [| • | |] min [| • | |]

Mean Depth: [| • | |] m

Mean Channel Width: [| | | • |] m

Method: 10 m kick only [ ]
10 m kick & gleaning rocks of different sizes (5) [ ]
60 min random pick [ ]
Other _____ [ ]

Canopy Cover: [| |] %

Width of Riparian Zone: LB [| |] m RB [| |] m

Composition of Riparian Zone:
Native [| |] % Exotic [| |] %

***Riparian Vegetation:**
Grass [| |] % Trees <10 m high [| |] %
Shrubs [| |] % Trees >10 m high [| |] %

Substrate Description:

Bedrock	[| |] %	Gravel (4 - 16 mm)	[| |] %
Boulder (> 256 mm)	[| |] %	Sand (1 - 4 mm)	[| |] %
Cobble (64 - 256 mm)	[| |] %	Silt/Clay (< 1mm)	[| |] %
Pebble (16 - 64 mm)	[| |] %		

Substrate Cover:

Periphyton	0	1	2	3	4
Moss	0	1	2	3	4
Filamentous algae	0	1	2	3	4
Macrophytes	0	1	2	3	4
Detritus	0	1	2	3	4

0 = <10% 1 = 10-35% 2 = 35-65% 3 = 65-90% 4 = >90%

Bank Overhang Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

Trailing Bank Vegetation:
extensive [ ] moderate [ ] slight [ ] nil [ ]

* Can add to > 100%

Adjacent Landuse:

Upstream Landuse:

****Percent of habitat types in 100 m reach:**

Riffle [| |] % Run [| |] % Macrophytes [| |] %
Pool (rocky) [| |] % Pool (sandy) [| |] % Dry [| |] % Edge [| |] %

** Riffle + Run + Pool + Macrophyte + Dry = 100%; Edge is % of habitat available to sample from L and R banks

TOTAL NO. VIALS: **OTHERS:**

DU502676RSC.PM5 (LM8883) 20/8/98

1. LONGITUDINAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate
1. Biological sampling sites for each habitat type and % of reach.
2. Water quality measurement and water sample collection sites.
3. Location from where photograph(s) taken.
4. Location of cross-sectional profile sketch.

2. CROSS-SECTIONAL PROFILE SKETCH OF STREAM REACH

Scale: _____

Please indicate
1. Approx. bank height/bank width (overflow), stream width and depth.
2. Approx. riparian vegetation height.

3. COMMENTS

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Checked on ____/____/____ **By** _____

River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET

NATURAL RESOURCES Queensland Government

SITE NUMBER: [| | | | | |] **SITE NAME:** _____

Date: ____/____/____ **Time (24 hrs): [| | |]** **GPS:** _____ **Project Name:** _____

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
1. Bottom substrate/available cover	Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. 20, 19, 18, 17, 16	30-50% rubble, gravel or other stable habitat. Adequate habitat. 15, 14, 13, 12, 11	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. 10, 9, 8, 7, 6	Less than 10% rubble, gravel or stable habitat. Lack of habitat is obvious. 5, 4, 3, 2, 1, 0
2. Embeddedness	Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. 20, 19, 18, 17, 16	Gravel, cobble and boulder particles are between 25% & 50% surrounded by fine sediment. 15, 14, 13, 12, 11	Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. 10, 9, 8, 7, 6	Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. 5, 4, 3, 2, 1, 0
3. Velocity/depth category	Slow deep (<0.3 m/s & >0.5 m); slow shallow; fast deep; fast shallow; habitats all present. 20, 19, 18, 17, 16	Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). 15, 14, 13, 12, 11	Only two of the four habitat categories present (missing riffles/runs receive lower score). 10, 9, 8, 7, 6	Dominating by one velocity/depth category (usually pool). 5, 4, 3, 2, 1, 0
4. Channel alteration	Little or no enlargement of islands or point bars and/or no channelisation. 15, 14, 13, 12	Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. 11, 10, 9, 8	Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled with silt; and/or embankments on both banks. 7, 6, 5, 4	Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. 3, 2, 1, 0
5. Bottom scouring and deposition	Less than 5% of the bottom affected by scouring and deposition. 15, 14, 13, 12	5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. 11, 10, 9, 8	30-50% affected. Deposits and scours at obstructions and bends. Some deposition in pools. 7, 6, 5, 4	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. 3, 2, 1, 0

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River Bioassessment Program

HABITAT ASSESSMENT FIELD SHEET cont.

Habitat Variable	CATEGORY			
	Excellent	**Good**	**Fair**	**Poor**
6. Pool/riffle, run/bend ratio. *(Distance between riffles divided by stream width)*	0-7 Variety of habitat. Deep riffles and pools. 15, 14, 13, 12	7-15 Adequate depth in pools and riffles. Bends provide habitat. 11, 10, 9, 8	15-25 Occasional riffle or bend. Bottom contours provide some habitat. 7, 6, 5, 4	>25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 3, 2, 1, 0
7. Bank stability	Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. 10, 9	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. 8, 7, 6	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. 5, 4, 3	Unstable. Many eroded areas. Side slopes > 60% common. 'Raw' areas frequent along straight sections and bends. 2, 1, 0
8. Bank vegetative stability	Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. 10, 9	50-79% of the streambank surfaces covered by vegetation, gravel or larger material. 8, 7, 6	25-49% of the streambank covered by vegetation, gravel or larger material. 5, 4, 3	Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. 2, 1, 0
9. Streamside cover	Dominant vegetation is of tree form. 10, 9	Dominant vegetation shrub. 8, 7, 6	Dominant vegetation is grass, sedge, ferns. 5, 4, 3	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 2, 1, 0

Column Totals				

Score

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DRAFT

GOVERNMENT OIL & GAS INFRASTRUCTURE POWER INDUSTRIAL

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