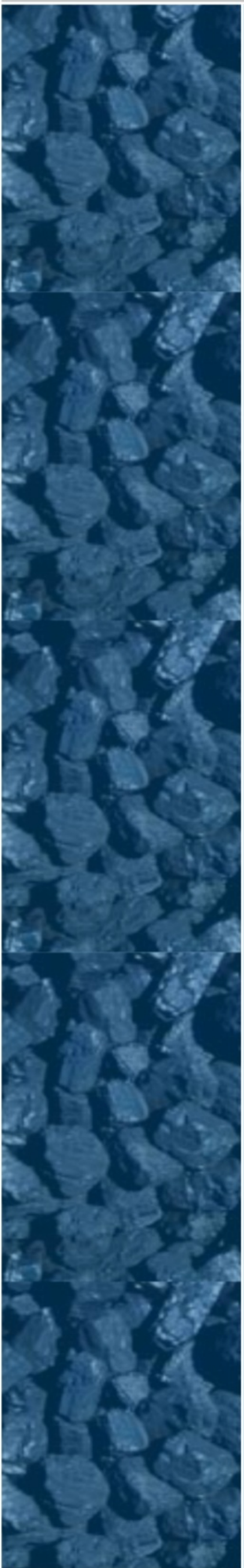
Adani Mining Pty Ltd

adani



Carmichael Coal Mine and Rail Project SEIS

Report for Update Mine Hydrology

14 November 2013

GHD

This Carmichael Coal Mine and Rail Project SEIS: Updated Mine Hydrology (the Report) has been prepared by GHD Pty Ltd (GHD) on behalf of and for Adani Mining Pty Ltd (Adani) in accordance with an agreement between GHD and Adani.

The Report may only be used and relied on by Adani for the purpose of informing environmental offset assessments and production for the proposed Carmichael Coal Mine and Rail Project and may not be used by, or relied on by any person other than Adani.

The services undertaken by GHD in connection with preparing the Report were limited to those specifically detailed in this Report.

The Report is based on conditions encountered and information reviewed, including assumptions made by GHD, at the time of preparing the Report.

To the maximum extent permitted by law GHD expressly disclaims responsibility for or liability arising from:

- *any error in, or omission in connection with assumptions, or*
- *reliance on the Report by a third party, or use of this Report other than for the Purpose.*

Executive summary

Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. On 26 November 2010, the Queensland (Qld) Office of the Coordinator General declared the Project a 'significant project' and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (referral No. 2010/5736). The Project was assessed to be a controlled action on the 6 January 2011 under section 75 and section 87 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

As part of the Supplementary EIS (SEIS) several studies were either updated or executed as part of the mine hydrology assessment. It concerns:

1. Groundwater study (GHD, 2013) (SEIS Appendix K1 Updated Mine Hydrogeology Report). The hydrogeology study concerns an update of the study done as part of the EIS study. The update includes a new geological model, hydraulic test data and the mine plan presented in the project description (SEIS Volume Appendix B Project Description). This report only includes those components from this study that are related to mine hydrology.
2. Water balance study (GHD, 2013) (SEIS Appendix K2 Water Balance Report). While the water balance model for the EIS was developed with Excel the SEIS water balance makes use of GoldSim modelling software, allowing for a better understanding of water movements on site. In addition a salt balance was developed within the GoldSim environment.
3. Preliminary Flood Mitigation and Creek Diversion Design study (GHD, 2013) (SEIS Appendix K4 Preliminary Flood Mitigation and Creek Diversion Design Report). The study done as part of the EIS was updated to better represent the mine plan presented in the project description. In addition the proposed creek diversions have been detailed.
4. Geomorphology assessment (included as Appendix A in this report). In response to comments on the EIS a geomorphology assessment has been added to this report.

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. The mining activities, in particular the development of the pits and underground workings are expected to have an impact on surface water at and around the Project (Mine) area. Groundwater modelling results indicate a reduction of around 1,000 m^3/d of river baseflow within the mine areas during the operation stages and 950 m^3/d at post closure.

The water balance study identifies all inflows and outflows on site and includes the proposed mine water management principles. As part of the study the required major water management infrastructure, i.e. the water storages, have been identified, located and preliminary sized. The designed water management strategy focusses strongly on reusing water on site as much as possible and on minimising volumes of mine affected water (MAW) on site. MAW is collected in two (2) central MAW dams, one (1) on each site of the Carmichael River. These dams are identified as the two (2) potential discharge points for MAW. Besides these dams only the sediment dams for the overburden areas are expected to overflow or require controlled

discharge. The water balance predicts total discharges to the Carmichael River of MAW to be in the order of magnitude of 3,000 to 4,000 ML per year for the first 40 years of the mine life, and approximately 5,500 ML per year for the last 20 years of the mine life. Results from the salt balance are not included in this report but in the SEIS water quality report.

As part of the Preliminary Flood Mitigation and Creek Diversion Design study (GHD, 2013) a range of flood protection and mitigation infrastructure is proposed with the most significant being:

- 1 in 1,000 year ARI-immune flood protection levees for the Carmichael River corridor
- 1 in 100 year ARI-capacity local waterway diversion drains with the ability to provide 1 in 1,000 year ARI flood immunity to the pits through the mine site, through the use of supplementary adjacent levees; maintaining natural flow paths and hydrology to the maximum extent practicable
- 1 in 50 year ARI-immune haul road and conveyor crossing of the Carmichael River

Subsequent modelling of the Carmichael River corridor with this proposed infrastructure in place and modelling of all the diversion drains indicated the ability of this infrastructure to protect the mine site from large flood events. Afflux was found to be significant within the mine area due to the combined effect of minor increased inflows from some of the diverted waterways, reduced runoff coming from the developed mine internal areas and hydraulic constriction by the flood protection levees, haul road and conveyor crossing. Upstream of the haul road crossing afflux was modelled to peak at 0.98 m for the 1 in 1,000 year ARI event, but at the downstream eastern boundary this had already reduced to peak at 0.09 m adjacent to the Carmichael River and 0.27 m downstream of Cabbage Tree Creek. These values are reduced in smaller events, with afflux at the mine area boundaries generally being relatively insignificant (0 to 0.09 m, with the higher values being confined to the eastern boundary downstream of Cabbage Tree Creek). It is believed that the significant reduction in afflux values is predicted over this short distance indicates that neighbouring properties are likely to experience minimal increase in flood extents both downstream and, especially, upstream of the mine area. The most significant afflux is confined within the mine area.

The potential key components of the Project (Mine) that could impact on the geomorphology of waterways include construction of infrastructure within the waterways or flood plains and the subsidence effects of underground mining. This geomorphology assessment has determined that the on-site and downstream significance of these potential impacts will be negligible to low if appropriate mitigation measures are taken.

Table of contents

Table index

Figure index

Appendices

Abbreviations and glossary

Project specific terminology	
Abbreviation	Term
the Project SEIS	Carmichael Coal Mine and Rail Project Supplementary Environmental Impact Statement
the Proponent	Adani Mining Pty Ltd
the Project (Mine and Rail)	Carmichael Coal Mine and Rail Project
the Project (Mine)	The mine component of the Project
the Project (Rail)	The rail component of the Project

Generic terminology	
Abbreviation	Term
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BOM	Bureau of Meteorology
CEMP	Construction Environment Management Plan
CHPP	Coal Handling and Preparation Plant
CSG	Coal seam gas
DSDIP	Department of State Development, Infrastructure and Planning
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (former DEWHA, Department of Environment, Water, Heritage and the Arts)
EIS	Environmental Impact Statement
EM Plan	Environmental Management Plan
EFO	Environmental Flow Objectives
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999 (Cwlth)
EPC	Exploration Permit for Coal
EVs	Environmental Values
GBRMP	Great Barrier Reef Marine Park
GL	Giga litre
Ha	Hectares
Km	Kilometres
MAW	Mine Affected Water
MIA	Mine Infrastructure Area
ML	Mining Lease
MLA	Mining Lease Application
Mtpa	Million tonnes per annum
OBSD	Overburden Sediment Dam
PMF	Probable Maximum Flood
PWB	Preliminary Water Balance
ROM	Run of Mine
ROP	Resource Operations Plan
SDPWO Act	State Development and Public Works Organisation Act 1971

Generic terminology	
Abbreviation	Term
SAW	Sediment Affected Water
SEIS	Supplementary Environmental Impact Statement
ToR	Terms of Reference
WMP	Water Management Plan
WRP	Water Resource Plan

1. Introduction

1.1 Project overview

Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. On 26 November 2010, the Queensland (Qld) Office of the Coordinator General declared the Project a 'significant project' and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (referral No. 2010/5736). The Project was assessed to be a controlled action on the 6 January 2011 under section 75 and section 87 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions for the Project include:

- World Heritage properties (sections 12 & 15A)
- National Heritage places (sections 15B & 15C)
- Wetlands (Ramsar) (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- The Great Barrier Reef Marine Park (GBRMP) (sections 24B & 24C)
- Protection of water resources (sections 24D & 24E)

Protection of water resources (sections 24D & 24E)The Qld Government's EIS process has been accredited for the assessment under Part 8 of the EPBC Act in accordance with the bilateral agreement between the Commonwealth of Australia and the State of Queensland.

The Proponent prepared an EIS in accordance with the Terms of Reference (ToR) issued by the Qld Coordinator-General in May 2011 (Qld Government, 2011). The EIS process is managed under section 26(1) (a) of the *State Development and Public Works Organisation Act 1971* (SDPWO Act), which is administered by the Qld Government's Department of State Development, Infrastructure and Planning (DSDIP).

The EIS, submitted in December 2012, assessed the environmental, social and economic impacts associated with developing a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the northern Galilee Basin, approximately 160 kilometres (km) north-west of Clermont, Central Queensland, Australia. Coal from the Project will be transported by rail to the existing Goonyella and Newlands rail systems, operated by Aurizon Operations Limited (Aurizon). The coal will be exported via the Port of Hay Point and the Point of Abbot Point over the 60 year (90 years in the EIS) mine life.

Project components are as follows:

- The Project (Mine): a greenfield coal mine over 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 (the Mine) and the Mine (offsite) infrastructure including a workers accommodation village and associated facilities, a permanent airport site, an industrial area and water supply infrastructure

- The Project (Rail): a greenfield rail line connecting to mine 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, respectively including:
  - Rail (west): a 120 km dual gauge portion running west from the Mine site east to Diamond Creek
  - Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah
  - Quarries: five local quarries to extract quarry materials for construction and operational purposes.

Figure 1 shows the Project location.

1.2 Purpose of this report

This report forms part of the Supplementary Environmental Impact Statement (SEIS) for the Carmichael Coal Mine and Rail Project (Project).

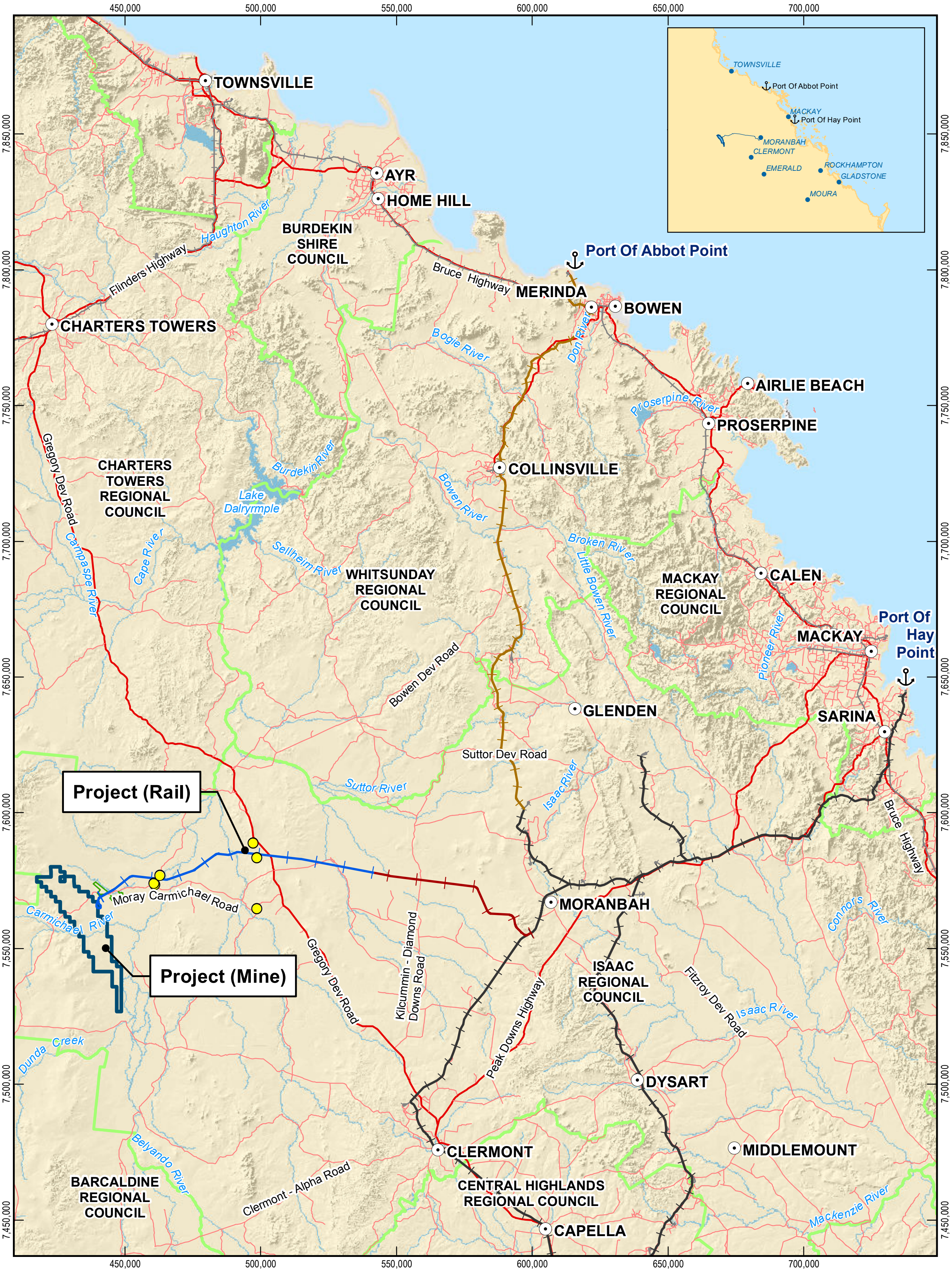
Potential impacts of the mine on the region's surface water include the following:

- Changes to availability of water to downstream users
- Change in local flow pattern and regime
- Changes to receiving water quality

This report specifically focuses on the change in flow patterns and regime and water users affected by the Project (Mine). Surface water quality has been assessed separately in the SEIS Appendix K3 Water Quality Report.

This report should be read in conjunction with the following SEIS reports:

- SEIS Appendix K1 Updated Mine Hydrogeology Report
- SEIS Appendix K2 Water Balance Report
- SEIS Appendix K3 Water Quality Report
- SEIS Appendix K4 Preliminary Flood Mitigation and Creek Diversion Design Report
- SEIS Appendix K6 Addendum to Hydrogeology Report



LEGEND

- Town
- Major Port
- Other Rail Network
- Goonyella System
- Newlands System
- Local Road
- Watercourse
- Local Government Area
- Project (Rail)
  - Rail (West)
  - Rail (East)
- Project (Mine)
- Mine (Offsite)
- Quarry

Based on or contains data provided by the State of QLD (DNRM) [2013]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Job Number	41-26422
Revision	2
Date	14-10-2013

Project Location

Figure 1

G:\41\26422\GIS\Maps\MXD\0000_Overview\41-26422_117_rev_2.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DNRM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008);
Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Offsite, Quarry (2013). Created by: MS

1.3 Legislative framework

The following sections provide an overview of the key regulatory and non-regulatory instruments, guidelines and policies relevant to the surface water resources of the Burdekin River Basin.

1.3.1 Commonwealth legislation and policies

Commonwealth Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as matters of national environmental significance.

On 21 June 2013, the EPBC Act was amended to include a new matter of national environmental significance in relation to coal seam gas (CGS) and large coal mining development - the 'water trigger'. As a result, any CSG development or large coal mining development that has, will have or is likely to have a significant impact on water resources now requires referral and possibly approval by the Commonwealth Environment Minister under the EPBC Act.

Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Guidelines (ANZECC, 2000) provide recommended parameters for:

- Water and sediment quality that will sustain the ecological health of aquatic ecosystems
- Irrigation and general water use
- Livestock drinking water
- Aquaculture and human consumers of aquatic food
- Waters for recreational activities, such as swimming and boating
- Preservation of the aesthetic appeal of these waters.

1.3.2 Queensland legislation and policies

Environmental Protection Act 1994

The aim of the *Environmental Protection Act 1994* (EP Act) is to protect Queensland's environment while allowing for development that improves the quality of life as well as maintaining the ecological processes on which it depends.

The EP Act also imposes a general environmental duty on all persons (including corporations) such that they must not conduct any activity that causes, or is likely to cause, environmental harm, unless they take all reasonable and practicable measures to prevent or minimise the harm.

The *Environmental Protection Regulation 2008* identifies environmental relevant activities (ERAs) prescribed under the EP Act, for which development approval is required.

Environmental Protection (Water) Policy 2009

The *Environmental Protection (Water) Policy 2008* (EPP Water) (part 2, Section 6) provides a framework for:

- Identifying environmental values (EVs) for Queensland waters
- Deciding and stating water quality guidelines and objectives to enhance or protect the EVs
- Making consistent and equitable decisions about Queensland waters that promote the efficient use of resources and best practice environmental management
- Involving the community through consultation and education, and promoting community responsibility.
- The EVs considered applicable to the Project (Mine) to be particularly enhanced or protected under the EPP (Water) are the following:
- Biological integrity of an aquatic ecosystem
- Suitability for agricultural use and
- The cultural and spiritual values of the water.

Guideline: Preparation of Water Management Plans for Mining Activities

A Water Management Plan (WMP) may be mandated within the conditions of an approval under the EP Act or to comply with the EPP Water. This guideline (2010) is to assist the operators of mining activities to plan and implement water management practices in a manner that protects EVs and meets obligations under the EP Act. The guideline applies to all existing and proposed level 1 mining projects.

Manual for Assessing Hazard Categories and Hydraulic Performance of Dams constructed as part of environmentally relevant activities pursuant to the Environmental Protection Act 1994, Version 2

The Manual (2011) sets out the requirements of the Department of Environment and Heritage Protection (the administering authority), for hazard category assessment and certification of the design of dams and other land-based containment structures, constructed as part of ERAs under the EP Act.

Guideline: Regulated dams in environmentally relevant activities

This guideline (2010) provides information about the procedures of the administering authority, for dealings involving dams and related containment structures, constructed as part of ERAs pursuant to the EP Act. This Guideline should be read in conjunction with the Manual described above.

Sustainable Planning Act 2009

Under the SP Act, development authorised to occur on a mining lease is generally exempt from the requirements for assessment and approval. However, there are some limited exceptions, such as approvals for building, plumbing and drainage work. Adani seeks recommendations from the Coordinator-General that development approval be given for all of the identified aspects of assessable development for the Project, subject to appropriate conditions. As an alternative, if considered more appropriate by Coordinator-General, Adani seeks a recommendation that a preliminary approval be granted, subject to appropriate conditions.

Water Act 2000

The *Water Act 2000* provides a framework for management and allocation of water resources and licences, based on development of catchment-based Water Resource Plans (WRPs). The WRPs are then activated through related Resource Operations Plans (ROPs) which provide detail on how the water resources will be managed to implement the strategies and objectives as set out in the WRP.

The *Water Act 2000* defines a watercourse as a:

- river, creek or stream in which water flows permanently or intermittently in a natural channel, whether artificially improved or not
- or in an artificial channel that has changed the course of the watercourse.

Approvals are required for activities that interfere with a watercourse. However, recent amendments to the Water Act by the *Land Water and Other Legislation Amendment Bill 2013* (Qld) (LWOLA Bill), which was introduced into Parliament on 15 March 2013. The Act was assented to on 14 May 2013. It introduces a ‘Waterway Diversion Exemption’ in section 20(4) Water Act which exempts proponents from the requirement to get a water licence for the diversion of a watercourse on a mining lease where the impacts of the diversion were assessed as part of the grant of an environmental authority (EA) for the mining lease and the EA was granted with a condition about the diversion of the watercourse. This particular amendment to section 20 Water Act is due to commence on proclamation once guidelines and an assessment manual have been finalised.

The *Water Act 2000* also sets out the law with respect to:

- rights to surface and groundwater
- control of works with respect to surface and groundwater conservation and protection
- irrigation, water supply, drainage and flood control.

Under the *Water Act 2000,* an approval/licence will be required for any works which may affect surface and groundwater. The following permits may be required under relevant sections of the *Water Act 2000*:

- Section 206 – taking water from a watercourse, lake, spring or underground water source (Water Licence)
- Section 286 – destroy vegetation, place fill or excavate in a watercourse (Riverine Protection Permit).

Water Regulation 2002

The *Water Regulation 2002* is subordinate to the *Water Act 2000* and defines the purpose of use (such as stock / domestic use) that do not require authorisation to take water and, by omission, those purposes that do require authorisation.

Water Resource (Burdekin Basin) Plan 2007

The Burdekin Basin WRP serves to provide a framework for sustainably managing water and the taking of water within the Burdekin Basin, within which the Project (Mine) lies. The Project (Mine) lies within sub-catchment E of the WRP area (see Schedule 2 of the ROP discussed below) thus waterway diversions and stormwater collection systems required for the Project will come under Section 147 of the WRP which establishes need for monitoring of various parameters by the operators of infrastructure for interfering with water (including overland flows).

Burdekin Basin Resource Operations Plan 2009

The Burdekin Basin ROP implements the provisions made by the Burdekin Basin WRP, specifically the rules and operational requirements for managing the surface water in that basin. The ROP also informs the granting of a licence for the interference with water under Section 206 of the *Water Act 2000*, which will apply to the Project (Mine).

Water Resource (Great Artesian Basin) Plan 2006

The Project (Mine) lies within the Great Artesian Basin WRP management area. The purpose of the Great Artesian Basin WRP is to:

- Define the availability of water in the plan area
- Provide a framework for sustainably managing water and the taking of water
- Identify priorities and mechanisms for dealing with future water requirements
- Provide a framework for establishing water allocations
- Provide a framework for reversing, where practicable, degradation that has occurred in natural ecosystems.

Great Artesian Basin Resource Operations Plan February 2007 Amended November 2012

The Great Artesian Basin Resource Operations Plan (GABROP) specifies rules and operational requirements for managing ground water resources that are defined to be within one of the 25 groundwater catchments listed under the Water Resource Plan (WRP). The Project as a whole triggers various aspects of the WRP depending on the activity and location.

Guideline: Activities in a watercourse, lake or spring associated with a resource activity or mining operations

This guideline is to allow activities in a watercourse, lake or spring associated with a resource activity or mining operations without the need for a riverine protection permit. Activities include the destruction of native vegetation, excavation and placement of fill in a watercourse, lake or spring. The *Water Regulation 2002* permits these activities provided the activity is in accordance with this guideline.

This guideline outlines the requirements, providing outcomes and acceptable solutions to ensure activities minimise adverse impacts on water quality, water flow, vegetation and the physical integrity of the watercourse, lake or spring.

Water Supply (Safety and Reliability) Act 2008

Failure impact assessment determines whether a dam is a referrable dam, that is, a dam that would put population at risk in the event of failure, by reference to the provisions of the *Water Act 2000* and the *Water Supply (Safety and Reliability) Act 2008* (WSSR Act).

The 10 gigalitre (GL) storage dam for the Project (Mine) will require failure impact assessment in the detailed design phase, and on an ongoing basis as required under the WSSR Act.

Guidelines for Failure Impact Assessment of Water Dams

These guidelines have been developed by the Department of Energy and Water Supply (2012) to help owners comply with the WSSR Act and dam safety conditions for referable dams (these include both conditions relating to dam safety imposed on development permits and safety conditions imposed under the Act).

The Guidelines provide information about:

- Referable dams
- Failure impact ratings
- Failure impact assessment and how it is done
- Certification of a failure impact assessment
- Lodging a failure impact assessment for an existing dam
- Lodging a failure impact assessment for a new or proposed dam
- Lodging a failure impact assessment for works on an existing dam
- Timing requirements for undertaking failure impact assessments
- Processes for accepting, rejecting or reviewing a dam failure impact assessment
- Responsibilities, penalties and provisions for appeals.

Queensland Water Quality Guidelines 2009

These guidelines interpret the ANZECC 2000 Guidelines by:

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

2. Potential impacts and mitigation measures – Construction phase

2.1 Overview

Construction will progressively occur over a period of several years and provide for the following Project (Mine) and Project (Offsite) infrastructure components (includes on lease and off lease elements):

- Mine Infrastructure Areas (MIA's)
- Coal Handling and Preparation Plant (CHPP)
- Water and waste management facilities
- Mine airport
- Flood protection levees
- Roads
- Haul road and conveyor bridge crossing of the Carmichael River
- Offsite water supply infrastructure
- Offsite Industrial Area
- Mine Workers Accommodation Village (MWAV)
- Upgrade of Elgin Moray and Moray Carmichael Road.

Key construction activities associated with this work include the use of construction vehicles and machinery, storage of materials, bulk earthworks and works within or next to existing watercourses.

The construction of open pits, underground mines, haul roads and water storages are considered in the impacts of operation phase section 3 as this infrastructure will be part of the operational staging of the Project (Mine).

2.2 Potential impacts of construction activities

2.2.1 Change in flows and flooding

The potential effects of construction activities on surface water hydrology and hydraulics include:

- Temporary increased surface runoff as a result of vegetation clearance, topsoil removal and soil compaction on land adjacent to watercourses
- Changed flow velocities, increased erosion and subsequent changes in bed and bank stability as a result of works within or adjacent to watercourses

- Change in local flows (higher in some regions, lower in others) as a result of watercourse diversions or temporarily restricted flows during construction. This would be a localised effect and not expected to impact outside of the construction area.

Carmichael River

Major infrastructure construction works are proposed to be undertaken within the Carmichael River flood plain consisting of:

- The bridge over the Carmichael River to convey the haul road and conveyors
- The mine protection flood levees on the northern and southern banks of the River.

Works within the river flood plain can potentially cause scour and erosion leading to water quality problems and obstruction of flow leading to velocity and flood level problems. The impacts associated with the final infrastructure are detailed in section 3.

Local creeks and streams

The creeks and streams located adjacent to the proposed construction works are ephemeral and relatively small in size. Effects of any change to surface water flows within these creeks are therefore likely to be confined to the local vicinity. Furthermore, given the relatively small area of catchments to be disturbed during construction, it is unlikely that any loss of catchment area will substantially change runoff flow volumes. Notwithstanding this, mitigation measures to avoid and minimise potential impacts on surface water flows are recommended in section 2.3.

2.2.2 Change to available water supply

Construction water requirements are described in the SEIS Appendix K2 Water Balance Report. The predicted maximum water demand during the construction staging is expected to be in 2016 – 2017 where the water demand will reach 5.48 ML/day (refer Table 1). For the initial development and construction phases, the required water for 2014 – 2022 will be provided by river flood extraction.

2.3 Management, mitigation and monitoring activities – construction phase

2.3.1 Management

The key mitigation measure in relation to construction impacts on hydrology and hydraulics is to design all diversions and structures to minimise impacts on the natural hydrology of the catchment.

Construction activities should be undertaken in a way that minimises the disturbance in and immediately adjacent to waterways. Temporary fencing off of areas around waterways to avoid unnecessary disturbance should be implemented to help achieve this. Stormwater, erosion and sediment control infrastructure and management techniques such as:

- Erosion control mats
- Soil binding

- Geofabric lining
- Rock lining
- Sediment fencing
- Diversion and catch drains
- Berms
- Chute
- Energy dissipaters
- Sedimentation basins, should be implemented before any works upstream or within waterways commence.

Temporary creek crossings such as causeways or culvert crossings should be implemented immediately for any creek crossing where water is expected to flow during the time the crossing will be used. Allowing stream flows to pass over or under the crossing will minimise impacts on natural flows and allow water to reach downstream ecosystems.

Where practicable, preference should be given to completing works within watercourses or floodplains in dry periods. In areas where works cannot be completed before the wet season, work should be planned ahead so that all disturbed areas within or adjacent to watercourses can be stabilised and robust controls can be installed to minimise the potential effects of erosion.

The design of sedimentation ponds will be in accordance with IECA's (2008) *Best Practice Erosion and Sediment Control.* Water monitoring will be undertaken as described in SEIS Appendix K3 Water Quality Report and the Construction Environmental Management Plan (CEMP).

In addition, an erosion and sediment control plan should be prepared in accordance with IECA's (2008) *Best Practice Erosion and Sediment Control* (as described in SEIS Appendix K3 Water Quality Report) to minimise the risk of erosion and loss of bed and bank stability. Assuming the above mitigation measures are included as part of the Project proposal, no significant impacts are expected to occur on surface water quantity and quality during construction.

2.3.2 Mitigation during construction of diversions

The following measures should be included in the environmental management plan in relation to construction of the diversion drains and levees:

- Construction works should be undertaken in low flow periods and preferably in dry periods
- Weather conditions should be monitored and if significant rain events are forecast, any in-stream works should cease and disturbed streams should be stabilised
- Requirements of the guideline *activities in a watercourse, lake or spring associated with a resource activity or mining operations* (WAM/2008/3435) should be adhered to, or if these cannot be met, conditions of a riverine protection permit should be complied with

- An operational erosion and sediment control plan should be prepared to minimise the risk of erosion and bed and bank stability. The plan should follow the IECA's (2008*)* erosion and sediment control guideline.

2.3.3 Mitigation during construction of the haul road crossing

The following measures should be included in the environmental management plan in relation to construction of the haul road crossing across the Carmichael River:

- Construction will be preferentially undertaken in dry conditions to prevent a flow event from damaging the construction work and spreading of contaminants during a flow event
- Even during dry periods, weather conditions will be monitored and if a significant rain event is forecasted any in-stream work should cease, works should be stabilised and any equipment removed from the floodplain
- Disturbance areas on either side of the haul road crossing should be kept minimal
- All disturbed areas will be stabilised as soon as reasonably possible
- An operational erosion and sediment control plan should be prepared to minimise the risk of erosion and bed and bank stability. The plan should follow the IECA's (2008*)* erosion and sediment control guideline.

2.3.4 Mitigation during construction of the levees

The following measures should be included in the environmental management plan in relation to construction of the levees:

- Construction of the pit protection levees should be undertaken in low flow periods and preferably in dry periods
- Construction of the Carmichael River levees to be preferentially undertaken in dry conditions to prevent a flow event from damaging the construction work and spreading of contaminants during a flow event
- For the construction of the pit protection levees it is important that the lowest section, the final drainage point is build last to:
  - prevent runoff being captured during construction within these areas
  - prevent damage to the levees during construction
- Weather conditions should be monitored and if significant rain events are forecast, any work within floodplain areas should cease, works should be stabilised and any equipment removed from the floodplain
- Disturbance areas on either side of the levees should be kept minimal
- All disturbed areas will be stabilised as soon as reasonably possible
- An operational erosion and sediment control plan should be prepared to minimise the risk of erosion and bed and bank stability. The plan should follow the IECA's (2008*)* erosion and sediment control guideline.

2.3.5 Monitoring

Monitoring will be undertaken in accordance with the Project (Mine) construction management plan (CEMP). The CEMP will include:

- Requirements for water quality monitoring and sampling;
- Criteria for discharges
- Performance indicators
- Reporting requirements
- Corrective actions
- Responsibilities.

3. Potential impacts and mitigation measures – Operation Phase

3.1 Overview

Potential operational impacts in relation to hydrology and hydraulics include:

- Exacerbation of flooding due to the presence of structures in the flood plain or channel of rivers and creeks. This in turn may affect the extent and duration of inundation of upstream lands in flood events
- Changes in flow characteristics (velocity) may also occur which may result in localised or more extensive scouring of channels
- Reduced or increased flows downstream of the mine due to diversions, storage overflows inter-catchment transfer, water extraction, site discharge and changes in surface runoff characteristics
- Stream and overland flows may flow into open cut and underground mine working areas, resulting in excessive water inventory within the mine.

3.2 Surface water design components

The baseline studies indicate that the Project (Mine) site will become inundated during flood events therefore the Project (Mine) site requires flood protection in order to operate and some method of stormwater management on-site to minimise the impact of the site on overland flow.

The necessary flood protection and stormwater management infrastructure identified includes the following:

- Levees to protect the adjacent pits from flooding by the Carmichael River
- A bridge to allow passage of haul vehicles and the conveyor from the south to the north of the mine during relatively frequent flood events
- Diversion drains to allow local waterways to pass through the site without causing flooding and also redirect overland flow around operational areas
- Water storages to manage runoff on-site.

Design criteria for the conceptual staged drainage scheme and the preliminary flood protection infrastructure are summarised below.

3.2.1 General criteria

General criteria used for the concept design comprise the following:

- All mine infrastructure is to be contained within the mine area
- Open cut pits are to have 1,000 year ARI flood immunity provided
- Overburden areas are to have 100 year ARI flood immunity
- Haul road crossing are to have 50 year ARI immunity

- Minimum freeboard of 600 mm is to be provided above the design immunity water level.

3.2.2 Diversion drain design

Diversion drain design was based on the following criteria:

- Drains to carry 100 year ARI capacity
- Drain banks to have 1 to 3 slope batters
- Drain to have a minimum grade of 0.2 percent
- Hydraulic constraints as described in the departmental regional guideline entitled Central West Water Management and Use Regional Guideline: Watercourse Diversions – Central Queensland Mining Industry Version 5 (DERM, 2011), namely:
  - A channel flow velocity that doesn't exceed 2.5 m/s and
  - A peak shear stress that doesn't exceed 80 N/m^2.

The diversion drain alignments were selected based on the existing terrain, known infrastructure (including mine protection bund and top soil spoil piles) that alter the existing flow paths through the mine lease area, and an aim to minimise the change in ultimate discharge point for the diverted catchments. The chosen alignments were generally based on a balancing of the following factors:

- Intersecting low points upstream of both the open cut mine protection bund and the top soil spoil piles
- Minimising cut
- Limiting the catchment area draining in to the areas of predicted subsidence
- Avoiding drains intersecting predicted subsidence panels and haul roads to reduce potential maintenance issues and the number of additional culverts required
- Preferred discharge location.

This process resulted in the twelve diversion drain alignments shown in Figure 14.

3.2.3 Levee design

Levee design was based on the following criteria:

- The alignment should not block the effluent flow path from the Carmichael River to Cabbage Tree Creek
- For the purposes of this design, and without any consideration of the geotechnical engineering issues at this stage, the batter slopes on the levees have been set at 1 vertical to 3 horizontal. If depth is greater than 5 – 6 m, sides should be benched
- Levee top width of 6 m
- Minimum levee height of 2 m (to limit trafficability).
- Provide flood protection to the mine open cut pits and waste heap areas for floods up to and including a 1 in 1,000 ARI storm event
- Include 600 mm of additional freeboard above the 1 in 1,000 year ARI storm event.

3.2.4 Haul road and conveyor crossing design

Haul road and conveyor crossing design was based on the following criteria:

- The haul road and conveyor crossing was to align with the concept haul road and overland conveyor design, being constrained to the central corridor of the mine area
- Haul road and conveyor crossing width is to be 40 m
- The conveyors are not expected to affect the flood hydraulics. For this reason it is not represented in the crossing for the purposes this assessment.

3.3 Impacts on determined watercourses

In a desktop assessment by DNRM in May 2013 of Mining Lease application (MLA) 70441, MLA 70490, MLA 70487 and the “Moray Downs” property, the following features were determined as watercourses as defined under the Water Act:

- Carmichael River
- Belyando River
- Logan Creek
- Dyllingo Creek
- Surprise Creek
- Mistake Creek
- North Creek [1]
- Cabbage Tree Creek [2]

There is currently no proposal to divert any of the watercourses listed above. There is however a proposal to divert the upper reaches of Eight Mile Creek which has been categorised by DNRM in August 2013 as a drainage feature.

.

The guidelines state that for the diversion of watercourses the engineering design of the diversion should include consideration of:

- The channel capacity must be at least equivalent to the natural stream channel capacity
- The length of the channel should be nearly the equivalent length of the watercourse it replaces
- The diversion channel must exhibit features similar to the natural existing watercourses such as meanders, terraces, benches, etc.

---

[1] Between approximate bearings: 21o 55’ 10.7” S 146o 23’ 28.4” E and 21o 55’ 56.4” S 146o 32’ 59.6” E

[2] Between approximate bearings: 22o 06” 24.1” S 146o 23” 57.4” E and 22o 06” 33.0” S 146o 25” 25.7” E 22o 06” 26.3” S 146o 26” 11.6” E and 22o 06” 15.2” S 146o 27” 44.4” E 22o 05” 45.7” S 146o 28” 33.9” E and 22o 05” 58.7” S 146o 29” 33.4” E

- Assessment of the stability and erosion characteristics of the diversion design
- The capacity of the floodplain to deal with out of channel flows
- Potential hydraulic and geomorphic impacts of the diversion channel on the adjoining natural reaches of the watercourse both upstream and downstream of the diversion.

Stream powers, velocities and shear stress upper limits will also apply to the diversion design. The design should also adopt the principles outlined in the ACARP report – "Maintenance of Geomorphic Processes in Bowen Basin River Diversions, Stages 1, 2 & 3".

3.4 Impacts on flooding

3.4.1 Change in flow rates – Carmichael River

Hydraulic modelling of the mine site hydrology under post-development conditions predicted changes to the flood flows in the Carmichael River due to the removal or changes to the catchment areas by the proposed mine and diversion drains areas. These changes are summarised in Table 1.

Table 1 Peak flows in the Carmichael River at the location of the proposed Haul Road and conveyor crossing – post-development donditions

ARI	Critical Duration	Peak Flow (m^3/s)	Change Compared to Existing (%)
10 year	30 hr	1195.0	-0.08
50 year	18 hr	2150.7	-0.08
100 year	18 hr	2614.6	-0.07
1,000 year	36 hr	5606.9	-0.13

Results indicate that the contribution of the diversion drains has a negligible influence on the approximate peak flow at the haul road crossing. This is because the timing of the peak flow from the reasonably small diverted catchments relative to that of the larger Carmichael River catchment, which will result in the combined peak flow downstream of their confluence being no higher than the current peak at the haul road. This also results in the diversion channels having no influence on the storm event producing the peak flow, or critical duration, at this location.

3.4.2 Change in flow rates – local waterways

Table 2 gives the peak outflows in the proposed diversion drains. A discussion on how the diversion drains affect local waterway flow can be found in section 3.5. The drain locations are illustrated in Figure 14.

Table 2 Peak outflows at outlet of proposed diversion drains

Diversion Drain	100 yr ARI	1,000 yr ARI
1	161	336
2	223	482
3	55	123
4	6	14
5	50	109
6	18	41
7	414	759

Diversion Drain	100 yr ARI	1,000 yr ARI
8	153	330
9	2	4
10	233	446
11	104	228
12	71	159

Climate change impacts assessment for local waterways

According to the Queensland Government Scientific Advisory Group (SAG) guidelines (DERM 2010a and DERM 2010b), rainfall is likely to increase or decrease by 5 percent per degree of global warming. The Carmichael Mine is designed to be operational until 2071 (final rehabilitation in 2074). The SAG recommends adopting a 4 degree increase in temperature by 2100. This corresponds to a 10 to 15 percent increase in rainfall intensity over the mine design life. By inputting these increased intensities to the hydrologic model it is possible to estimate potential peak flow rates under climate change conditions. The increase in rainfall intensity is expected to produces an estimated 20% increase in runoff. However, this estimated increase in runoff is highly discussable and other climate change scenarios are possible as well. The risk of climate change over the period of the mine infrastructure and operations should be considered during future mine planning and design. Potential increases in peak flow rates and the resultant impact they may have on the operation of the flood protection infrastructure are of particular risk in this regard. However, considering the large uncertainties regarding climate change in general at this stage climate change has not been incorporated.

3.4.3 Change in flood levels, velocity and inundation duration – Carmichael River

Flood levels, velocity and duration of flooding in the Carmichael River may be influenced by changes in flow or changes to the river profile. The changes in flow rate are provided in section 3.4.1. Changes in the river profile may be caused by the following infrastructure:

- A haul road and conveyor bridge crossing
- The mine protection flood levees (northern and southern banks of the Carmichael River).

The bridge crossing and flood levees were modelled using one and two dimensional hydraulic modelling software (refer SEIS Appendix K4 Preliminary Flood Mitigation and Creek Diversion Design Report for modelling details). The models were created for existing conditions and developed conditions to determine the impacts on flood levels and inundation duration within the Carmichael River.

Key features of the concept hydraulic design of the crossing include:

- A 180 m bridge comprising 7 x 25 m bridge spans located over the river channel
- Six cylindrical piers of 1 m diameter aligned in the direction of flow for each bridge support
- Bridge deck level of 230 m AHD
- The bridge soffit level of 228.8 m AHD (i.e. a 1.2 m deep bridge deck structure). At this stage the soffit level is approximately 0.5 – 0.9 m above the 50 year ARI flood level (based on the 1D and 2D modelling respectively) to allow for debris passage

- Four culverts of 3.1 m diameter located approximately at a low point in the floodplain approximately 250 m from the centreline of the Carmichael River
- Four culverts of 2.75 m diameter located at approximately 175 m from the centreline of the Carmichael River
- Riprap placement at and just downstream of the bridge to minimise scour potential and protect the abutments and piers due to high velocities through the bridge and
- Haul road has a maximum longitudinal gradient of 10 percent.

Flood inundation maps indicating the depth of flooding pre and post development can be found in the SEIS Appendix K4 Preliminary Flood Mitigation and Creek Diversion Design Report. The predicted change in flood level (afflux) for the 10, 50, 100 and 1,000 year ARI design events under post-development site conditions are provided in Figure 2 to Figure 5. With the establishment of the Mine site and accompanying flood mitigation infrastructure, the Carmichael River is now confined to the corridor between the flood levees with no runoff being received from the area behind the flood levee. The contraction of the floodplain causes a minor increase in flood extent upstream of the MLA for any of the simulated flood events. This outcome reflects the relative distance of the contraction from the western MLA boundary.

The proposed levees and mine pit bund successfully prevent flooding of either the underground mining area or the open cut pit areas. The Carmichael River (haul road) bridge is immune to the 10 year or 50 year ARI events. As discussed in the following sections the velocity through the bridge is high, leading to a potentially substantial risk of scour in floods larger than the 50 year ARI event.

Table 3 presents the afflux values for the ARI events considered as part of the Project (Mine) modelling and are as summarised below in the following paragraphs.

Table 3 Projected afflux from proposed development at selected locations

Location	Description	Afflux (m) For ARI			
		10 year	50 year	100 year	1,000 year
1	Carmichael River Model Inflow Boundary	0.01	0.00	0.00	0.00
2	2 km Downstream of Carmichael River Model Inflow	0.02	0.00	0.00	0.01
3	Western Project (Mine) area Boundary	0.02	0.01	0.01	0.06
4	Upstream of Haul Road Crossing	0.11	0.19	0.23	0.98
5	Downstream of Haul Road Crossing	0.03	-0.04	-0.08	0.31
6	Upstream Cabbage Tree Creek	0.04	0.16	0.23	0.70
7	Midway through Project (Mine) area	0.02	0.14	0.21	0.59
8	Eastern Project (Mine) area Boundary	0.01	0.00	0.01	0.07
9	Downstream Cabbage Tree Creek	0.01	0.07	0.09	0.17

10 Year ARI

The redistribution of flows due to the diversion drains and bunds, together with the restriction of the haul road on the Carmichael River floodplain has generally resulted in a reduction or only marginal afflux (less than 0.1 m) in the 10 year ARI event (refer Figure 2). A few notable exceptions to this are:

- The area immediately upstream of the haul road – which experiences between 0.1 and 0.5 m afflux (with the higher afflux south of the bridge and along the local drainage path at the second set of culverts north of the bridge)
- A localised area midway along the southern levee in Cabbage Tree Creek which experience up to 0.3 m afflux
- A local drainage path adjacent to the northern levee midway along the constriction – which also experiences up to 0.3 m afflux.

Importantly afflux was shown to be negligible at both the western and eastern boundary of the mine area (afflux was up to 20 mm and 10 mm respectively).

In terms of velocity afflux (refer Figure 6), the results show that the proposed mine infrastructure will generally reduce or cause only a minor increase (less than 0.1 m/s) in the velocity throughout the model, except in some localised areas. The areas of increase are generally along the proposed diversion drains (and/or upstream of the proposed top soil spoil piles), through the crossings (bridge and culverts) under the haul road, and immediately downstream of the crossings (especially along the Carmichael River). The most significant change in terms of magnitude is along the diversion drains, which generally show increases in excess of 0.5 m/s, and the biggest change in terms of area is at and downstream of the Carmichael River bridge (which generally shows an increase of between 0.1 and 0.5 m/s).

Figure 10 illustrates the flood depth over time immediately upstream of the bridge where the flood afflux is generally the most significant. It can be seen that the depth hydrograph generally follows the same trend both pre (existing) and post development. There will be a period of approximately 15 hours where the flood levels will be deeper than existing (0-0.5 m).

50 Year ARI

The overall pattern of afflux in the 50 year ARI event is similar to that in the 10 year ARI, with the majority of the afflux being confined to the immediate floodplain of the Carmichael River and proposed diversion drains (refer Figure 3). The magnitude and extent of the afflux has however increased as follows:

- The pond upstream of the haul road has expanded to cover the bridge and three culvert crossings to the north and now experiences afflux of between 0.1 and 0.6 m afflux (with the higher afflux being either side of the bridge)
- The entire length of the Cabbage Tree Creek effluent path adjacent to the southern Carmichael River levee experiences afflux of between around 0.1 to 0.4 m (a likely result of the levee redirecting some water that would have otherwise left the creek as overland flow to the south)
- The full first half of the area confined by the Carmichael River levees experiences between 0.1 and 0.2 m afflux

- The area midway along the northern levee experiencing higher afflux (now up to 0.4 m) has grown and shifted upstream
- Connection to the Carmichael River has resulted in afflux of up to 0.5 m in a localised area near the downstream end of proposed Drain 5.

The results also show a reduction in flood levels immediately downstream of the bridge, due to the restriction of flow along the floodplain. Similarly to the 10 year ARI event, the afflux was shown to be negligible at the western mine area boundary (up to 10 mm) and relatively insignificant at the eastern mine area boundary (afflux was close to 0 mm near the Carmichael River, but up to up to 70 mm downstream of Cabbage Tree Creek).

The velocity afflux in the 50 year ARI event (refer Figure 7) shows a similar trend to the 10 year ARI event, with an increase in the magnitude of the changes in velocity in the localised areas of increase. At the Carmichael River Bridge, the velocities increase by up to 0.9 m/s. This event also identifies two additional areas of increased velocities, one immediately upstream of the haul road crossing along Drain 8 and one just downstream of the point of greatest constriction between the Carmichael River levees.

Figure 11 illustrates the flood depth over time immediately upstream of the bridge where the flood afflux is generally the most significant. It can be seen that the depth hydrograph generally follows the same trend both pre (existing) and post development although has a longer period of change than the 1 in 10 year ARI. There will be a period of approximately 30 hours where the flood levels will be deeper than existing (0-0.6 m).

100 Year ARI

As expected, the impacts expected for the 50-year ARI event are marginally worsened in the 100-year ARI event. The key changes in this event are:

- The pond upstream of the haul road has expanded to connect in with the downstream end of proposed Drain 5 and now experiences afflux of between 0.1 – 1.0 m (with the higher afflux being either side of the bridge and along the downstream end of Drain 5)
- The afflux along the Cabbage Tree Creek effluent path has increased to be between around 0.1 to 0.6 m
- The area midway along the northern levee experiencing higher afflux has grown in the upstream direction
- The area of reduced afflux downstream of the haul road has reduced due to flows overtopping the terrain between Drain 5 and the Carmichael River downstream of the haul road.

These changed conditions (refer Figure 4) did not significantly change the afflux at the mine area boundary compared to the 50 year ARI event (refer Figure 3), with the western boundary and eastern boundary near the Carmichael River experiencing afflux up to 10 mm and the eastern boundary downstream of Cabbage Tree Creek experiencing up to 120 mm afflux.

The velocity afflux in the 100 year ARI event (Figure 8) shows the same general areas of change as the 50 year ARI event (Figure 7), with an increase in the magnitude of the velocity changes in these localised areas. The largest increases are as follows:

- At the Carmichael River bridge and culverts, which show a velocity increase of up to 1.5 m/s and in excess of 2 m/s respectively

- Just downstream of the point of greatest constriction between the Carmichael River levees.

These results also identify an additional area of increased velocities where flow bypasses the modelled haul road via the marginally lower terrain between Drain 5 and the Carmichael River.

Figure 12 illustrates the flood depth over time immediately upstream of the bridge where the flood afflux is generally the most significant. It can be seen that the depth hydrograph generally follows the same trend both pre (existing) and post development although has a marginally longer period of change than the 1 in 50 year ARI. There will be a period of approximately 32 hours where the flood levels will be deeper than existing (0.1 – 1.0 m).

1,000 Year ARI

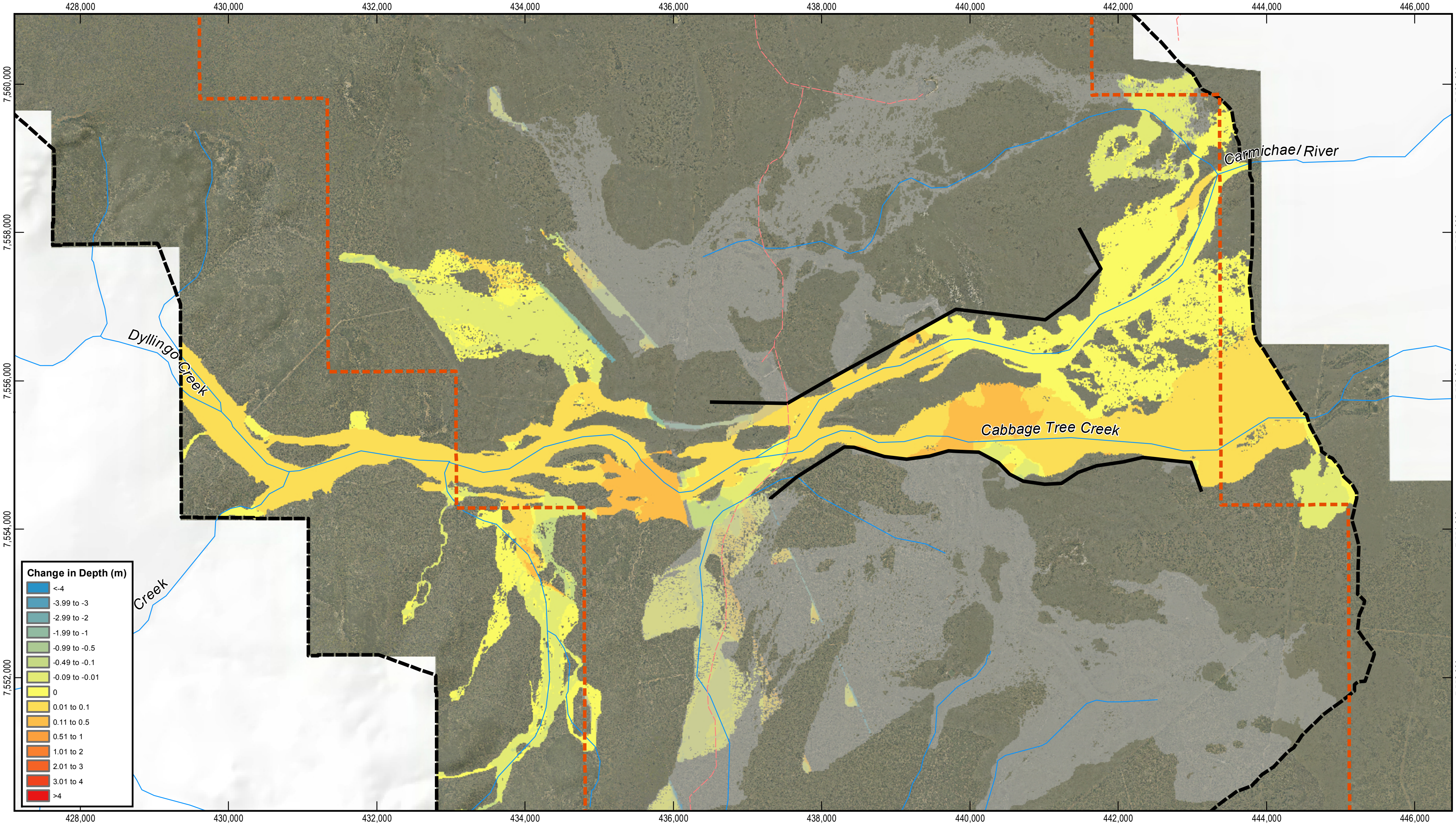
Due to the haul road being overtopped in the 1,000 year ARI event the afflux shown in the study areas is more extensive and significant than the other events throughout (refer Figure 5). The key properties of the 1,000 year ARI results are:

- Minimal afflux (less than 0.1 m) from approximately 3 km upstream of the haul road
- Afflux of between 0.5 and 1.9 m from immediately upstream of the haul road to approximately 3 km upstream (with the higher afflux being either side of the bridge and along a significant portion of Drains 5 and 8)
- Afflux of between 0.1 and 1.1 m in the Carmichael River levee corridor.

These changed conditions increase the afflux at the mine area boundary compared to the 100 year ARI event, with the western mine area boundary showing afflux up to 70 mm and the eastern mine area boundary showing afflux of up to 90 mm near the Carmichael River and 270 mm downstream of Cabbage Tree Creek.

Although the 1,000 year ARI event overtops the haul road the areas of change in relation to the velocity afflux are quite similar to the 100 year ARI event, with the exception of the area immediately upstream of the haul road outside the banks of the Carmichael River which generally experiences a reduction in velocities (refer Figure 9). In terms of magnitude, the area along the Carmichael River around the bridge has not really changed, but there has been further increases just downstream of the point of greatest constriction between the Carmichael River levees (the majority of the area experiences an increase of between 0.25 m/s and 0.5 m/s) and downstream of the lower terrain between Drain 5 and the Carmichael River (a large portion of which experiences increases of in excess of 0.5 m/s).

Figure 13 illustrates the flood depth over time immediately upstream of the bridge where the flood afflux is generally the most significant. It can be seen that the post development hydrograph departs quite significantly from the pre (existing) development hydrograph. There will be a period of approximately 47 hours where the flood levels will be deeper than existing (0.5-1.9 m).



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area
- Flood Extent Change

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design
10 Year ARI Design Flood
Post Development - Depth Afflux

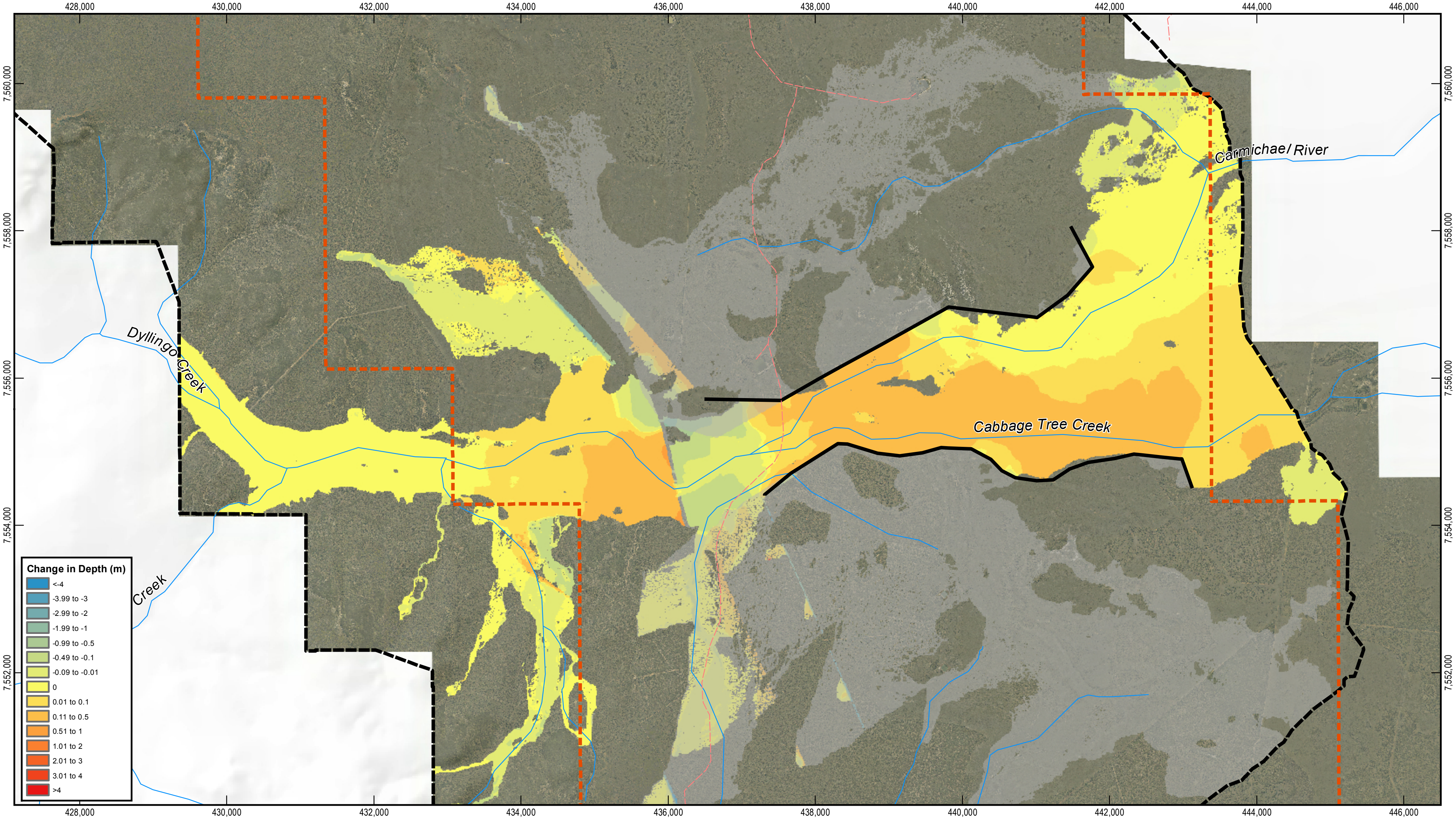
Job Number	41-26422
Revision	A
Date	01-08-2013

Figure 2

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-1_2013_10yr_DepthAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area
- Flood Extent Change

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

50 Year ARI Design Flood
Post Development - Depth Afflux

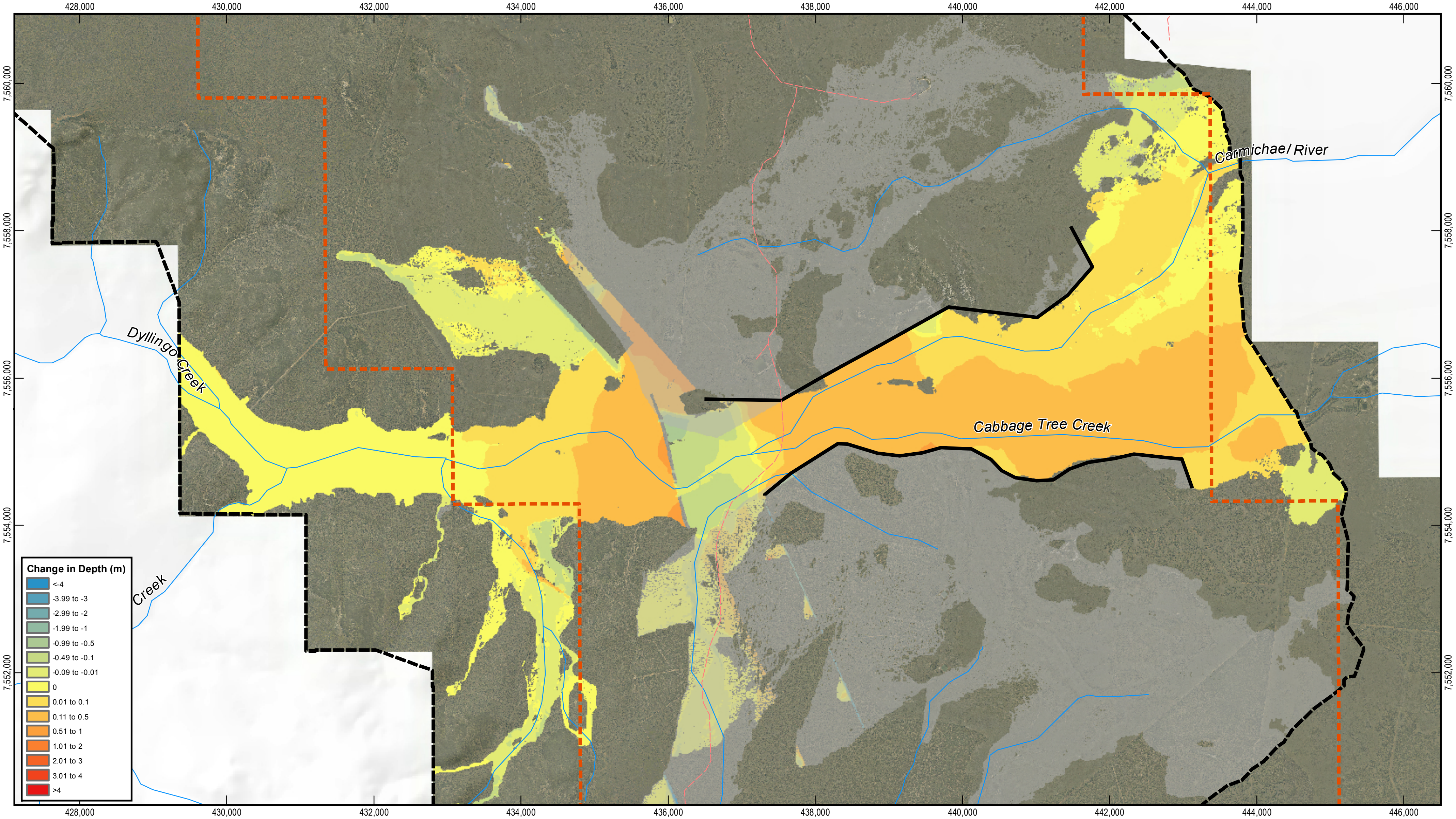
Job Number	41-26422
Revision	A
Date	01-08-2013

Figure 3

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-2_2013_50yr_DepthAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area
- Flood Extent Change

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

100 Year ARI Design Flood
Post Development - Depth Afflux

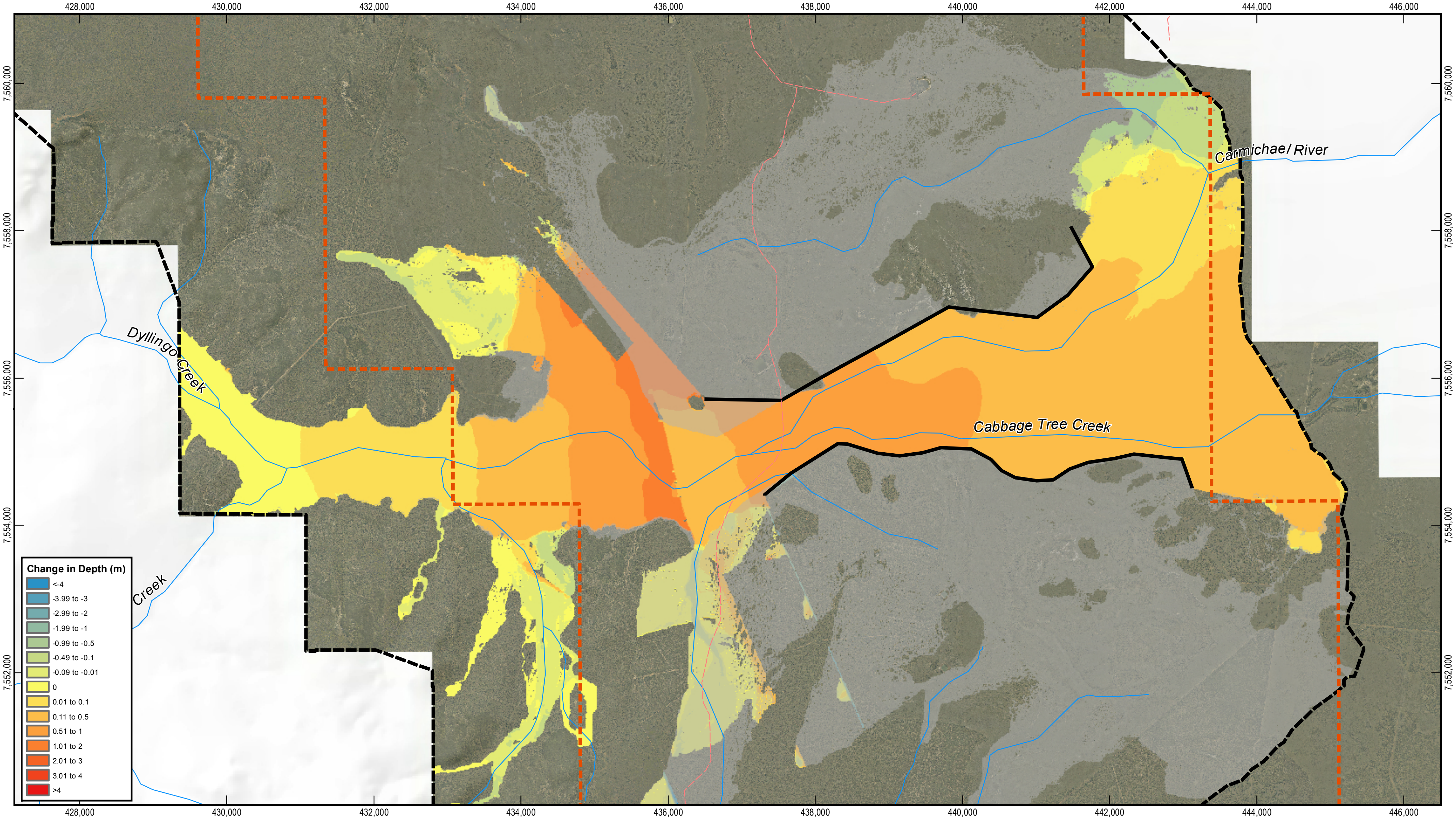
Job Number 41-26422
Revision A
Date 01-08-2013

Figure 4

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-3_2013_100yr_DepthAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area
- Flood Extent Change

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

1000 Year ARI Design Flood
Post Development - Depth Afflux

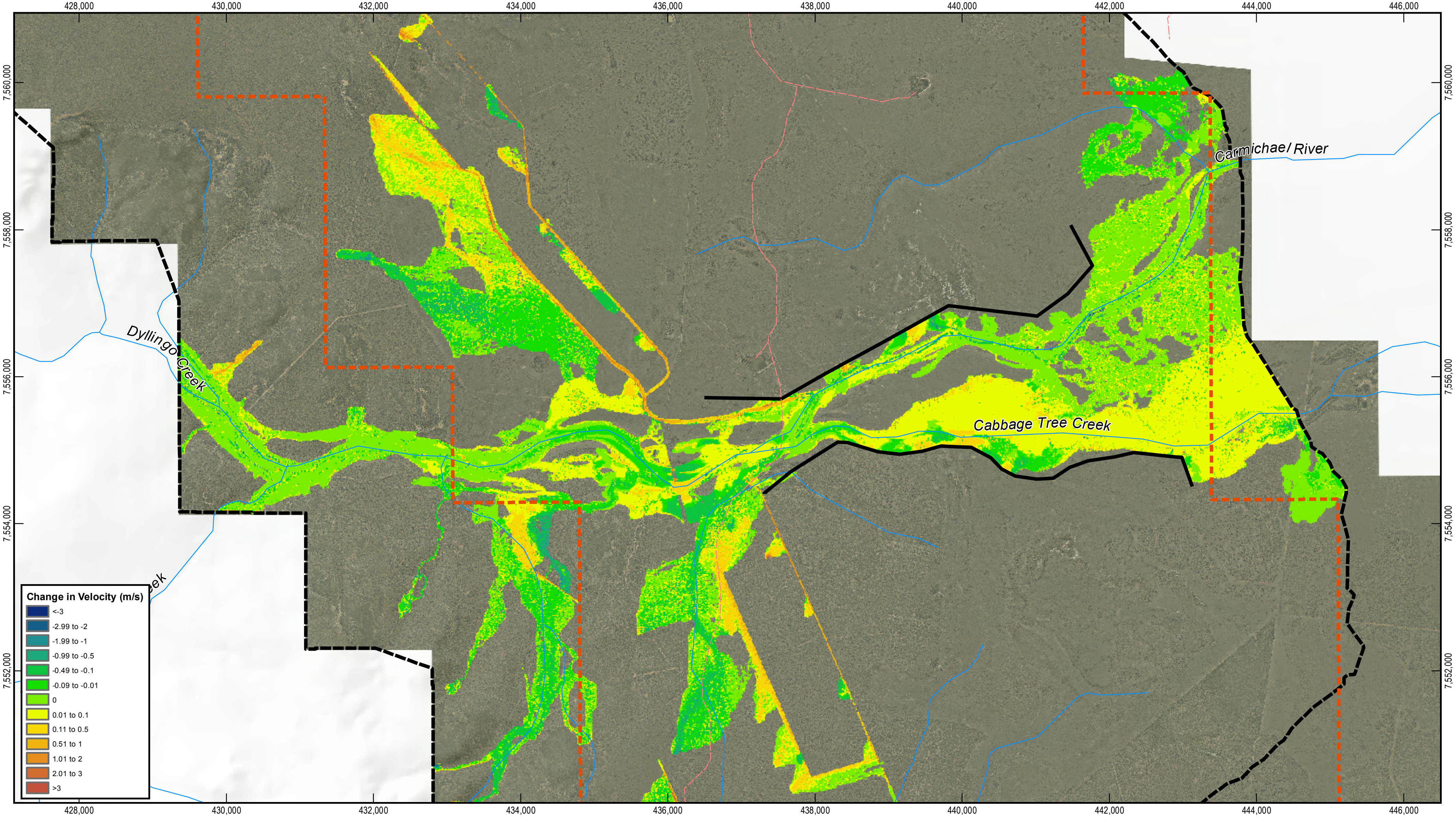
Job Number	41-26422
Revision	A
Date	01-08-2013

Figure 5

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-4_2013_1000yr_DepthAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

Watercourse
Track
Proposed Levee
2D Model Extent
Mine Lease Area

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design
10 Year ARI Design Flood
Post Development - Velocity Afflux

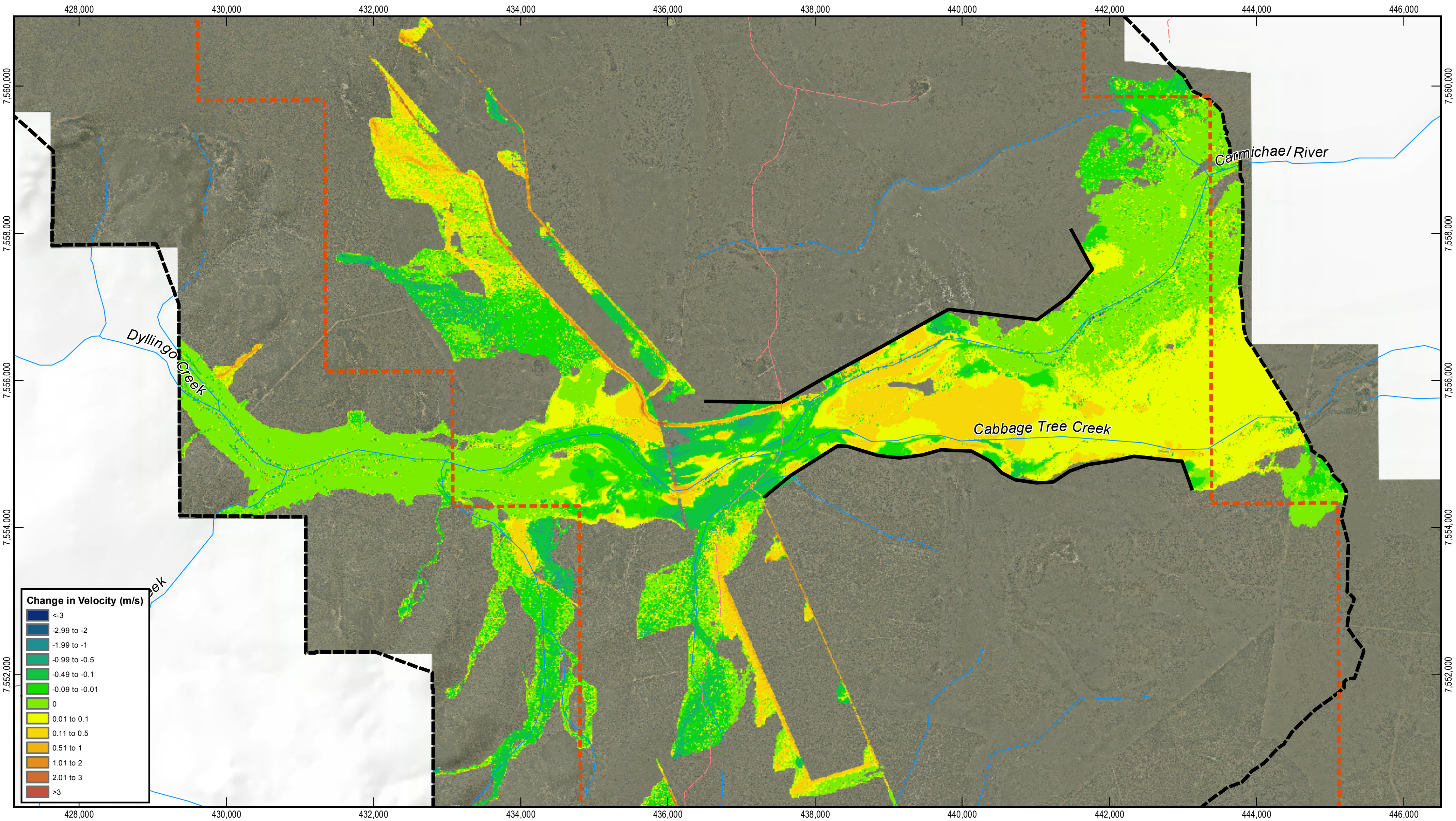
Job Number	41-26422
Revision	A
Date	01-08-2013

Figure 6

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-5_2013_10yr_VelAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

50 Year ARI Design Flood
Post Development - Velocity Afflux

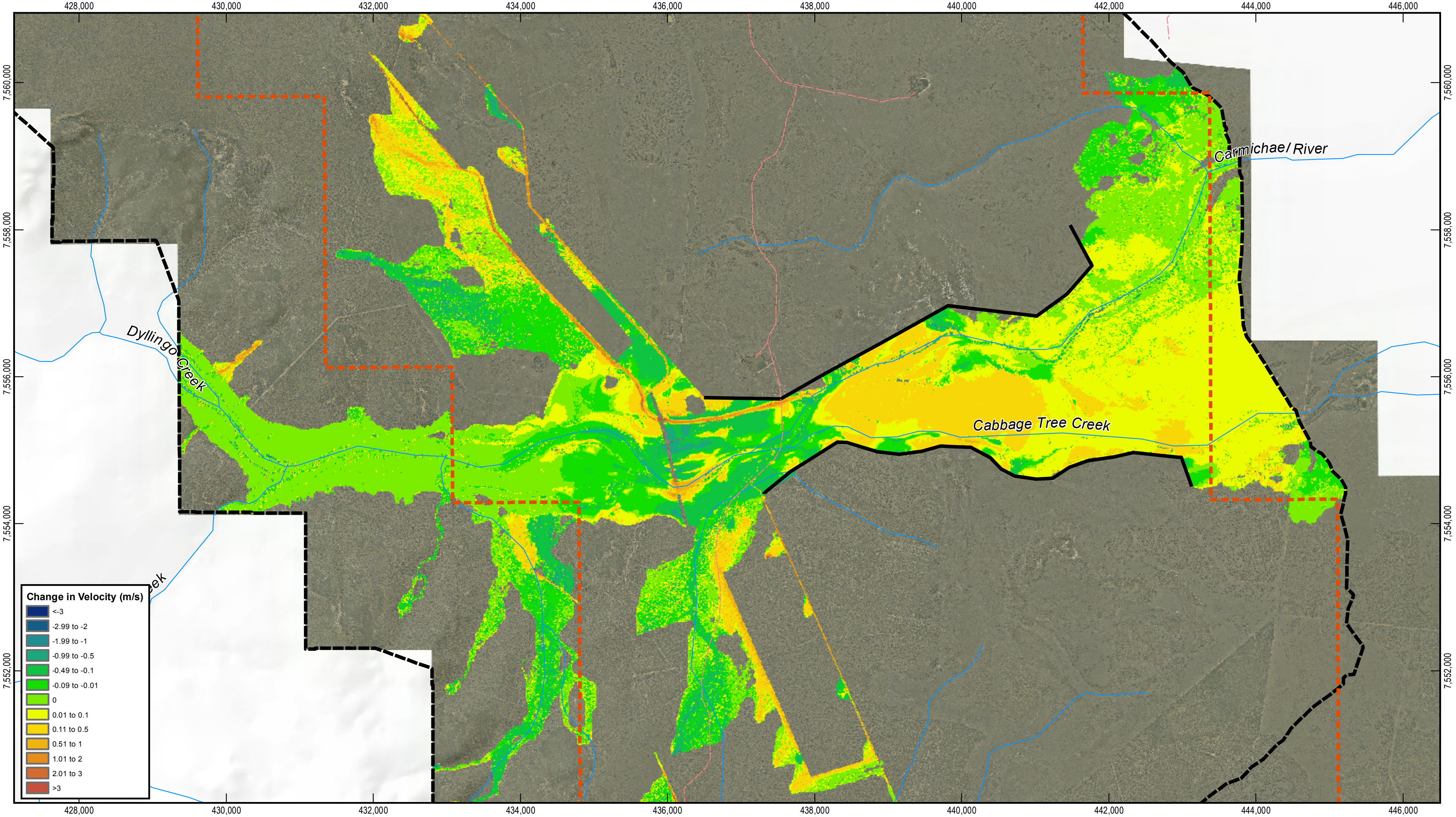
Job Number 41-26422
Revision A
Date 01-08-2013

Figure 7

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-6_2013_50yr_VelAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND

- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design
100 Year ARI Design Flood
Post Development - Velocity Afflux

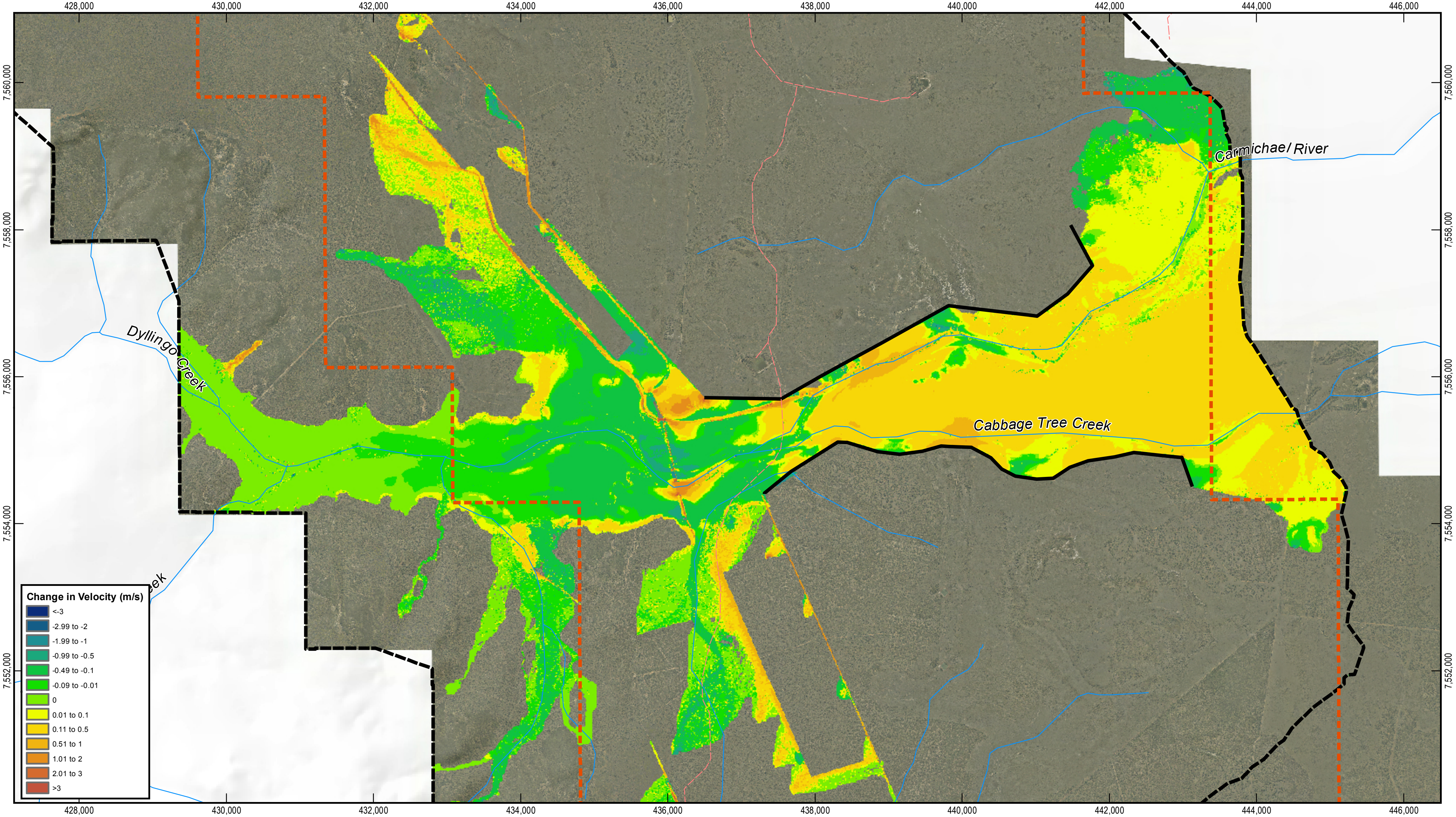
Job Number	41-26422
Revision	A
Date	01-08-2013

Figure 8

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-7_2013_100yr_VelAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS



1:70,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

LEGEND
- Watercourse
- Track
- Proposed Levee
- 2D Model Extent
- Mine Lease Area

Based on or contains data provided by the State of QLD (DNRM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relationto the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design
1000 Year ARI Design Flood
Post Development - Velocity Afflux

Job Number | 41-26422
Revision | A
Date | 01-08-2013

Figure 9

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\Fig_3-8_2013_1000yr_VelAff_Carmichael.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data source: DME: EPC1690 (2010)/EPC1080 (2011); ESRI: Hillshade (2008); © Commonwealth of Australia (Geoscience Australia): Watercourse, Roads, Tracks (2007); GHD: 2D Model Extent, Flood Surface (2013). Created by: LS

Figure 10 10 year ARI depth hydrograph upstream of proposed bridge

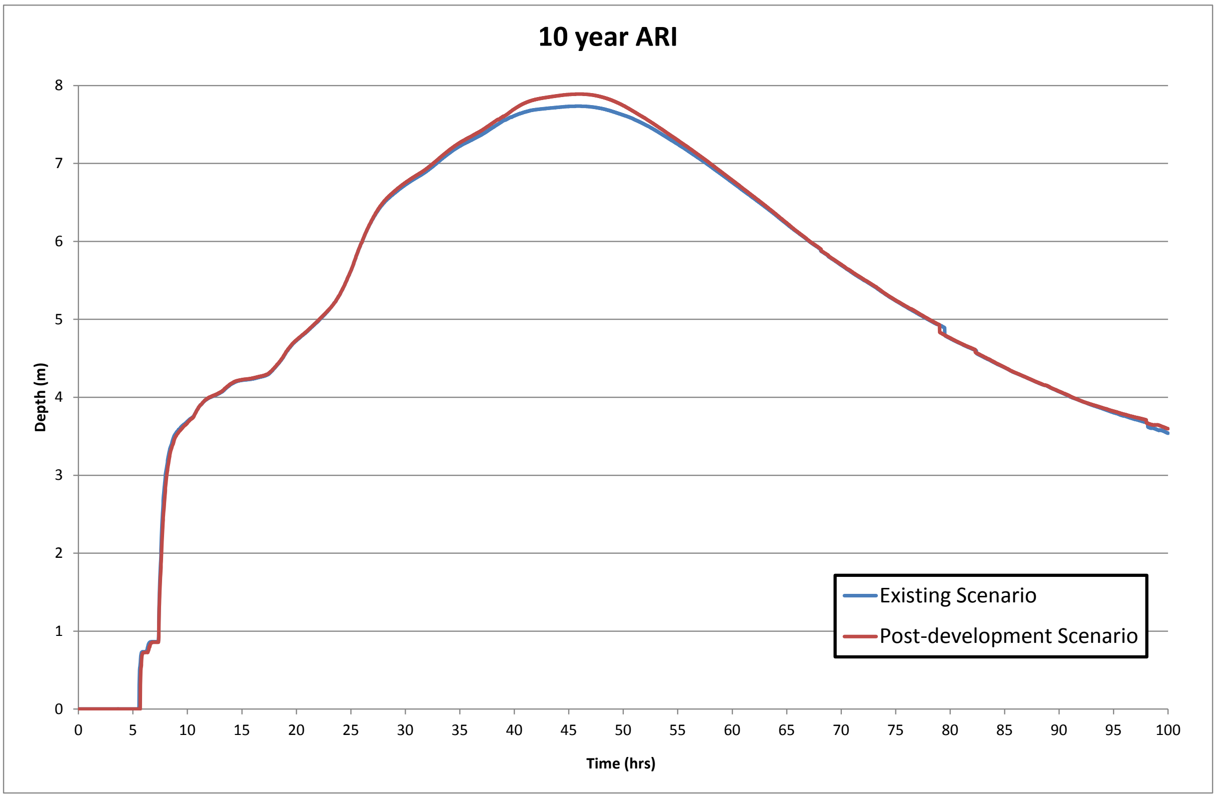


Figure 11 50 year ARI depth hydrograph upstream of proposed bridge

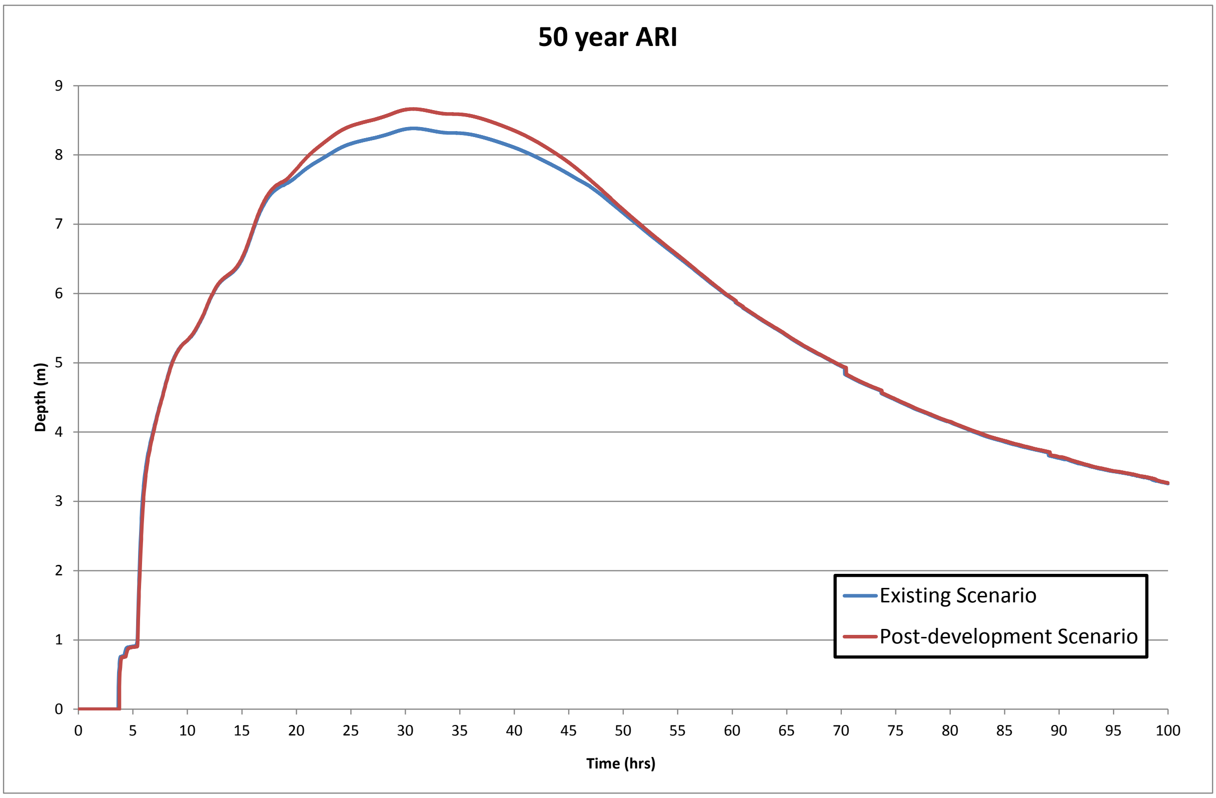


Figure 12 100 year ARI depth hydrograph upstream of proposed bridge

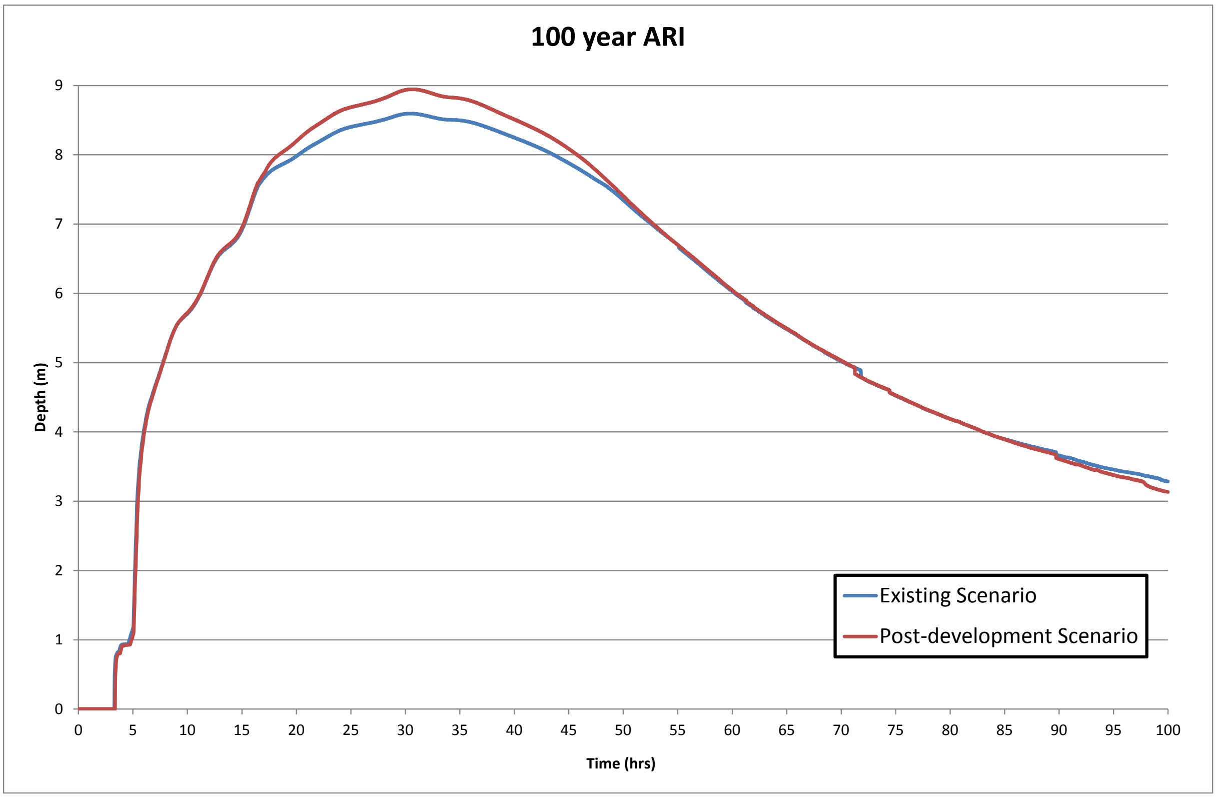
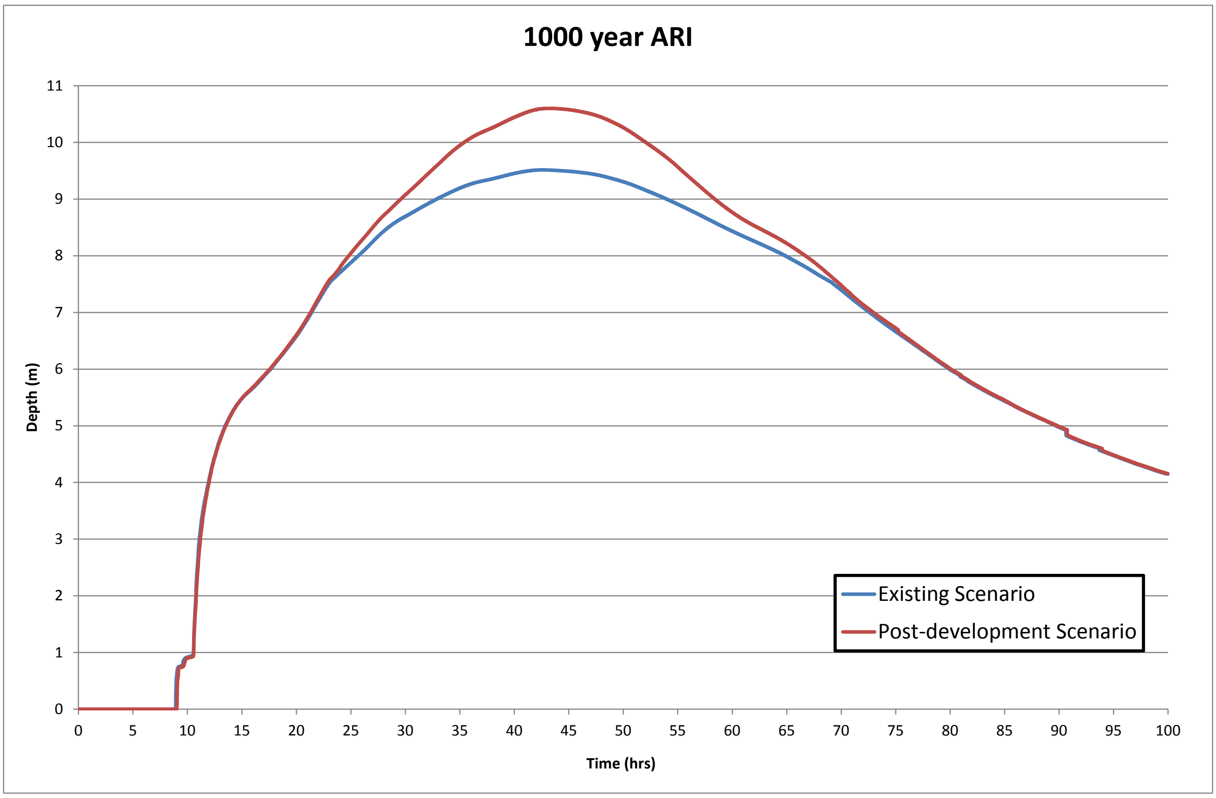


Figure 13 1,000 year ARI depth hydrograph upstream of proposed bridge



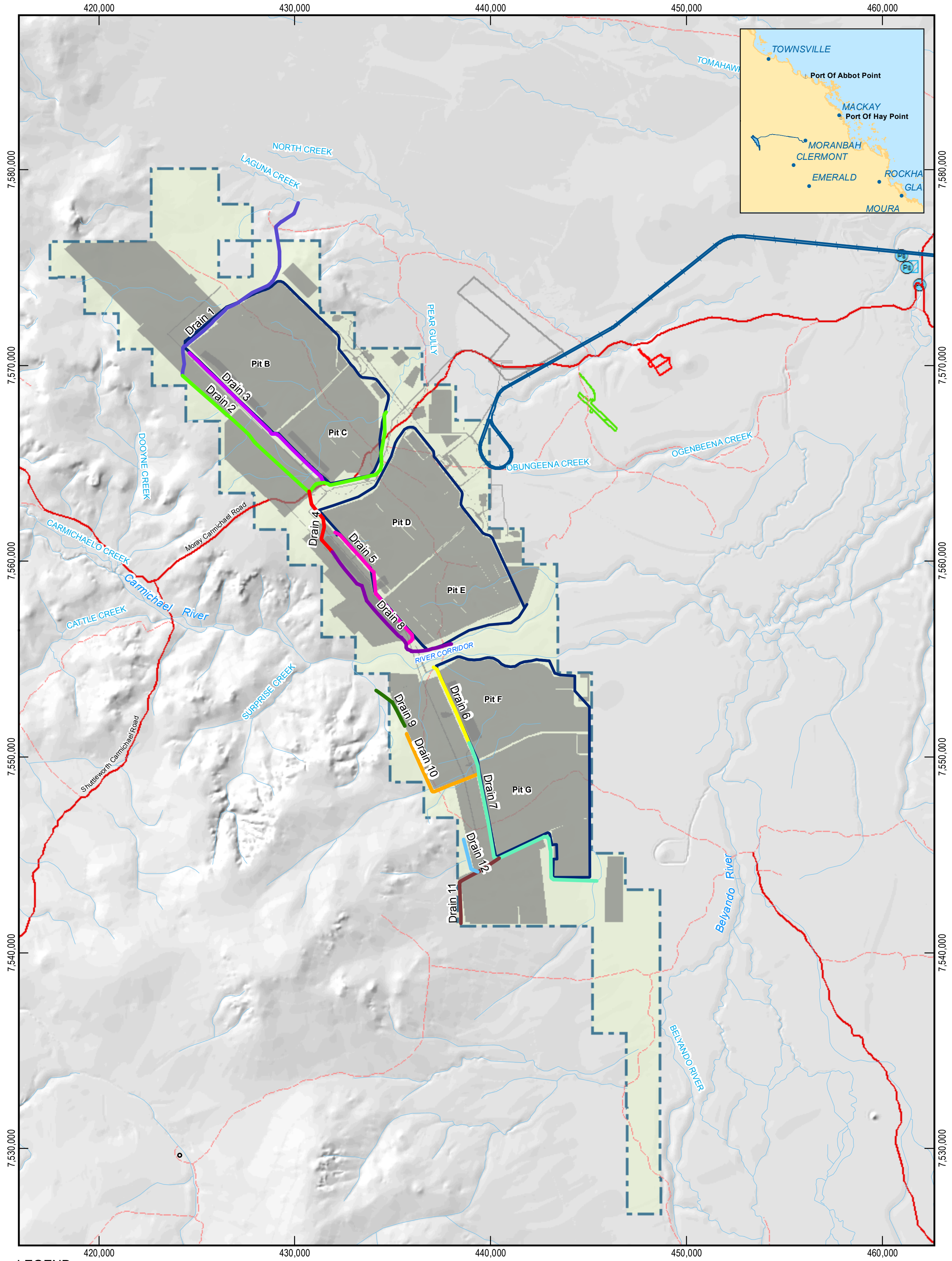
3.4.4 Diversion drains

The preliminary diversion drain designs show that design criteria are met in most situations, with some future refinement to be done during detailed design stages. However, importantly the preliminary design provides confidence that the proposed diversion drains are able to meet requirements and fit within the mine plan presented in the project description.

Table 4 provides an overview of the how much (%) of the different design criteria is met and provides options for future designs if a design criteria is not fully met. Longitudinal slopes are within an acceptable range and freeboard requirements are largely met. For some drains the velocity is currently too high, but with velocities in general being within 10% of the design criteria it is fully expected that velocities can be brought down in most situations. Requirements for scour protection and drop structures are expected to be minimal within the final design. If these additional design and mitigation measures are implemented the diversion drains are expected to have minimal impact on and possibly improve the erosion and scour issues of the catchment (refer section 3.12.1 for further discussion on erosion issues).

Table 4 Overview of diversion drain design results

Diversion Drain	Range of Base Widths (m)	Range of Longitudinal Slopes (%)	% of drain with ≥ 600 mm freeboard in channel1	% of drain with a velocity of ≤ 2.5 m/s in channel	% of drain with a shear stress of ≤ 80 N/m2 in channel	Detailed design considerations to meet design criteria
1	2 – 40	0.2 – 0.9	100.0	95.4	93.6	Local drain refinement and/or scour protection measures
2	2 – 40	0.05 – 1.4	88.52	73.7	70.5	Local drain refinement, including drop structures and/or scour protection measures between Chainage 7000 and 3000.
3	2 – 20	0.3 – 1.5	100.0	100.0	89.6	Local drain refinement and/or scour protection measures
4	2	0.2	100.0	91.7	83.3	Local drain refinement and/or scour protection measures
5	2 – 30	0.2 – 1.0	100.0	84.9	83.6	Local drain refinement, including drop structures and/or scour protection measures
6	2	0.3 – 0.5	100.0	100	97.7	Local drain refinement and/or scour protection measures
7	2 - 40	0.2	96.3	59.0	97.8	Local drain refinement and/or scour protection measures along much of drain (velocities are generally within 10% of criteria).
8	2 - 40	0.2 – 1.9	100.0	98.9	80.5	Local drain refinement, including drop structures and/or scour protection measures
9	2	0.2 – 0.3	100.0	100.0	100.0	-
10	5 – 40	0.2 – 1.0	100.0	77.2	77.2	Local drain refinement, including drop structures, and/or scour protection measures in last 1.5 km of drain
11	2 – 20	0.2 – 2.1	100.0	55.8	55.8	Local drain refinement, including drop structures, and/or scour protection measures in last 2 km of drain
12	2 – 20	0.4	100.0	100.0	100.0	-



LEGEND

Minor Road	Rail (West)	Airport
Track	Mine Site	Industrial Area
Watercourse	Mine Layout	Accommodation Village
Flood Protection Bund	Mine (Offsite)	
	Pump Station	
	Storage Facility (Offstream)	

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision D
Date 24-10-2013

Project (Mine) Diversion Drains

Figure 14

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\41_26422_351_rev_d.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Road, River / Watercourse (2007); DME: EPC1690 (2010), EPC1080 (2011); Adani: Mine Layout / Infrastructure (2013), Mine (Offsite) (2013); GHD: Diversion Drains (2013). Created by: ES

3.5 Impacts on seasonal flow

A catchment water balance was created to determine the impacts of the subsidence areas, diversion drains and mine pit areas on annual flow from the site. The assessment covered the site and local catchments impacted by the site. It did not include modelling of the entire Carmichael River catchment.

3.5.1 Assumptions

Climate data

Two climate stations have been used for this analysis. 6 minute data was required to best represent the outlet conditions of the subsidence ponds. BoM Pluviograph station Blair Athol (station no. 35010) was determined to be the closest to the site and the period of Jan 2005-June 2006 was selected as this provides the best continuous data set. Daily data has been used to show long term variability in runoff when comparing the existing and developed catchments. Patched point SILO data for the Bygana station was used for the daily long term set as this provided data closest to the site. Table 5 shows the mean annual rainfall for each station and time period adopted for the modelling. Table 6 shows annual data for the ten year period modelled using the daily climate data from the Bygana SILO station. The minimum annual rainfall (363 mm) occurs in 2005 and maximum (1,162 mm) in 2010.

Table 5 Comparative mean annual rainfall for two climate data sets

	Mean annual rainfall
Blair Athol, Pluviograph station no. 35010, Jan 2005 – June 2006 (6 minute)	573
Bygana Patched Point SILO station no. 36089, Jan 2003 – June 2013 (daily)	589

Table 6 Annual rainfall and evapotranspiration totals, 2003-2012, Bygana SILO climate data

Year	Annual Rainfall (mm)	Annual evapotranspiration (mm)
2003	508.4	1,930
2004	558.6	1,915
2005	362.8	1,916
2006	372.1	1,821
2007	491.3	1,736
2008	754.6	1,754
2009	433.6	1,813
2010	1,162.4	1,498
2011	545.8	1,652
2012	701.1	1,721
Average	589.1	1,776
Min	362.8	1,498
Max	1,162.4	1,930

Waterway sub catchment delineation

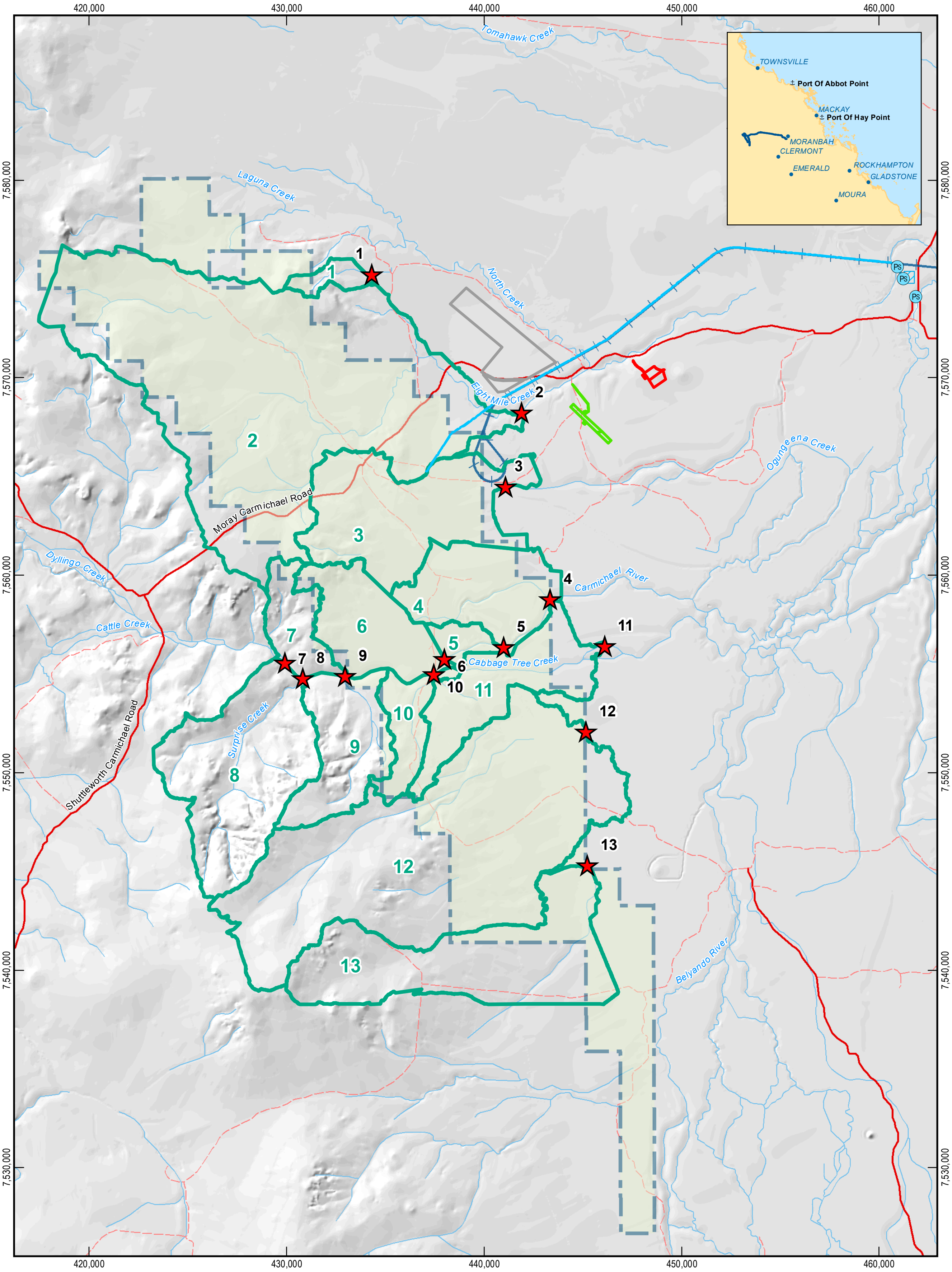
Sub-catchments were defined to tributaries of the Carmichael River, with 13 sites identified. Catchment delineation was based on the following data and assumptions:

- Catchment boundaries followed catchments delineated for XP-RAFTS modelling and contours
- Developed catchments defined based on proposed diversion drainage and extent of open-cut areas
- No catchments were considered outside of the site boundary.

Table 7 summarises the catchment area for existing and developed conditions and the relative change in size for each waterway. No change in catchment area is predicted for waterways 7, 8 and 9. Figure 15 illustrates the catchment boundaries for existing conditions and Figure 16 the developed conditions.

Table 7 Catchment areas for each receiving waterway

Receiving Waterway Ref.	Waterway Name	Existing Conditions, Contributing Catchment Area (ha)	Developed Conditions, Contributing Catchment Area (ha)	Change
1	Laguna Creek Tributary	456	5,330	1,069%
2	Eight Mile Creek	19,532	9,985	-49%
3	Obungeena Creek	5,225	1,457	-72%
4	Carmichael River	3,073	1,269	-59%
5	Carmichael River	504	255	-50%
6	Carmichael River	2,692	2,113	-22%
7	Dyllingo Creek	1,368	1,368	0%
8	Surprise Creek	5,740	5,740	0%
9	Unnamed	2,796	2,796	0%
10	Cabbage Tree Creek	1,265	1,073	-15%
11	Cabbage Tree Creek	3,148	1,549	-51%
12	Unnamed	14,848	790	-95%
13	Unnamed	6,313	16,572	163%
Total		66,960	50,296	-25%



LEGEND

- Recieving Waterway
- Local Road
- Track
- Watercourse
- Project (Rail)
- Project (Mine)
- Existing Sub-catchment Waterway
- Water Supply Pipeline
- Mine (Offsite)
- Pump Station
- Storage Facility (Offstream)
- Airport
- Industrial Area
- Accommodation Village

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

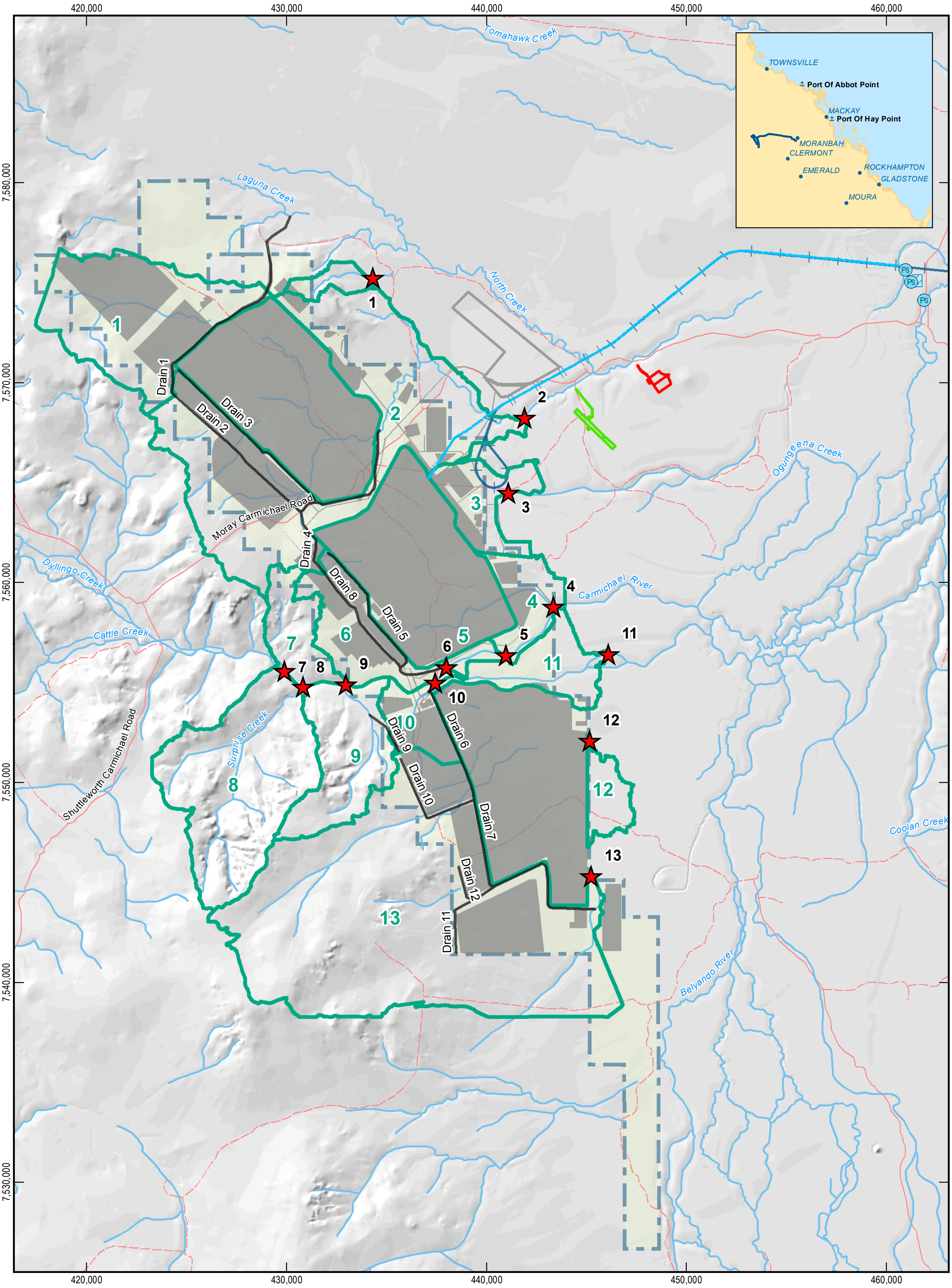
Job Number 41-26422
Revision B
Date 22-10-2013

Existing Conditions
Sub-Catchments

Figure 15

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\41-26422_fig_3-14_rev_b.mxd Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007);
GHD: Sub-catchment, Recieving Waterway (2013); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013). Created by: BW, MS



LEGEND

Recieving Waterway	Diversion Drain	Mine Layout	Mine (Offsite)	Airport
Local Road	Project (Rail)	Developed Sub-Catchment Waterway	Pump Station	Industrial Area
Track	Project (Mine)	Water Supply Pipeline	Storage Facility (Offstream)	Accommodation Village
Watercourse				

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision B
Date 22-10-2013

Developed Conditions Sub-Catchments

Figure 16

G:\41\26422\GIS\Maps\MXD\0300_Hydrology\41-26422_fig_3-15_rev_b.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007);
GHD: Sub-catchment, Recieving Waterway (2013); Adani: Project Rail, Project opperations, Project (Mine), Diversion Drains (2013), Facilities (2013). Created by: BW, MS, ES

3.5.2 Model development

To evaluate stormwater runoff within the catchment, a water balance model of the catchment was developed using MUSIC, the Model for Urban Stormwater Improvement Conceptualisation, developed by CRC for Catchment Hydrology. MUSIC provides the ability to simulate both quantity and quality of runoff from catchments ranging from a single house block up to many square kilometres, and the effect of a wide range of treatment facilities on the quantity and quality of runoff downstream using a range of time steps from daily down to 6 minutes.

Catchment parameters

For the purposes of the water balance modelling, the following catchment parameters were adopted:

- Impervious fraction of 0.02 (based on undeveloped catchment and consistency with assumptions for the XP-RAFTS modelling)
- Soil storage and field capacity as recommended for Brisbane region and other default MUSIC rainfall-runoff parameters summarised in Table 8.

Table 8 Rainfall-runoff parameter inputs

Rainfall-Runoff Parameter	Input
Field Capacity	120 mm
Impervious Area Rainfall Threshold	1 mm/day
Pervious Area Soil Storage Capacity	80 mm
Pervious Area Soil Initial Storage	25% (of capacity)
Groundwater Initial Depth	10 mm
Groundwater Daily Recharge Rate	25%
Groundwater Daily Base flow Rate	5%
Groundwater Daily Deep Seepage Rate	0%

Subsidence ponds

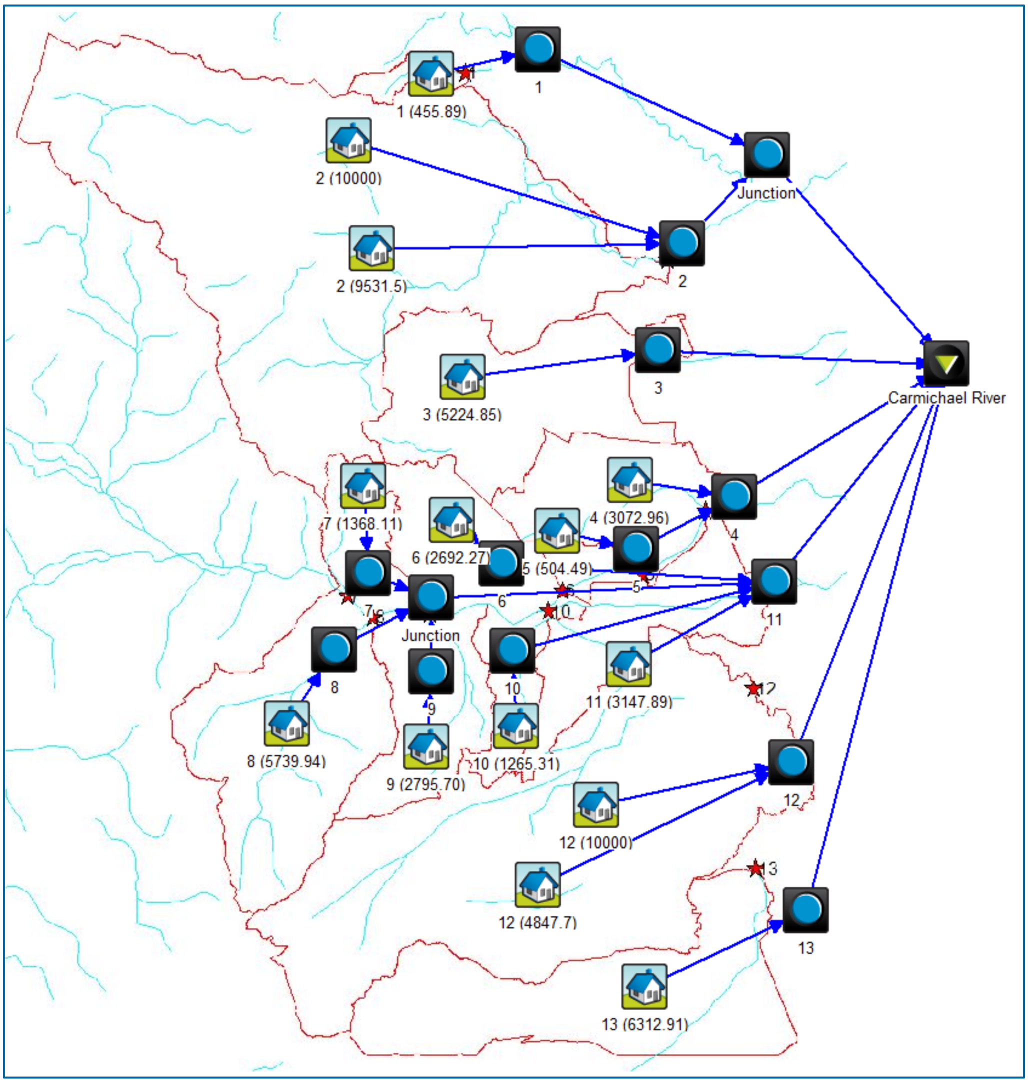
The following assumptions were made to determine the volumes of the subsidence ponds:

- Closed contours were selected to represent pond permanent pool boundary
- Volume of areas bound by permanent pool boundary calculated using the software package 12d to create a tin surface using subsidence contours
- Where contours showed pool depth less than 0.5 m (equivalent to contour interval) volume was calculated assuming a 0.25 m average depth over the area of the permanent pool boundary
- An exfiltration rate of 50 mm/h was adopted for the ponds. This reflects low-medium range for sandy loam soils. A sensitivity test was also undertaken to assess the effect of the adopted infiltration rate on losses and runoff estimates, this is discussed below.

3.5.3 Model layout

For existing conditions model runoff from each of the 13 sub-catchments was reported at relevant junction nodes and at the Carmichael River receiving waterway. The MUSIC model layout is presented in Figure 17.

Figure 17 MUSIC model layout – existing conditions model



Two developed conditions models have been constructed as follows:

- Developed Conditions Model 1 – shows changes in contributing catchment areas and run for 10 year period using daily climate data as for the existing conditions model. MUSIC model layout is shown in Figure 18
- Developed Conditions Model 2 – models individual sub-catchments where subsidence ponds occur (see Figure 20). Model run using 6 minute climate data to allow modelling of the outlet conditions at a sub-daily time step. Subsidence ponds were modelled as aggregated ponds, however a sensitivity was conducted for this approach compared to modelling individual ponds in series within sub-catchment 1 as shown in Figure 19. The sensitivity results indicated limited difference in evapotranspiration and infiltration losses between the two model layouts, thus the remaining ponds were aggregated based on sub catchments within each waterway contributing sub catchment.

Each developed case also includes the removal of the open pit areas from the catchment and site water storages as these areas will no longer produce runoff.

Figure 18 MUSIC model layout – developed conditions model 1

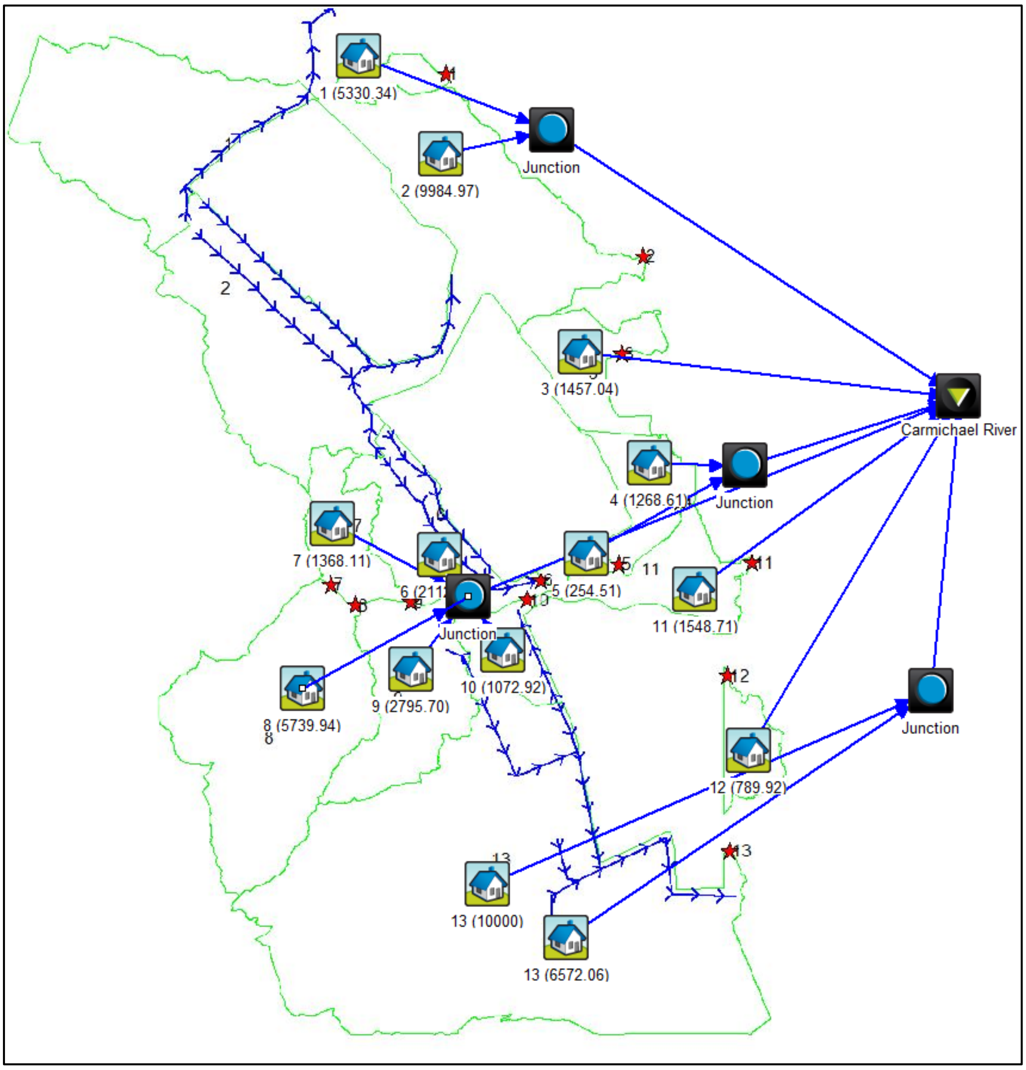


Figure 19 MUSIC model layout – sensitivity assessment ponds in series

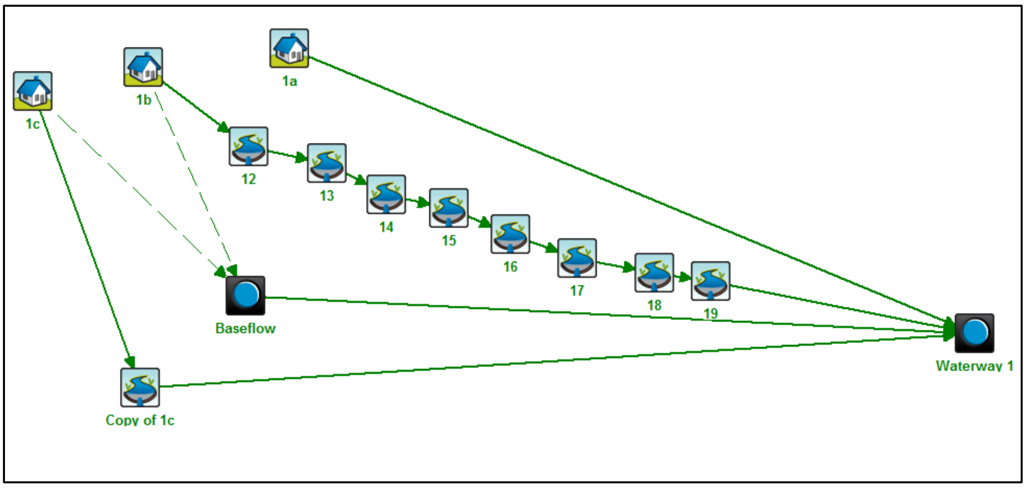
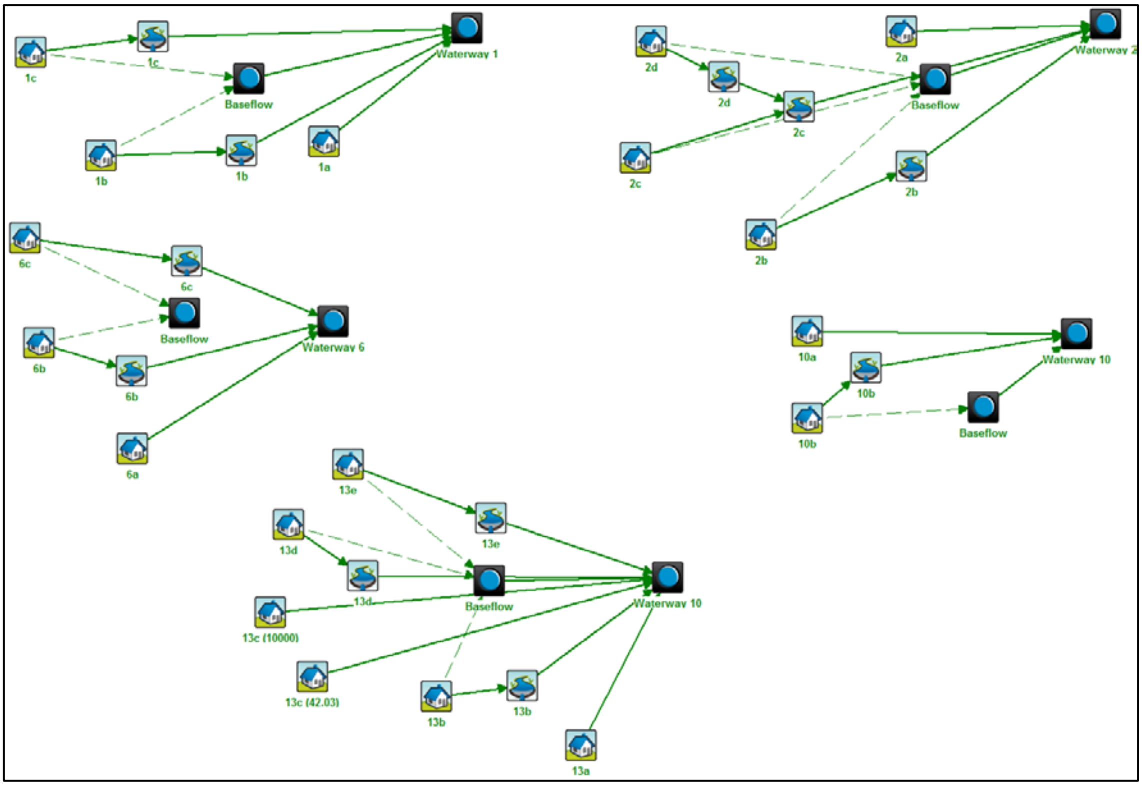


Figure 20 MUSIC model layout – developed conditions model 2



3.5.4 Results

Runoff to receiving waterways

The catchment has a high percentage (98 percent) of pervious surfaces and therefore runoff estimates are highly dependent on the assumptions of pervious rainfall-runoff parameters presented in Table 8.

Table 9 summarises the annual runoff for each sub catchment for dry (2005) and wet (2010) years and average of the simulated 10 year period (2003-2012). There is a relatively large difference between flows for each of these climate scenarios. The relative difference between existing and developed conditions is the same as the difference in catchment area shown in Table 7 as the runoff is proportional to the catchment size, where all other parameters (rainfall-runoff parameters) remain the same. For waterways 1, 2, 6, 10 and 13 there is an additional reduction in runoff resulting from the subsidence ponds which result in losses from infiltration and evapotranspiration.

The results that include the flow reduction due to subsidence presented in Table 9 are a “worst-case” scenario as the concept design of the internal site drains allows for the draining of the subsidence areas and therefore there will be limited ponding or reduction of flow due to ponding.

Table 9 Impacts to flow for each receiving waterway

	Existing conditions			Developed conditions					
	Annual runoff (ML/y)			Annual runoff (ML/y)					
Receiving Waterway Ref. no.	Dry year (2005)	Wet year (2010)	Average (2003-2012)	Dry year (2005)	Wet year (2010)	Average (2003-2012)	Reduction from subsidence ponds (ML/y)	Adjusted average annual runoff (2003-2013) considering subsidence ponds (ML/y)	Relative Change (%)
1	52	1,164	519	611	13,613	6,068	1,970	4,098	690%
2	2,239	49,882	22,234	1,144	25,501	11,366	1,590	9,776	-56%
3	599	13,344	5,948	167	3,721	1,659	n/a	1,659	-72%
4	352	7,848	3,498	145	3,240	1,444	n/a	1,444	-59%
5	58	1,288	574	29	650	290	n/a	290	-49%
6	309	6,876	3,065	242	5,396	2,405	267	2,138	-30%
7	157	3,494	1,557	157	3,494	1,557	n/a	1,557	0%
8	658	14,659	6,534	658	14,659	6,534	n/a	6,534	0%
9	320	7,140	3,183	320	7,140	3,183	n/a	3,183	0%
10	145	3,231	1,440	123	2,740	1,221	739	482	-67%
11	361	8,039	3,583	178	3,955	1,763	n/a	1,763	-51%
12	1,702	37,920	16,902	91	2,017	899	n/a	899	-95%
13	724	16,123	7,186	1,899	42,324	18,865	1,900	16,965	136%
Total	7,675	171,009	76,224	5,765	128,451	57,254	6,466	50,788	-33%

Table 10 Existing conditions runoff (average 2003-2013) (ML)

Receiving waterway no.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	Mega litres												
1	180	149	97	23	6	5	9	2	5	11	14	18	519
2	7,703	6,372	4,175	975	257	209	390	87	201	481	621	763	22,234
3	2,061	1,705	1,117	261	69	56	104	23	54	129	166	204	5,948
4	1,212	1,003	657	153	40	33	61	14	32	76	98	120	3,498
5	199	165	108	25	7	5	10	2	5	12	16	20	574
6	1,062	878	576	134	35	29	54	12	28	66	86	105	3,065
7	540	446	292	68	18	15	27	6	14	34	43	53	1,557
8	2,264	1,873	1,227	287	76	62	115	25	59	141	182	224	6,534
9	1,103	912	598	140	37	30	56	12	29	69	89	109	3,183
10	499	413	270	63	17	14	25	6	13	31	40	49	1,440
11	1,242	1,027	673	157	41	34	63	14	32	77	100	123	3,583
12	5,856	4,844	3,174	741	195	159	296	66	153	365	472	580	16,902
13	2,490	2,060	1,349	315	83	68	126	28	65	155	201	247	7,186
Total	26,409	21,845	14,314	3,343	881	718	1,336	297	691	1,648	2,127	2,615	76,224

Table 11 Developed conditions runoff (average 2003-2013) (excluding influence of subsidence ponds)

Receiving waterway no.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
	Mega litres												
1	2,102	1,739	1,139	266	70	57	106	24	55	131	169	208	6,068
2	3,938	3,258	2,134	498	131	107	199	44	103	246	317	390	11,366
3	575	475	311	73	19	16	29	6	15	36	46	57	1,659
4	500	414	271	63	17	14	25	6	13	31	40	50	1,444
5	100	83	54	13	3	3	5	1	3	6	8	10	290
6	833	689	452	105	28	23	42	9	22	52	67	83	2,405
7	540	446	292	68	18	15	27	6	14	34	43	53	1,557
8	2,264	1,873	1,227	287	76	62	115	25	59	141	182	224	6,534
9	1,103	912	598	140	37	30	56	12	29	69	89	109	3,183
10	423	350	229	54	14	11	21	5	11	26	34	42	1,221
11	611	505	331	77	20	17	31	7	16	38	49	60	1,763
12	312	258	169	39	10	8	16	4	8	19	25	31	899
13	6,536	5,407	3,543	827	218	178	331	74	171	408	527	647	18,865
Total	19,837	16,409	10,751	2,511	662	539	1,004	223	519	1,238	1,598	1,964	57,254

Subsidence ponds assessment

103 individual ponds were identified in this assessment. As described above ponds in series within the same sub catchment were aggregated to represent the combined storage volume and surface area. Table 12 summarises the inputs to MUSIC to represent the subsidence ponds.

Table 12 Subsidence pond sub catchments and aggregated pond volumes and surface area

Sub catch.	Sub catchment Area (ha)	Receiving Waterway	Aggregated Pond Volume (m^3)	Aggregated Pond Surface Area (m^2)
1a	1,152	1	no ponds	
1b	1,557	1	832,100	759,428
1c	2,623	1	930,519	1,024,370
2a	6,432	2	no ponds	
2b	144	2	2,348	9,390
2c	1,542	2	519,676	591,193
2d	1,867	2	303,230	482,283
6a	502	6	no ponds, d/s catch	
6b	952	6	1,888,460	1,732,660
6c	660	6	171,058	273,440
10a	508	10	no ponds	
10b	565	10	339,479	325,600
13a	2,305	13	no ponds	
13b	2,507	13	3,418,734	3,904,660
13c	10,042	13	no ponds	
13d	694	13	172,806	324,210
13e	1,027	13	502,605	606,890

3.6 Impacts on surrounding land use

Based on the results of the hydraulic modelling carried out as part of the Project (Mine), there is a slight decrease in flows at the Carmichael River levee for all events due to the decrease in catchment contributing to the Carmichael River at the Project (Mine) site.

The flood levels will increase in height and time of inundation due to the constriction of the Carmichael River caused by the levees and the bridge crossing as discussed in section 3.4.3. However these are not expected to impact on the surrounding land use and the land can continue to be used for cattle grazing irrespective of the increased flood heights.

The diversion drain design, in particular Drain 1 will have a significant impact on flows to Laguna Creek Tributary due to a significant increase in catchment area (1069%). This may have many follow on impacts in that area such as:

- increased erosion
- changes to geomorphology
- increased ponding of water
- changes to permanent habitats and ecology.

For the remaining proposed diversion drains, they generally maintain the connectivity of most of the existing watercourses traversing the mine site from west to east. Whilst most of the redirected water will return to flows within the Carmichael River and other watercourses to the east of the site, the interception of surface water within the mine workings will result in some losses in flows (refer 3.5). This in turn could potentially result in slight reduction in flows available to land users and aquatic ecosystems downstream of the Project (Mine).

The impact of runoff interception is apparent at the eastern boundary of the Project (Mine) as creeks flow through the site from west to east. It is therefore here that the relative reduction in flows would be greater. As the Study Area is relatively remote and undeveloped there are a limited number of roads or other infrastructure routes nearby which could be impacted by afflux. No significant change in existing flood extent or duration is predicted at any existing infrastructure corridors including the Moray-Carmichael Road or Shuttleworth Carmichael Road. The extent of afflux is local to the vicinity of the levees and unlikely to affect existing land use activities within the Study Area, including cattle grazing or homesteads.

3.7 On-site water

There are several types of water streams on the Project (Mine). Each stream has to be conveyed and stored on the site (see Table 13).

Table 13 Project (Mine) water streams

Water stream	Description	Source
Raw water	Raw water is water that is received from an external water supply as an input, is considered clean and has not been used in a task	Pit dewatering (groundwater) River flood harvesting (Belyando River)
Mine affected water	Mine Affected Water (also called worked water) is that which has been through a task and is potentially contaminated by the mining activities	Dewatering of open cut pits and underground workings. CHPP tailings decant dam. Runoff from industrial working areas including the Mine Industrial Area (MIA), the Run of Mine (ROM) coal area, Coal Handling and Processing Plant (CHPP) and the Train the Load Out (TLO) facility.
Sediment affected water	Sediment affected water contains a higher sediment load but has not been directly contaminated by mine activities	Stormwater runoff from disturbed catchments Stormwater runoff from overburden areas
Clean water	Clean water is runoff from undisturbed catchments and will be diverted around the Project. As such clean water is not part of the water balance	Surface runoff from undisturbed catchments
Treated water	Treated water is water that has been treated on site to achieve a particular water quality objective.	Treated raw water
Process water	Process water is that which is used on site to complete a task	Sediment affected water

A schematic representing the water management principles is provided in Figure 21. This schematic also forms baseline input into the water balance modelling (refer SEIS Appendix K2 Water Balance Report).

The following general water management principles are proposed for the Project (Mine):

- Raw water will be delivered and temporarily stored in a raw water dam
- MAW is to be retained on site and stored in the MAW storages that will be designed and managed in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012)
- MAW will, when necessary, be discharged into receiving waterways from the centrally located MAW collection storages (central MAW storages) one for north and the other for south of the Carmichael River. Discharges will be in accordance with relevant licence conditions under the Environmental Authority. The aim is not to discharge into the river system except during extreme climatic circumstances in which the AEP of the storm event exceeds the design parameters adopted.
- Runoff from disturbed catchments (SAW) has to be treated to achieve minimum reductions in key pollutant levels as per Urban Stormwater Quality Planning Guideline (DERM, 2010) before being reused, discharged into the natural environment (in accordance or it is considered MAW. Discharges will be in accordance with relevant licence conditions under the Environmental Authority. The aim is not to discharge into the river system except during extreme climatic circumstances in which the AEP of the storm event exceeds the design parameters adopted.
- Clean water runoff from undisturbed catchments is diverted around any mine workings or disturbed areas and released downstream into the same waterway where possible
- Mine workings are protected from local stormwater runoff and regional flooding
- Any controlled discharges are in accordance with Environmental Authorities licence conditions
- Acid Mine Drainage (AMD) water needs to be treated through neutralisation processes in the sediment basins of the MAW storages. The nature of treatment will depend upon the water quality
- Each pit area and associated overburden area and disturbed areas are protected from overland floods by a levee with a design height equivalent to a 1 in 1,000 year ARI flood level. Within those protected areas the pit will be specifically protected by a bund directly upstream of the highwall (refer to Figure A0 in Appendix A for the levee locations)
- Upstream (clean water) runoff is directed around the protected areas and will be diverted around the mine site to minimise the site water inventory and maintain pre-development discharges into Carmichael River
- Clean water catch drains will be developed to divert runoff from minor catchments around the mine site, where practical. Catch drains have been considered when delineating catchments, but have not been designed as part of the water management system. The size of catch drains will be considered further during detailed design. (refer to the Conceptual Flood Mitigation and Creek Diversion Design report)

- Each overburden area has a dedicated sedimentation basin that treats runoff to clean water. It concerns the overburden areas for pit B, C, F and G
- In the overburden areas of pit D and E dry tailings will be placed. The sediment basins for these overburden areas are sized as a MAW storage due to potential water quality issues
- Potentially disturbed areas upstream of the pits (on the advancing site of the highwall) are confined and protected by a levee in order to minimise any sediment affected water entering the natural waterways. Sediment affected water (SAW) (runoff) in these areas will be collected in sumps from which water will be transferred to the central process water storages. Controlled discharges from SAW dams may also be required.
- On both sides of the Carmichael River water from disturbed areas is collected in a central process water dam from which water will be extracted for dust suppression or coal washing
- Each pit has a dedicated MAW storage at the far end of the highwall. Inflows (both rainwater and groundwater) to the pit areas will be pumped to these dedicated MAW storages from which the MAW will be pumped to two central MAW storages
- MAW water from the underground workings is also pumped to the pit MAW storages, from which this MAW is also directed to the central MAW storages
- On the north and south side of the Carmichael River is a central MAW storage in which all MAW water on site is stored. These two storages also function as the dedicated discharges points for MAW, if required
- Raw water is stored in two storages of 1 GL each, one (1) north and one (1) south of the Carmichael River.

3.8 Dam storage allowances (DSA)

This dam storage allowance is associated with the hazard category of a particular dam. The *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (DERM, 2012) informs how to establish the hazard category. A preliminary hazard assessment in accordance with the Manual has been performed for the following dams:

- The central MAW dams where all MAW from the site will be collected
- The dams that capture the runoff in the overburden dams of pits D and E as it is understood that tailings and rejects are likely to be placed within these overburden areas.

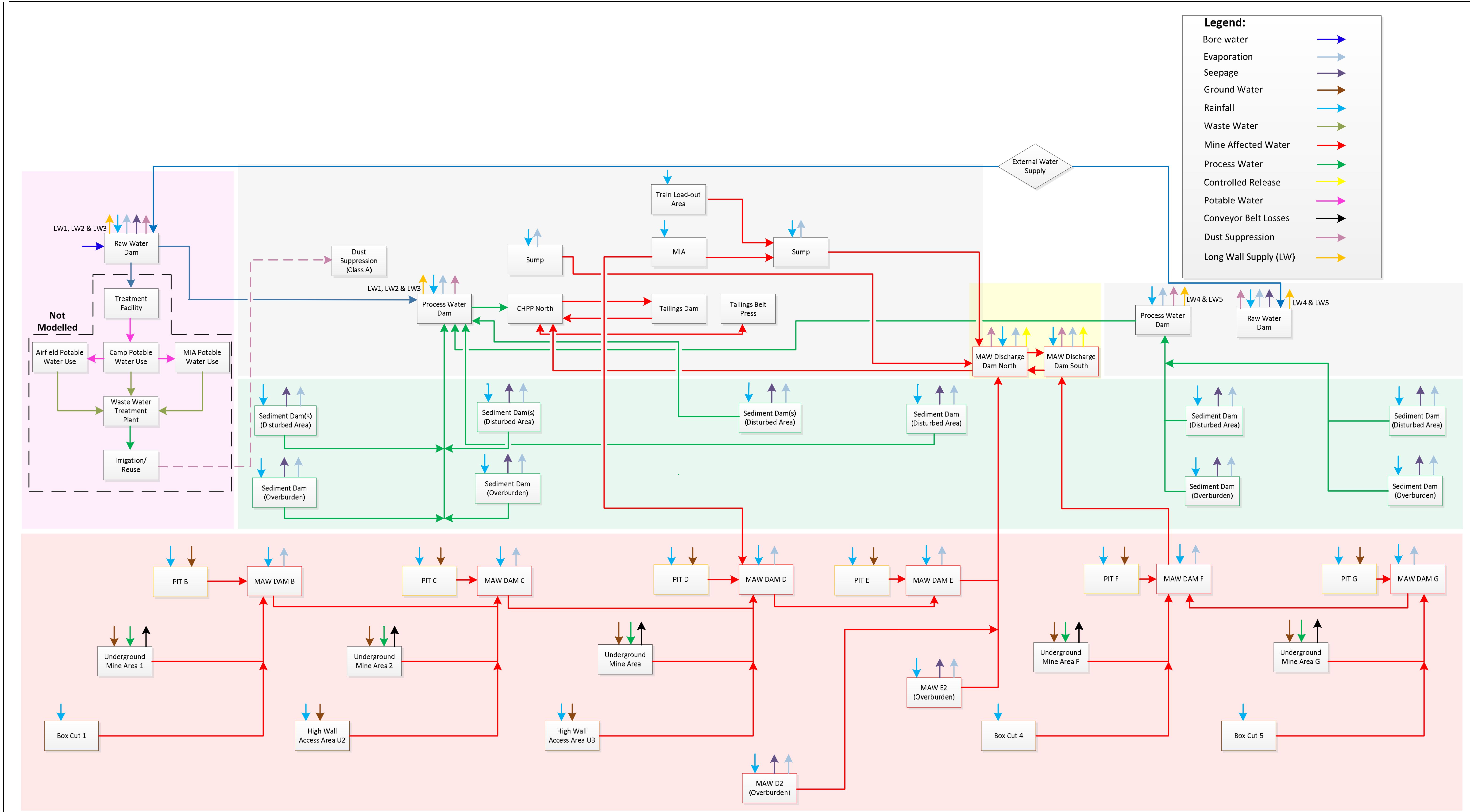
The preliminary hazard assessment for the central MAW dams assumes that each dam will maintain a Hazard Category of high and thus need to be designed to withhold a 1 in 100 year AEP event. Section 2.2.2 of the Manual states that two approaches are available for the assessment of DSA. These comprise the ‘Method of Deciles’ and the ‘Method of Operational Simulation for Performance Based Containment’ as detailed in Appendix A of the Manual. The ‘Method of Operational Simulation …’ is a water balance approach based on a series of historical rainfall data (in excess of 100 years) which is assumed to be representative of the extremes in climate that could occur at the site. This approach accommodates the occurrence of a range of individual storm event magnitudes and storm sequences together with operational variations in storage prior to and during storm events. It therefore allows a more detailed representation of the operational performance of the system compared to the alternative approach based on the ‘Method of Deciles’. This methodology has been applied for the central MAW dams, i.e. DSA is included in the presented dam dimensions.

The ‘Method of Deciles’ provides a more conservative estimate of the DSA given its reliance on the total volume of a wet season rainfall without losses and a disregard of system operation during the course of the wet season rainfall. This methodology has been applied for the overburden MAW dams as these are not sized within the water balance.

Both overburden MAW dams have been assumed to have a significant hazard category. This assumption is solely based on the understanding tailings and rejects materials will be placed in the overburden areas for these two pits. While this material is placed it will be exposed to rainfall events meaning that runoff potentially contains contaminants associated with the mining activities. The dam itself will be built as a sump (below natural ground level), hence the risk of a dam break failure is considered minimal. The Manual specifies for a significant hazard category a 1:20 AEP event (5 percent AEP).

Model (operational) rules allow for the MAW in the overburden MAW dams to be pumped, when available, directly into the north central MAW dam, henceforth ensuring that the allocated DSA volume is available within in each dam on 1 November each year. A hazard assessment for all dams on site will be required during future design stages. Note that for dams without an actual catchment, like the MAW transfer dams, allowing for the DSA will be a matter of increasing the storage depth.

Therefore the MAW storages are not expected to overflow or break during the life of the mine and release contaminants into the environment.



No	Revision	Drawn	Checked	Approved	Date
A	INITIAL SETUP OF WATER BALANCE				

Note: * indicate signature on original issue of drawing or last version of drawing

GHD CLIENTS | PEOPLE | PERFORMANCE

Level 4, 201 Charlotte St Brisbane QLD 4000 Australia
GPO Box 668 Brisbane QLD 4001
T 61 7 3316 3000 F 61 7 3316 3333
E bnemail@ghd.com.au W www.ghd.com.au

DO NOT SCALE

Drawn By Shaun Kelly
Designed
Drafting Check
Design Check
Approved
Date
Scale NTS

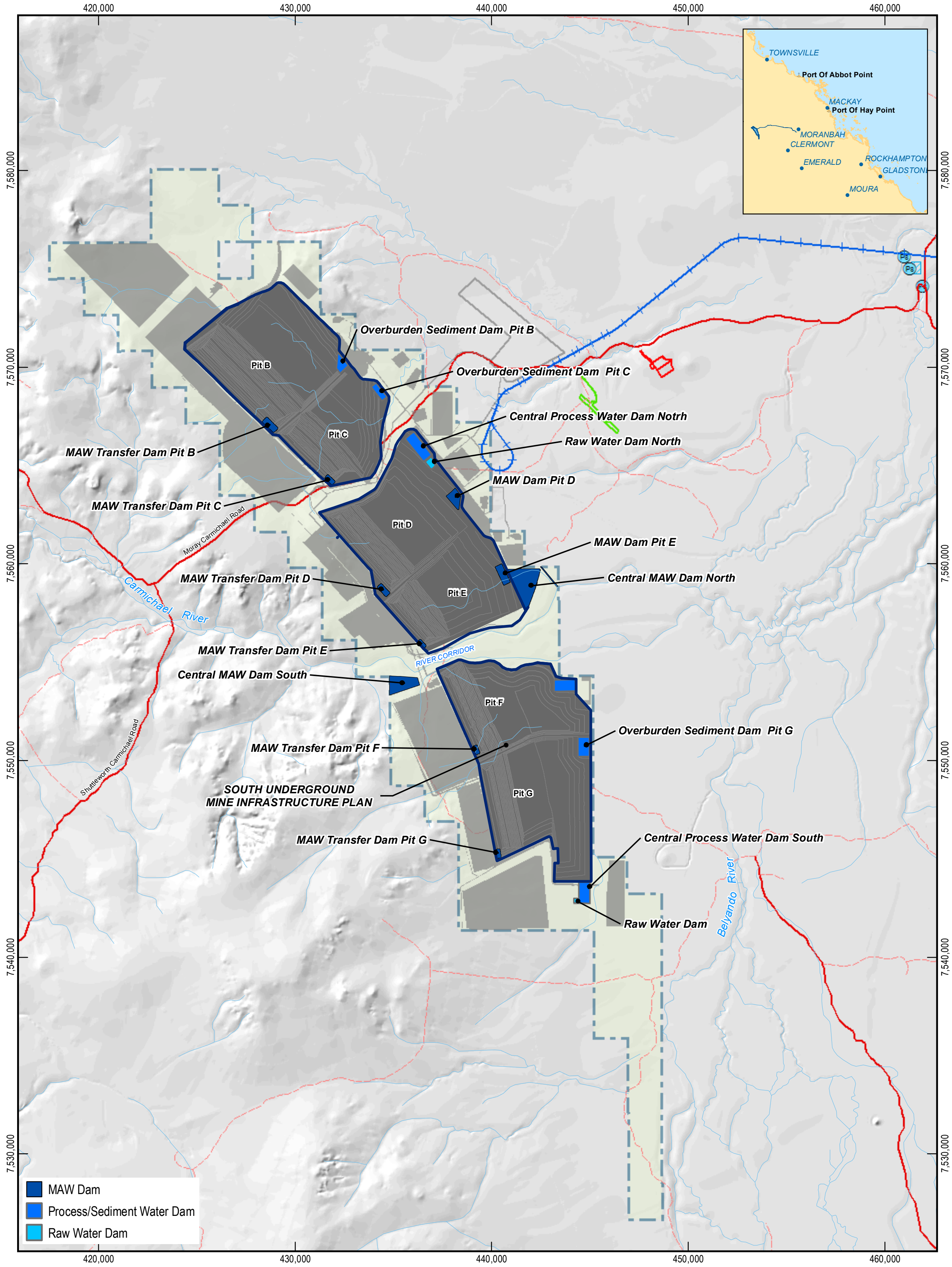
This Drawing must not be used for Construction Unless signed as approved

Client: ADANI MINING PTY LTD
Project: CARMICHAEL COAL MINE PROJECT
Title: WATER BALANCE SCHEMATIC

Original Size A3

Figure 21

Rev: A



LEGEND

- Minor Road
- Track
- Watercourse
- Flood Protection Bund
- Rail (West)
- Mine Site
- Mine Layout
- Pit Area
- Mine (Offsite)
- Pump Station
- Storage Facility (Offstream)
- Airport
- Industrial Area
- Accommodation Village

Based on or contains data provided by the State of QLD (DERM) [2010]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:275,000 (at A4)

0 2 4 6 8 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number	41-26585
Revision	B
Date	25-10-2013

On-site Water Storages and Bunding

Figure 22

G:\41\26585\GIS\Maps\MXD\41_26585_bunds_FigA0_rev_b.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: GA: Road, River / Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Mine Layout / Infrastructure (2013), Mine (Offsite) (2013). Created by: MS

3.8.1 Impacts of on-site water storages

The following storages (dams) will be located on site:

- Central MAW dams
- Central process water dams
- MAW transfer dams
- Overburden MAW dams have been sized equal to the DSA
- Overburden sediment dams
- Disturbed area sediment basins
- Raw water dams.

The sizing of the dams was optimised in the water balance model with the exception of the sediment dams/basin, the results of which can be found in Table 15.

Sediment dams and basins

Sediment dams can be found in both the overburden areas and the disturbed areas for each pit. For both situations the sediment dams are sized using the design criteria in the point below. The size of the catchment areas for the overburden dams and the disturbed area basins change over time with the disturbed areas decreasing over time and the overburden areas increasing over time. This is illustrated in

Figure 23.

The width of disturbed soil adjacent to each pit at the mine site regresses over the life of the mine at a rate of approximately 50 linear metres per year. As such, the area of disturbed soil adjacent to each pit is systematically reduced over the life of the mine.

The following assumptions were used to calculate a total required storage volume for the sediment basins/dams, in 1 year increments for the disturbed areas and 5 year increments for the overburden areas. This approach is expected to reflect actual mine operations as the sediment basins for the disturbed areas need frequent relocating due to pit progress, while the overburden sediment dams are fixed in location.

- Design rainfall event: 1 in 20 year ARI, 24 event
- Design rainfall depth: 6.77 mm/hr (over 24 hours)
- Runoff coefficient: 0.2 (20 percent of all rainfall reflecting relatively large catchment areas)
- Maximum basin width (disturbed area sediment basins): 80 m

Table 14 shows the maximum expected basin sizes for the disturbed areas. When these sediment basins overflow the water will drain into the corresponding pits. This design results in a negligible possibility of the sediment affected water being released to the environment. If required, controlled discharges to the environment will be undertaken in accordance with licence conditions under the Environmental Authority.

Table 15 shows the maximum basin sizes for the overburden sediment dams

Table 14 Disturbed area and corresponding maximum basin size

	Disturbed Area (ha)	Sediment Basin Storage Volume (ML)
Pit B	6.3	1,258
Pit C	3.0	602
Pit D	5.0	1,002
Pit E	4.4	883
Pit F	3.4	671
Pit G	3.4	670

Figure 23 Concept mine schematic for pits B-C-F and G

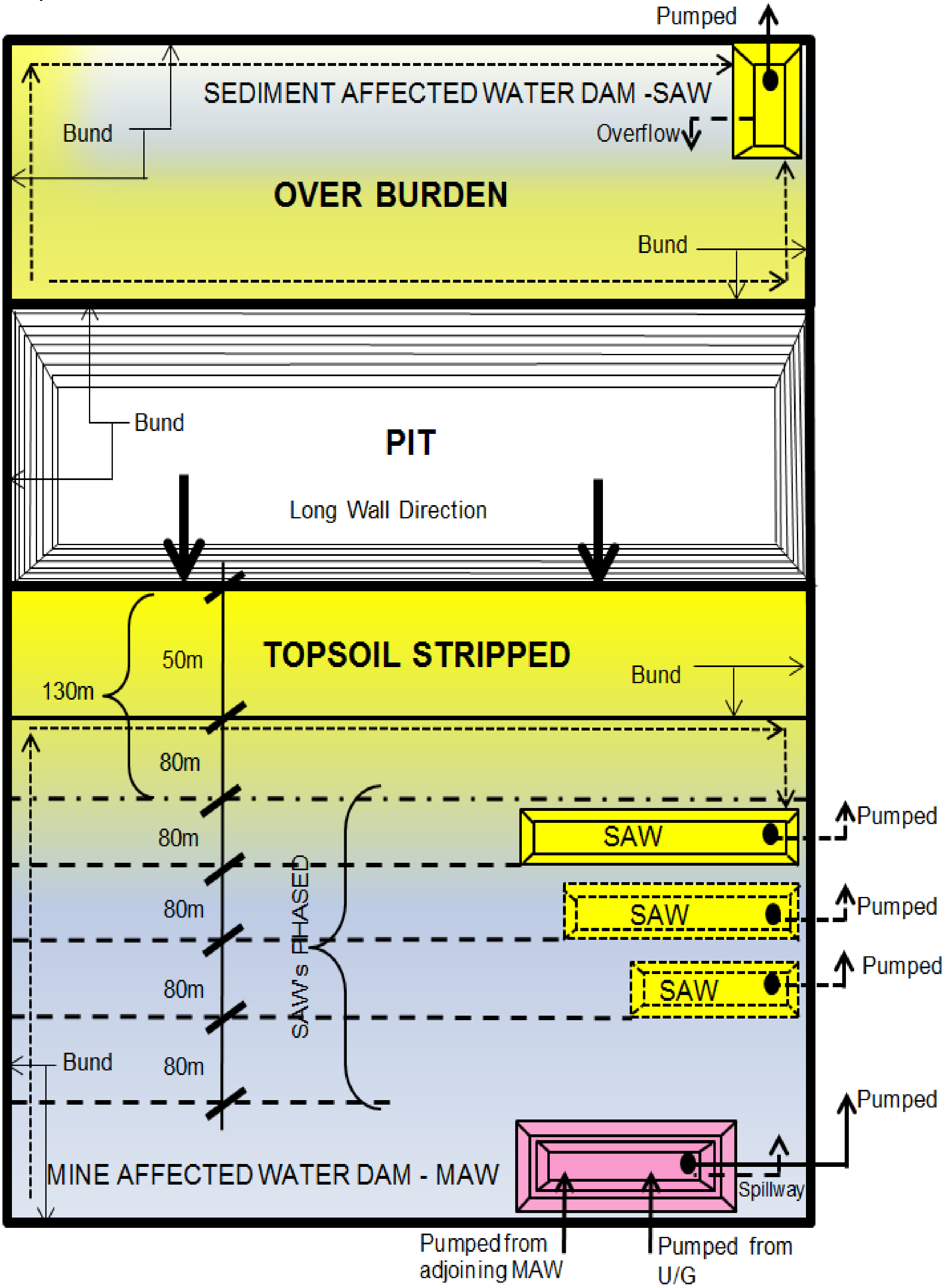


Table 15 Summary of water storage sizes

Dam	Required Volume (m^3)	Footprint Length (m)	Footprint Width (m)	Footprint Area (m^2)	Storage Depth (m)	Water Surface Area (m^2)
MAW Transfer Dam Pit B	200,000	191	191	36,481	13.4	25,728
MAW Transfer Dam Pit C	350,000	240	220	52,984	17.0	36,764
MAW Transfer Dam Pit D	600,000	335	235	78,953	18.4	55,292
MAW Transfer Dam Pit E	900,000	415	255	105,557	20.6	74,029
MAW Transfer Dam Pit F	650,000	356	236	84,016	18.4	59,100
MAW Transfer Dam Pit G	450,000	285	225	64,227	17.3	44,810
Central Process Water Dam North	3,000,000	593	413	244,909	27.5	172,525
Central Process Water Dam South	2,000,000	861	311	267,771	11.0	217,056
MAW Main DAM - North	8,000,000	-	-	695,810	15.9	574,709
MAW Main DAM - South	7,000,000	-	-	680,917	13.9	571,861
Raw Water Dam North	1,000,000	341	321	109,461	24.0	74,976
Raw Water Dam (South)	1,000,000	404	379	152,959	10.4	122,274
Overburden Sediment Dam Pit-B	744,505	656	200	131,121	10.0	131,121
Overburden Sediment Dam Pit-C	411,735	389	200	77,878	10.0	77,878
Overburden Sediment Dam Pit-F	565,468	348	400	139,276	5.0	139,276
Overburden Sediment Dam Pit-G	867,022	515	400	205,826	5.0	205,826
MAW Dam Pit D	13,660,000	1,197	600	718,414	20.0	718,414
MAW Dam Pit E	11,250,000	1,500	400	600,000	20.0	600,000

3.8.2 Storage Overflows

In the case of an overflow most of the dams will discharge inside the bunded area (refer Figure 22 and Table 16). The dams have been designed with the criteria in the following sections.

Table 16 Overflow locations for on-site water storages

Water storage	Within 1 in 1,000 year mine area bund	Receiving Waterway (Immediate)	Receiving Waterway (Downstream)
Overburden Sediment Dam (OBSD)			
OBSD Pit B	Yes	Unnamed Tributary/ Pear Creek	Eight Mile Creek
OBSD Pit C	Yes	Unnamed Tributary	Eight Mile Creek
OBSD Pit F	Yes	Cabbage Tree Creek	Cabbage Tree Creek
OBSD Pit G	Yes	Belyando	Belyando
Central Process Water Dam (CPWD)			
CPWD North	Yes	Carmichael River	Carmichael River
CPWD South	No	Unnamed	Unnamed
Raw Water Dam (RWD)			
RWD North	Yes	Obungeena Creek	Obungeena Creek
RWD (South)	No	Unnamed Tributary	Belyando
Central MAW Dams (CMD)			
CMD North	No	Carmichael River	Carmichael River
CMD South	No	Carmichael River	Carmichael River
Transfer Mine Affected Water Dam (MAW)			
MAW Transfer Dam Pit B	Yes	N/A	N/A
MAW Transfer Dam Pit C	Yes	N/A	N/A
MAW Transfer Dam Pit D	Yes	N/A	N/A
MAW Transfer Dam Pit E	Yes	N/A	N/A
MAW Transfer Dam Pit F	Yes	N/A	N/A
MAW Transfer Dam Pit G	Yes	N/A	N/A
MAW Dam Pit D	Yes	Obungeena Creek	Obungeena Creek
MAW Dam Pit E	Yes	Carmichael River	Carmichael River

N/A = The MAW transfer pits only have pumped inflows, no catchment area other than pond area.

Central MAW storages

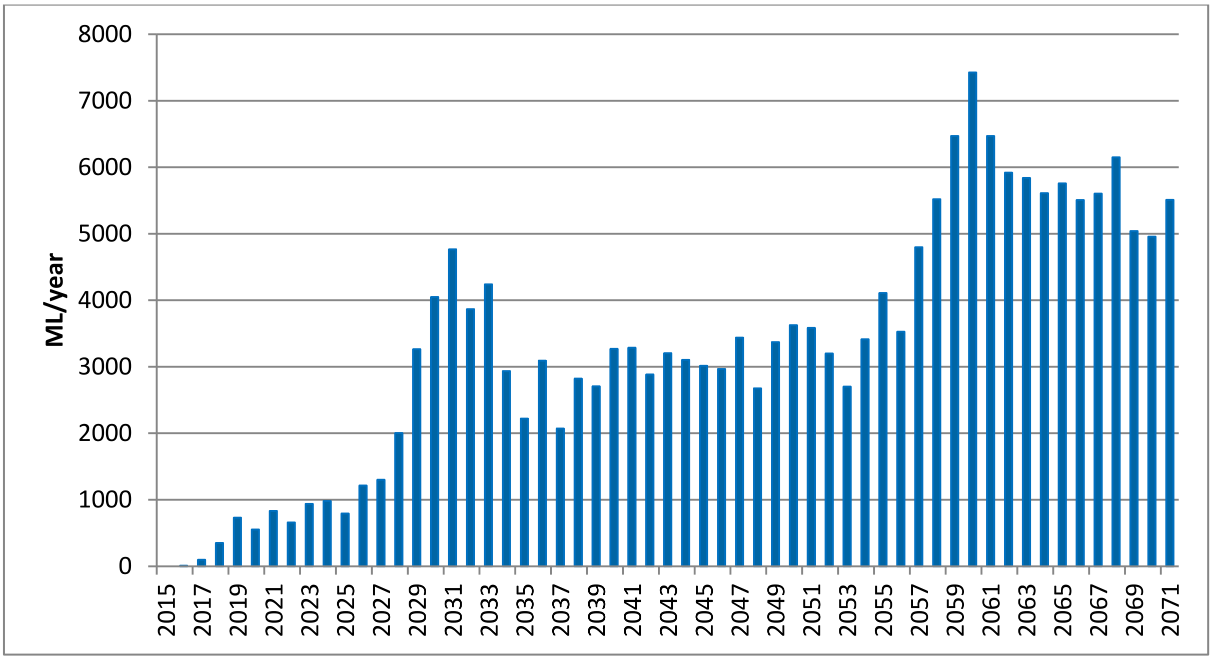
Required volumes for both of the MAW dams were extracted from the water balance model. Conceptual designs were generated for these volumes to accommodate the calculated volumes, including a 0.5 m freeboard and an 8 m crest width to the embankments. Batters for the dams were based on 1 in 3 slopes to all sides. The dams have also been fitted within the allocated dam areas provided in the mine plans. For the Central MAW storages a non-rectangular area is available. Storage curves were developed to provide the relationship between volume of water in the dam and the associated area. This allows for a more accurate prediction of evaporation losses in the dams.

Controlled discharges of MAW are only allowed from the two central MAW dams. The number and frequency of overflows of both dams has been estimated using outputs from the water balance model. As part of the water balance a sensitivity check was performed on the controlled discharge requirements by increasing the sizes of the dams in order to decrease the frequency and volumes of discharges.

Site discharges

Potential discharges to the Carmichael River are presented in Figure 24. Results are presented for the mean situation in order to show potential yearly overflows.

Figure 24 Combined discharges volumes central MAW north & south



The figures above show that further optimisation of the water balance, in particular in regard to discharges, is required during future design stages. Current water balance results show that the applied chemicals to reduce evaporation on the central MAW dams and the central process water dams will not be required continuously. A trigger level in the storages should be identified. This will bring down the frequency and volume of overflows.

Dust suppression requirements for smaller linear infrastructure, among others access roads, is currently not included in the water balance. Henceforth current volumes for dust suppression are conservative. An increase in this demand will reduce potential overflows. Potentially another option to reduce overflows is to increase evaporation losses by increasing the dam areas.

The above presented refinements of the water balance will be undertaken during future design stages. Importantly the water balance shows that potential discharges from the Project are, considering the size of the Project, limited in particular in the first years of the mine operations.

Refer to SEIS Appendix J1 Updated Mine Ecology Report (GHD, 2013) for a discussion on impacts of contaminants on aquatic ecology.

MAW transfer dams

The MAW transfer dams were sized in accordance with expected pump rates of the two input sources (open cut pits and underground mine dewatering). The volume of the dams is equivalent to a 7 day pumping volume, disregarding evaporation and seepage losses. The transfer dams have no catchment and only have pumped inflows. If operated correctly there should be no overflows from these dams.

Overburden MAW dams

Overflows from these dams are unlikely as these dams are sized as per the DSA event. Any MAW entering these dams is pumped into the central MAW dams meaning that overflows are extremely unlikely considering the pump capacities (100 L/s) There is a risk of overflow if the pumps cease to operate and therefore the site operations plan should include an allowance for this type of event in regards to backup pumping facilities.

Sediment dams and basins

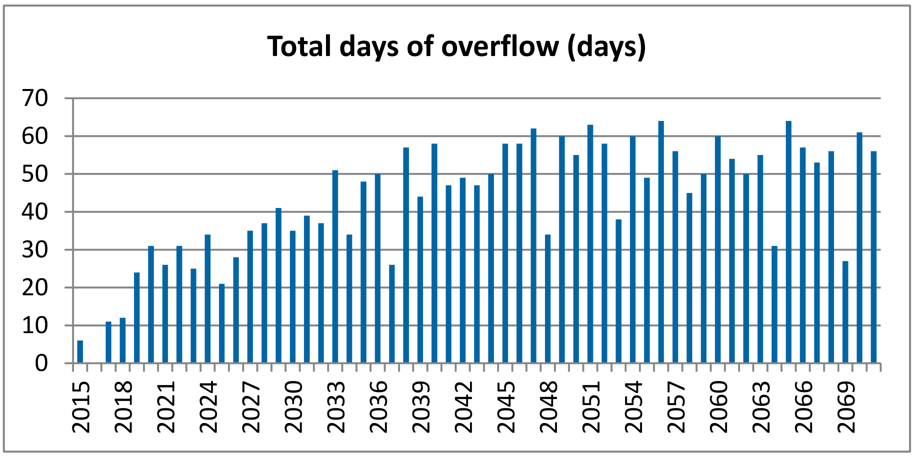
The overburden sediment dams are designed to overflow during more extreme events. In Figure 24 to Figure 27 expected overflows from the overburden sediment dams are presented. The figures show that on average each year some overflows can be expected. While the total overflow volumes seem large it should be kept in mind that the total catchment areas for these dams are significant with the maximum catchment sizes being (year 2071):

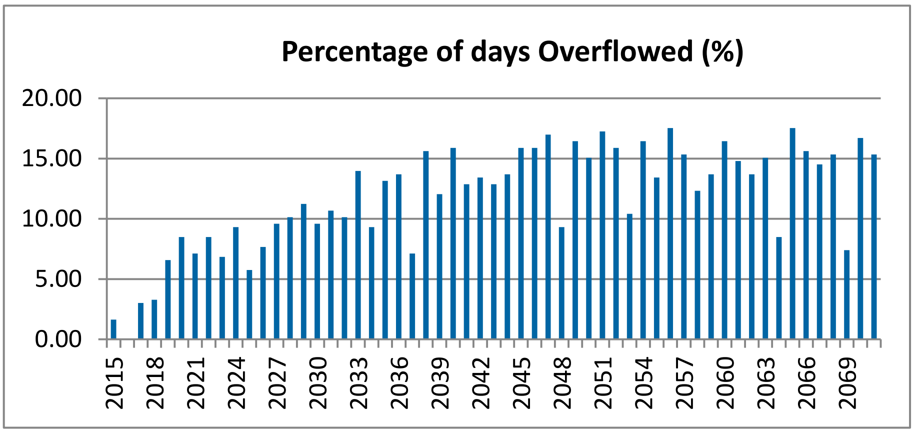
- Pit B: 22.91 km^2
- Pit C: 12.65 km^2
- Pit F: 17.40 km^2
- Pit G: 26.68 km^2

Water quality of overflows is expected to be relatively good, with total dissolved solids (turbidity / sediments) being the critical contaminant. When the basins overflow smaller particles suspended in the water column will leave the basin, however larger particles will settle in the basin. Results are presented for the mean situation in order to show potential yearly overflows.

There may also be a requirement for controlled discharges from these dams. If required, these would be undertaken in accordance with the relevant licence conditions contained in the Mining Environmental Authority. The design of the overburden sediment dams will be revised if necessary design during future design stages to optimise the sizes and to confirm the (treatment) efficiencies.

Figure 25 Overflow data for overburden sediment dam B





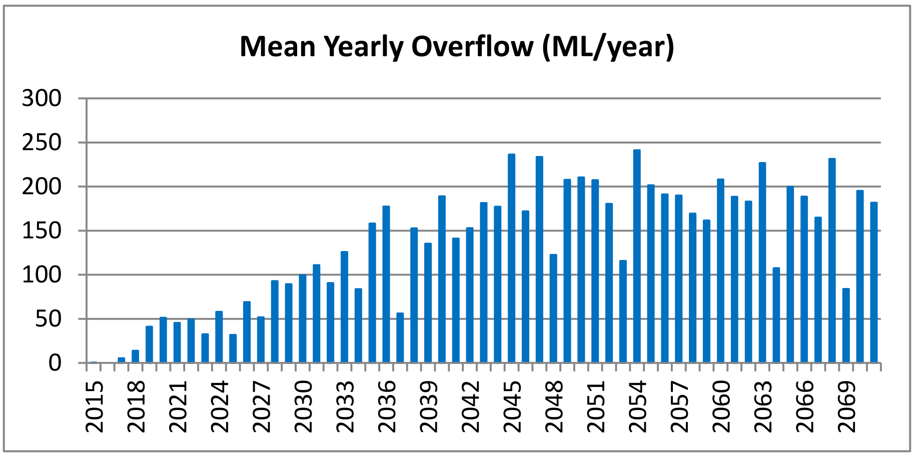


Figure 26 Overflow data for overburden sediment dam C

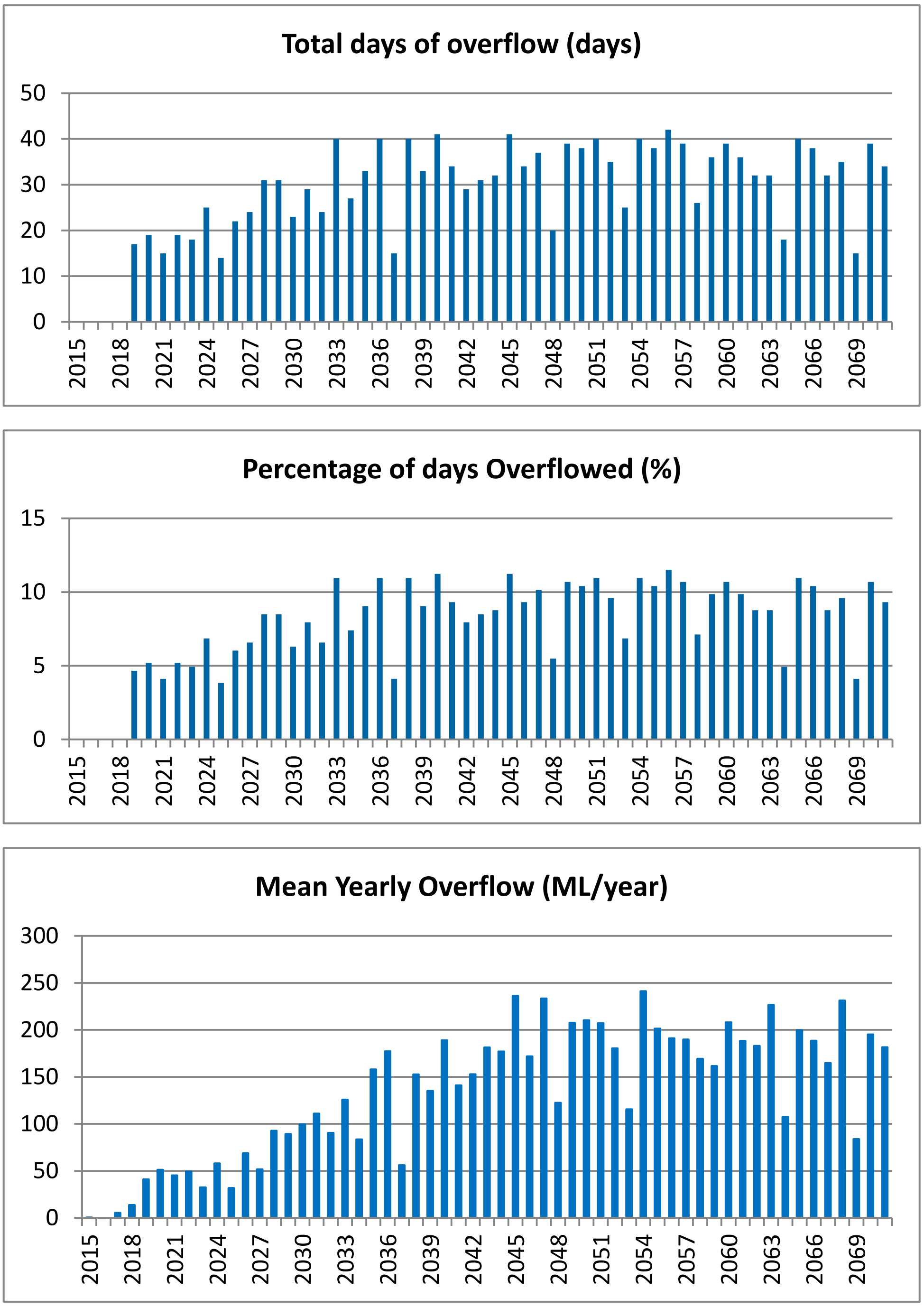


Figure 27 Overflow data for overburden sediment dam F

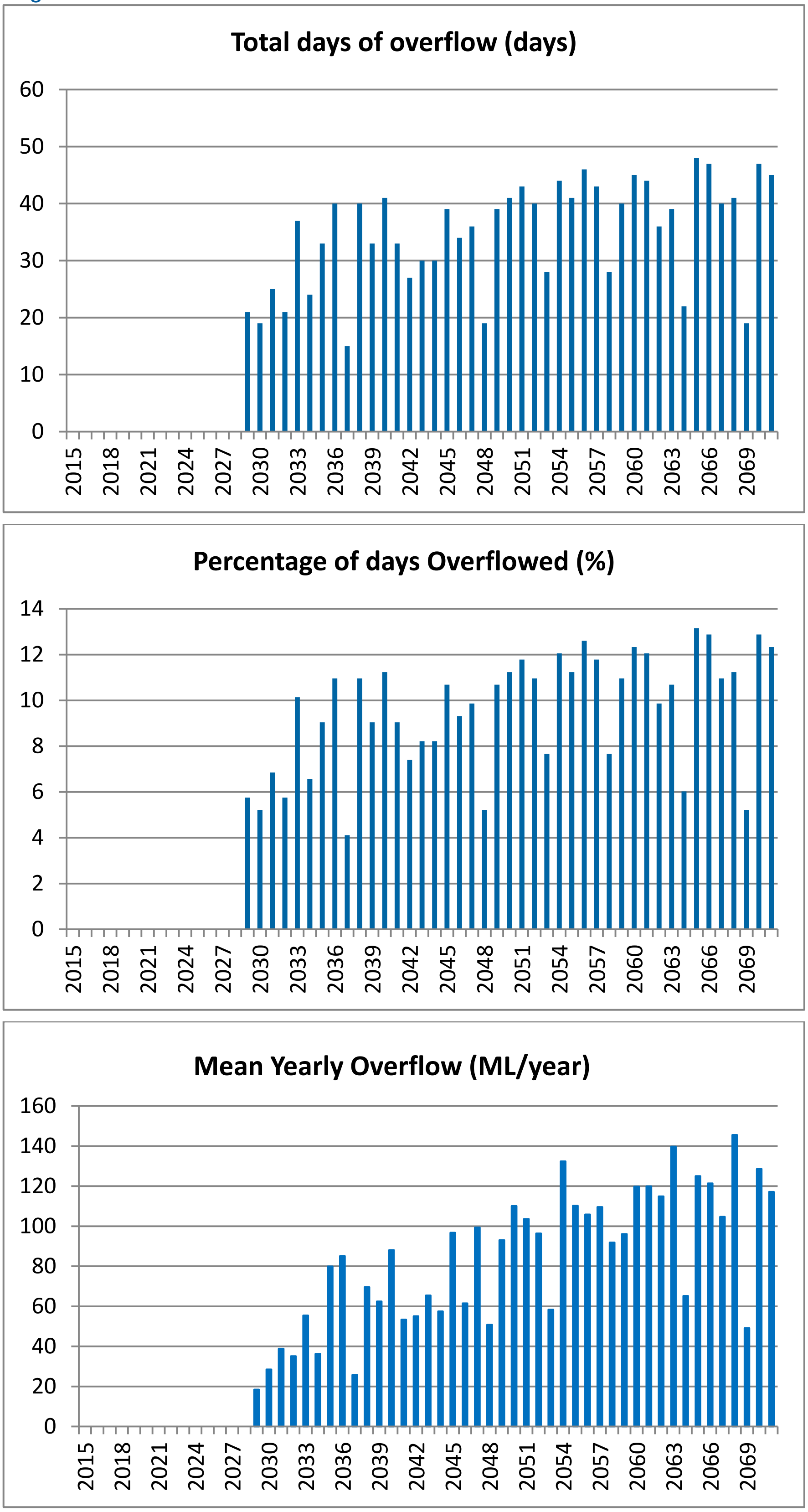
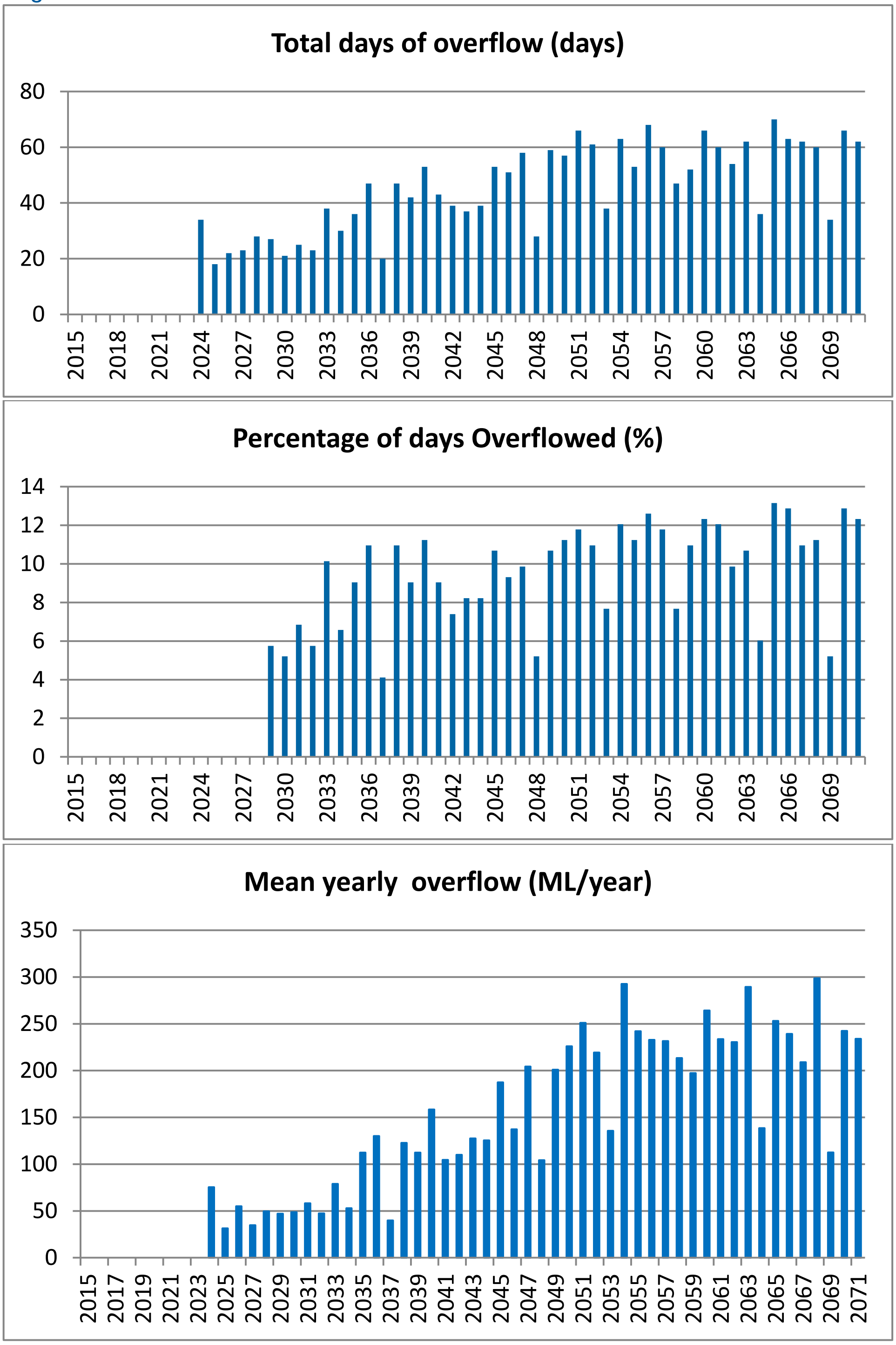


Figure 28 Overflow data for overburden sediment dam G



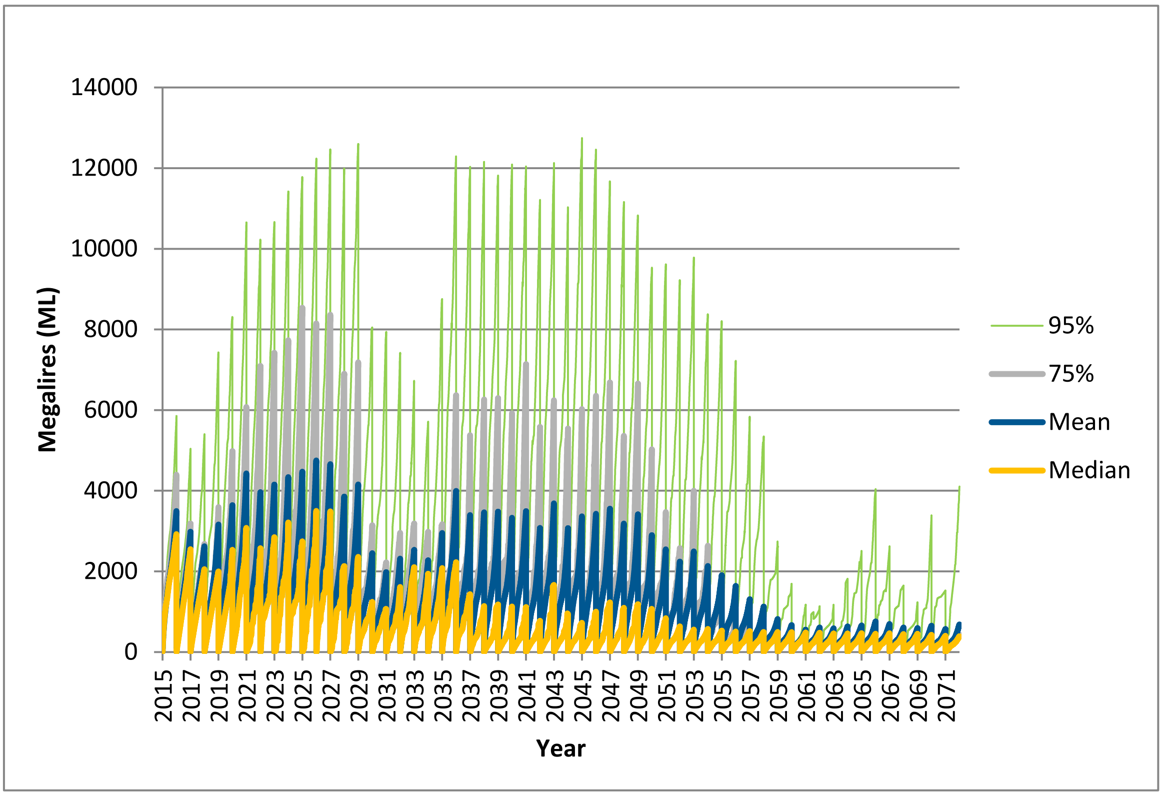
3.9 Impacts of flood harvesting from the Belyando River

Hyder Consulting (2012a) undertook an assessment on the option of river flood harvesting from the Belyando River. River flood harvesting must comply with the following legislation:

- *Water Act 2000*
- *Native Title Act 1993*
- *Sustainability Planning Act 2009*
- *Environmental Protection Act 1994*
- *State Development and Public Works Organisation Act 1971*

It was determined in the Project (Mine) water balance (refer to SEIS Appendix K2 Water Balance Report) that the maximum external raw water demand for the Project is in the order of 12 GL per year with 95 percent reliability (refer Figure 29). It is understood this volume is dependent on raw water supply from offsite raw water infrastructure.

Figure 29 Raw water demand for the Project (Mine)



3.9.1 Stream flow information

Stream flow data is available for the Belyando River at the Gregory Development Road Station (120301B). Data is available for this station from 06/08/1976 to 17/07/2012. The station is located approximately 200 km from the Project (Mine) site and has an upstream catchment area of 35,410 km^2 (DNRM, 2012). As can be seen in Table 17 the monthly mean flow is between 3,826 ML/mth and 190,889 ML/mth. Adopting the monthly mean flow of 54,755 ML/mth, the mean yearly flow can be estimated at 657,060 ML/yr.

Table 17 Flow volume summary Belyando River Station 120301B (ML) (DNRM, 2012)

	Daily				Monthly
Jan	Max	Min	Mean	Median	Mean
Feb	355,455	0	4,727	368	146,527
Mar	131,532	0	6,762	702	190,889
Apr	170,063	0	3,502	242	108,569
May	56,011	0	1,282	12	38,451
Jun	169,262	0	2,152	1	66,718
Jul	19,811	0	486	0	14,566
Aug	5,528	0	123	0	3,826
Sep	11,016	0	151	0	4,640
Oct	12,612	0	203	0	6,095
Nov	34,049	0	381	0	11,816
Dec	51,312	0	962	0	28,827
TOTAL	54,624	0	1,320	131	40,930

It is proposed that water will be extracted via the Strategic Reserve Volume withheld in sub-catchment E of the Burdekin Basin Water Resource Area. The main extraction point will be at the main channel of the Belyando River as it crosses the main access road to the Moray Down property. The upstream catchment area at this crossing is approximately 35,400 km^2 or 70 percent of the total Belyando Basin Catchment area.

Table 18 Reserve volumes – Burdekin Basin Resource Operations Plan (2010)

Sub-Catchment	Reserved Purpose	Mean Annual Diversion (GL)
Burdekin Basin Sub Catchment E	General reserve	130
Burdekin Basin Sub Catchment E	Strategic reserve for state purposes	20
TOTAL		150

The infrastructure requirements for the Belyando River flood harvesting option are:

- River extraction pump station at the Moray Anabranch (Belyando River)
- Access roads
- Storage dam at the existing quarry site
- Transfer pump station adjacent to the quarry storage
- Main storage dam within the mine infrastructure area
- Interconnecting pipelines.

The Belyando River storage dam is an off-stream storage and will be located on the footprint of an old quarry. There would be a 1.1 km pipeline required from the Belyando River pump station to the quarry site storage dam and another 34.1 km of pipeline required from the storage dam (transfer pump station) to the raw water storage dam in the MIA. Pipeline routes have been selected based on length, accessibility, environmental factors and locations of existing and proposed infrastructure. The flood harvesting infrastructure has been located to avoid environmentally significant areas (such as remnant and high value regrowth vegetation) where possible.

The available licence information does not include references to daily, monthly or annual volumetric allowances or maximum diversion (or extraction) rates, making it difficult to make more than generalised assessments of the adverse effects of the disruption of the natural catchments by the Project (Mine) and the discharge of mine process water and runoff on local water users who include the local cattle stations, namely Bygana and Moray Downs. The impact of proposed water extractions for the Project (Mine) from the Belyando River system was assessed by Hyder[3]. This is in line with the requirement of the WRP to limit impacts to existing users on a system.

The proposed operation scenario is based on the ROP model (BH020R.sys) with modifications that are described in subsection below and Table 19 (values from Adani, 2013).

Table 19 Operations scenarios

Case	Belyando River Trigger Flow (ML/day)	Pump Capacity (ML/day)	Maximum volume of extraction (GL/year)	Annual Average (GL)
Case 1	350	340	15	10
Case 2	200	400	12.5	10

The scenarios modelled produced a range of maximum flood harvesting water take from 15,000 ML/a to 10,000 ML/a, for each scenario analysed. Case 2 was structured in a way that the trigger for flood harvesting starts at lower level (200 ML/day) and Case 1 (Hyder's Case) assumes a flow trigger of 350 ML/day. The Belyando River is flood event dependent as shown in Figure 30; with low inflows have occurred every ten years in the simulation period except for the period 1920 to 1950. The case 2 was optimised iteratively (pump capacity and river flow threshold) to provide the maximum yield at the highest probability of exceedance for the cases 1 and 2 undertaken in this study.

Figure 31 shows ranked plots of Belyando River flow at the extraction point for the ROP case and Case 2. The lowest annual water take is recorded during the driest period of 1901 – 02 and late 1920s and late 1940s with the Belyando River recorded minimum or no inflows and the storage volumes for the Burdekin Falls Dam was at the lowest level in the simulation period 1890 – 2004. Figure 31 shows little or no impact occurs for flows up to 350 ML/d and minor impact between 500 ML/d and 1,200 ML/d river flows. Figure 32 shows ranked plots of annual volume of water extractions at Belyando River. This figure shows that the annual volume of water take is 56 percent equal to or exceeded the annual demand (case 1) and 75 percent for case 2, and only 44 percent is less or equal to the current demand for case 1 and 25 percent for Case 2 (Adani, 2013).

Figure 33 shows that the time series of annual water extractions for the two cases. This figure shows the 1901-02 period for the Belyando River flood harvesting was at the lowest annual water take in the simulation period 1890 – 2004.

[3] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report.

Figure 30 Belyando River flows for the simulation period (1890-2004) [Adani, 2013]

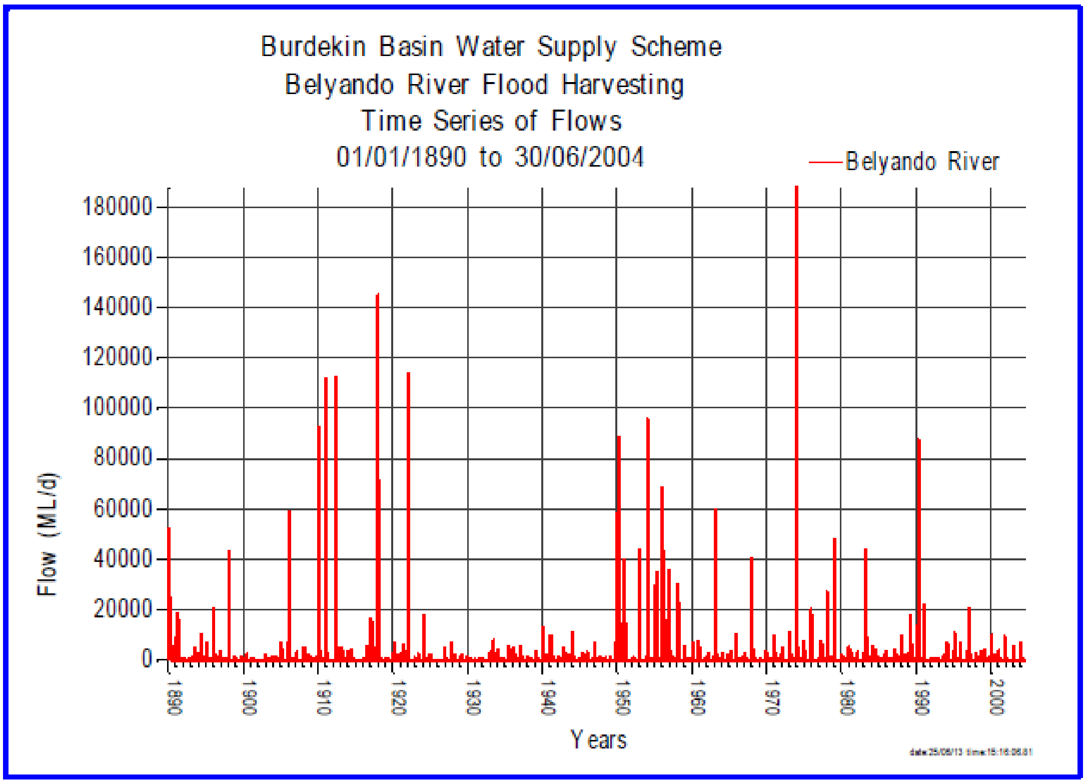


Figure 31 Flow duration at Belyando River (1890-2004)[Adani, 2013]

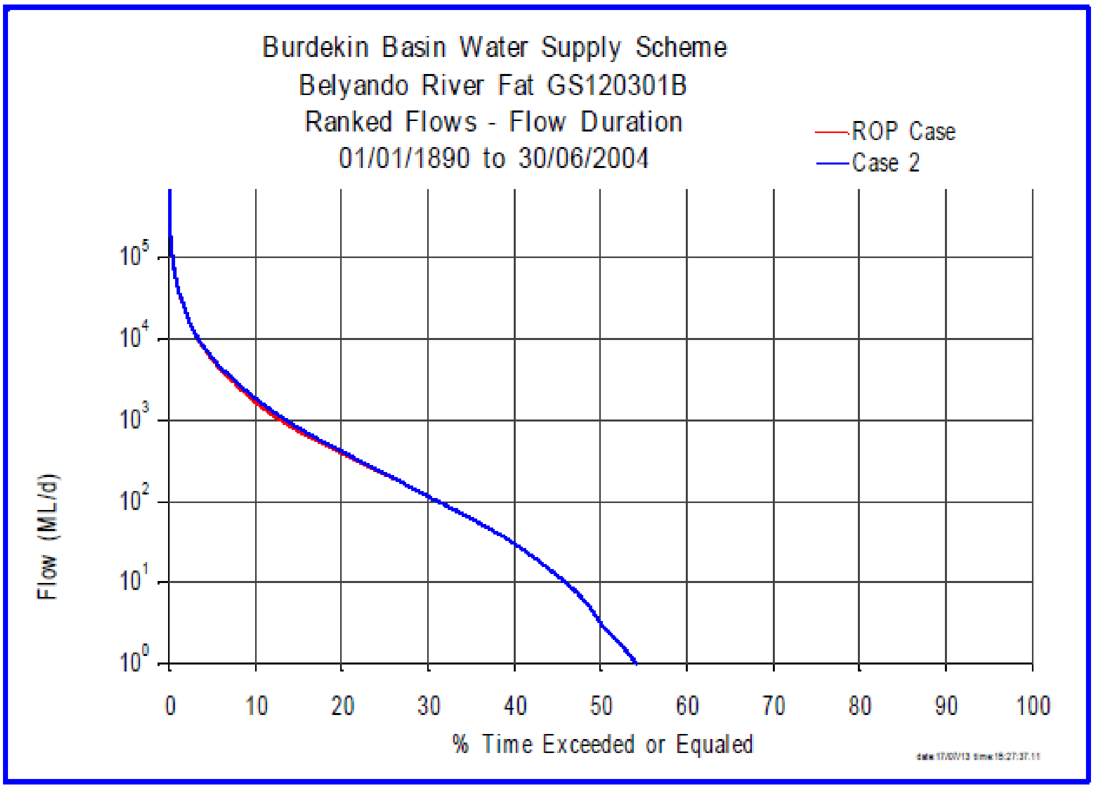


Figure 32 Annual maximum extractions at Belyando River (1890-2004) [Adani, 2013]

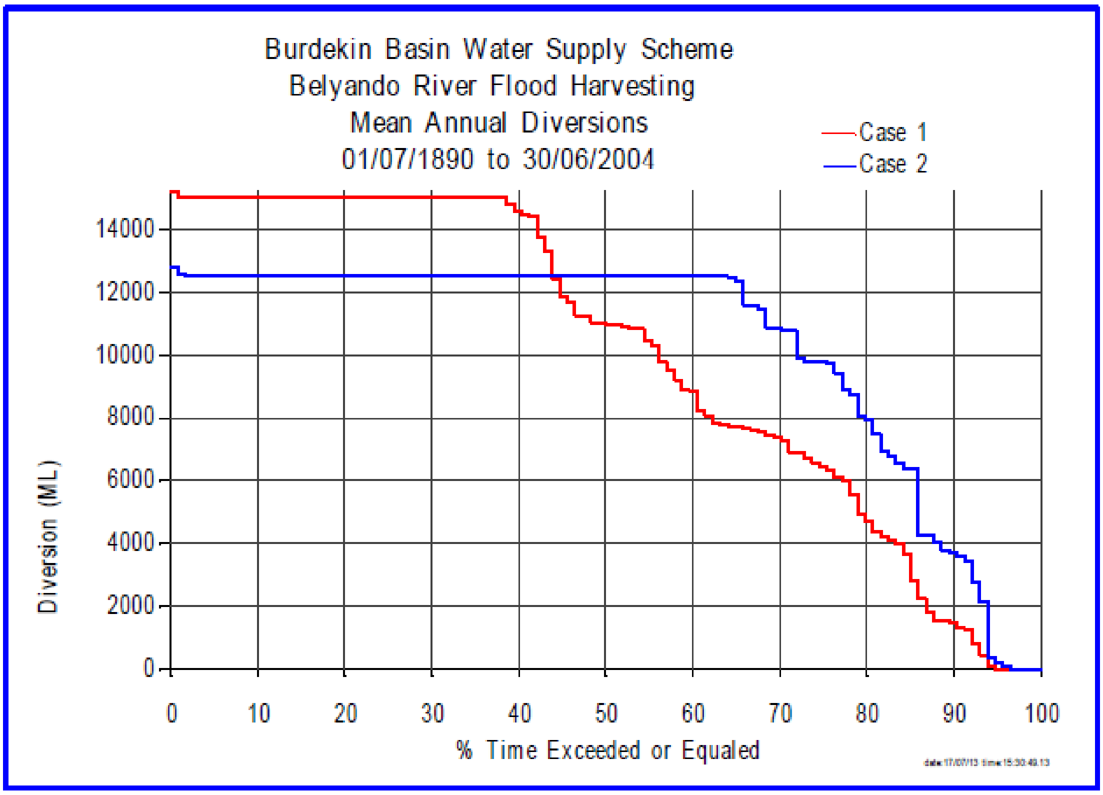
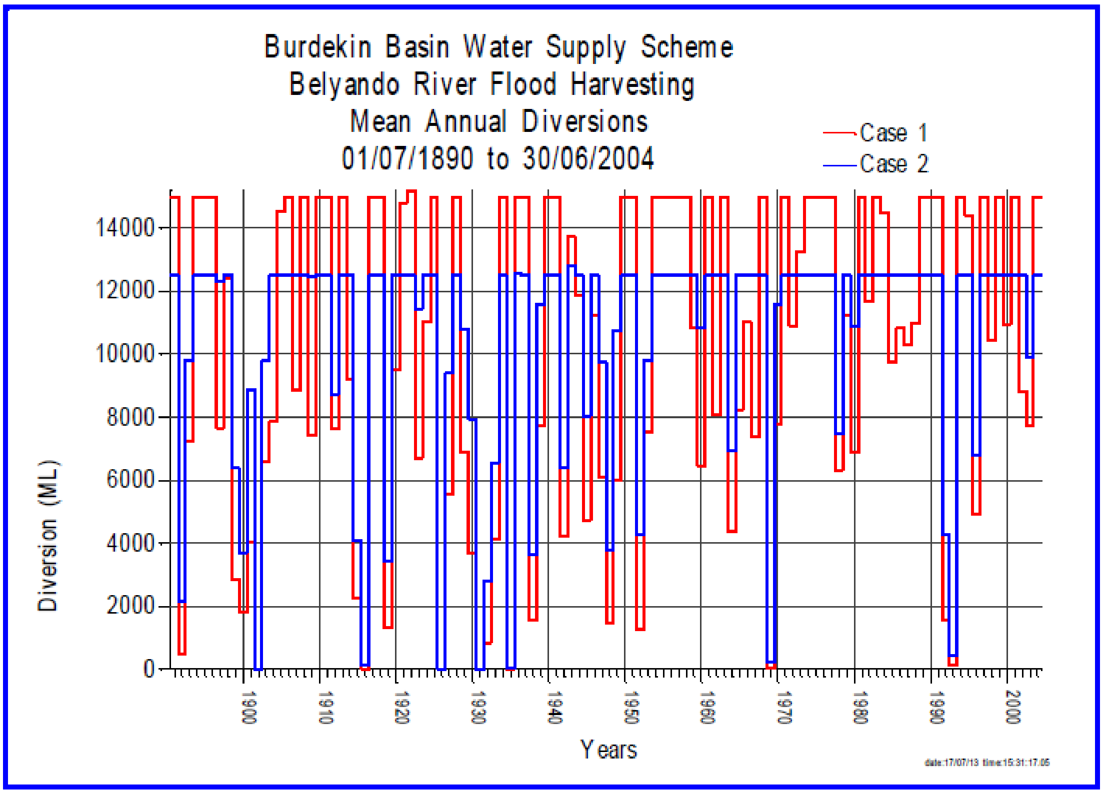


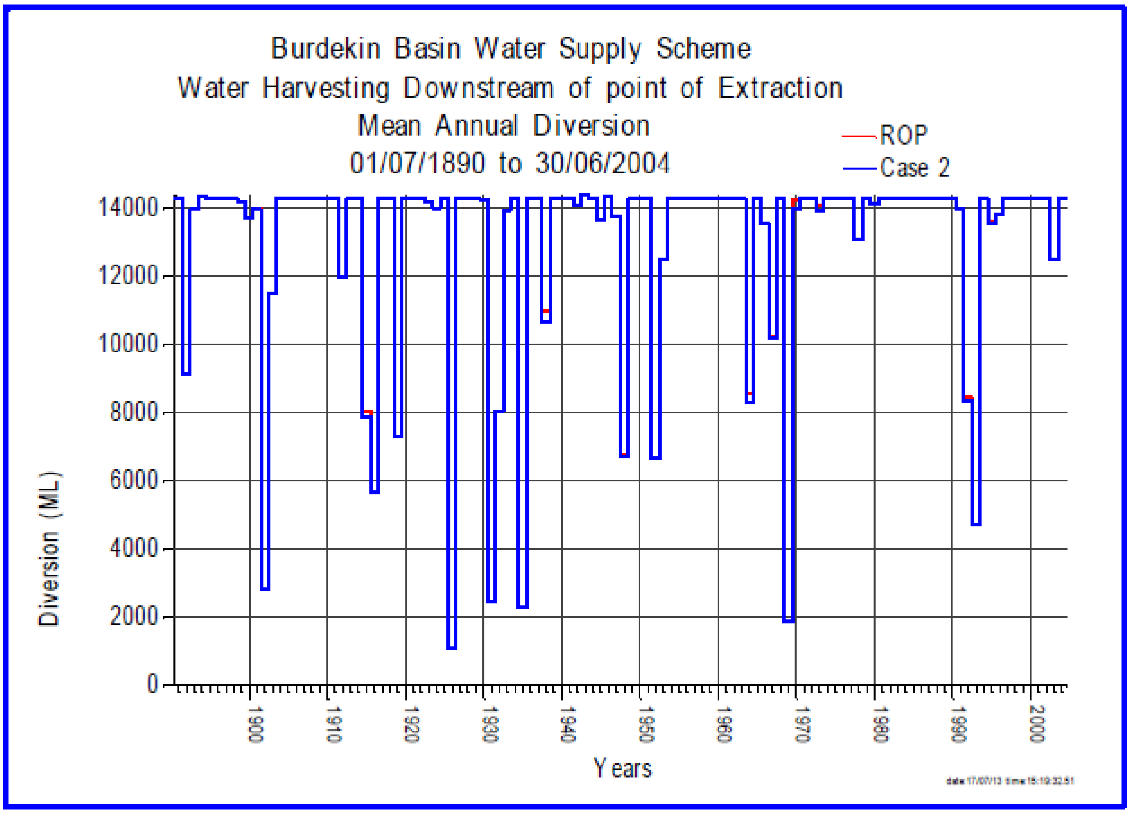
Figure 33 Annual maximum extractions Belyando (1890-2004)[Adani, 2013]



Downstream Users

The operating rules or the trigger level have been developed so that they will not impact on the downstream water users. This approach was carried by using an iterative runs with the IQQM model that provided the required volume of extraction needed by the Project. The proposed operation case (case 2) meets the WRP performance indicator EFOs and has limited to no impact on downstream users. Figure 34 shows the total annual diversion of downstream water harvesters for ROP case and Case 2.

Figure 34 Annual water harvesters downstream of extraction location (Adani, 2013)



3.9.2 Impacts on environmental flow objectives

Water extractions for the Project (Mine) within the Burdekin Basin have the potential to impact on other users and will be required to meet all of the EFOs set out in the WRP.

To limit the impact, the extraction operating rules have been developed such that they will not impact on the flows (low) which are critical to EFO requirements. Using an iterative approach with the IQQM model, a set of operating rules were developed (refer Table 20) that provided the required volume of extraction needed by the Project (Mine) and meet all EFOs, and had limited or no impact on downstream users.

Table 20 IQQM model operating rules (Adani, 2013)

Operating Rule	Quantity
Start to pump level	River flow of 200 m3/s
Maximum pump rate	400 ML/day
Cease to pump	River flow less than 200 m3/s
Seasonal fresh allowance	First small flood of the season (up to 700 ML/day) is not extracted
Transfer pump rate (between storages)	50 ML/day

Impacts (EFO benchmarks) on the environmental flows were checked using the environmental nodes specified in the WRP. Within Belyando River, node 347 within the IQQM ROP model described in Hyder[4] has been identified as the Environmental Flow Indicator. Modelling showed that all required WRP EFOs conditions were met when the extractions for the Project (Mine) were included, therefore creating a minimal impact (refer Table 21 for IQQM results).

Table 21 Environmental flow conditions (Adani, 2013)

	WRP performance Criteria	ROP IQQM Case (GL/y)	Case 2 10GL/y Project Extraction (GL/y)
Percentage change of flows from natural conditions			
Mean Annual Flow	92%	92.8	92.8%
Median Annual Flow	88%	89.1	89.1%
Low flow objectives (compared against natural flow conditions)			
Total number of days 50% non-zero daily flow is equalled or exceeded	32%	32.6	32.4%
Total number of days 80% non-zero daily flow is equalled or exceeded	52%	53.2	53.2%
Medium to high flow objectives			
1.5 year daily flow volume in the simulation period, expressed as a percentage of the 1.5 year daily flow volume for the pre-development flow pattern	94%	94.7	94.5%
5 year daily flow volume in the simulation period, expressed as a percentage of the 5 year daily flow volume for the pre-development flow pattern	96%	96.8	97.1%
20 year daily flow volume in the simulation period, expressed as a percentage of the 20 year daily flow volume for the pre-development flow pattern	98%	98	98.2%
APFD	1.0	0.9	0.9

[4] Hyder, October 2012, Adani Carmichael Coal Mine Water Demands Report.

Other impacts due to flood harvesting

There are other potential associated impacts of the flood harvesting such as:

- Destruction of habitat along the river bank
- Clearing of vegetation
- Aquatic fauna being potentially pumped through the intake
- Scour and erosion caused by the intake channel
- Pollutants (petrochemicals) entering the river from the pump station.

Mitigation measures for these impacts are discussed in section 3.13.

3.10 Impacts relating to groundwater

The following groundwater related activities on site are expected to have an impact on surface water at and around the Project (Mine) area:

- The creation of open pits that will be excavated to well below the natural groundwater table resulting in inflows of groundwater to be pumped out and managed within the site
- The creation of underground mines that will be excavated to well below the natural groundwater table resulting in inflows of groundwater to be pumped out and managed within the site

The impact of these activities was assessed in the SEIS Appendix K1 Revised Mine Hydrogeology Report and have been summarised in the following sections.

3.10.1 Pit inflows

Groundwater modelling (refer SEIS Appendix K1 Updated Mine Hydrogeology Report) results suggest a peak total mine inflow of around 26 ML/d occurring in 2029 of which around 60 per cent is associated with underground mining and the remaining with open-cut mining. The predicted peak mine inflow in 2029 is consistent with the underground mining schedule that plans the largest number of active underground developments in that specific year.

Predicted total mine inflows recede gradually from 2029 to 2061 to around 6.5 ML/d at the end of the proposed 59 year mine life. Longwall mining terminates in 2058 thus the total mine inflows in 2061 and 2071 are exclusively associated with open-cut mining activities.

3.10.2 Open Pit

Open cut pit groundwater inflows have been included in the water balance based on results from hydro-geological modelling conducted for the mine. Inflows used for each open cut pit are presented in Table 22.

Table 22 Open cut pit ingress (ML/day)

Year	Pit B	Pit C	Pit D	Pit E	Pit F	Pit G
2015	0.2	0.0	2.9	1.8	0.0	0.0
2016	0.1	0.1	3.2	3.6	0.0	0.0
2017	0.9	2.4	3.7	4.6	0.0	0.0
2018	1.4	1.8	3.8	3.7	0.0	0.0
2019	1.6	2.8	3.4	3.9	0.0	0.0
2024	0.7	1.3	2.2	2.2	0.0	4.8
2029	0.6	1.0	2.0	2.0	2.3	2.7
2034	0.4	0.9	1.8	1.6	2.0	1.8
2039	1.2	1.1	1.3	1.8	1.4	1.0
2044	1.0	0.8	1.1	1.3	1.2	2.4
2049	0.8	0.3	0.6	1.3	1.1	2.9
2061	0.8	0.2	0.6	1.2	0.9	2.9
2071	0.5	0.1	0.7	1.3	0.7	2.7

3.10.3 Underground mines

Underground mine groundwater inflows have been included in the water balance based on results from hydro-geological modelling conducted for the mine. Inflows used for each open cut pit are presented in Table 23.

Table 23 Underground mine inflows (ML/day)

Year	M1 Total	M2 Total	M3 Total	M4 Total	M5 Total
2015	0.0	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0	0.0
2017	0.0	0.0	0.0	0.0	0.0
2018	0.1	0.0	0.0	0.0	0.0
2019	1.0	0.0	0.0	0.0	0.0
2024	5.3	0.0	0.0	0.0	0.0
2029	3.2	0.0	0.0	0.6	11.7
2034	0.0	0.0	0.0	1.2	4.6
2039	0.0	0.0	2.8	1.9	2.8
2044	0.0	1.7	2.9	0.0	0.0
2049	0.0	4.1	2.3	0.0	0.0
2061	0.0	0.0	0.0	0.0	0.0
2071	0.0	0.0	0.0	0.0	0.0

3.10.4 Base flow impacts – Operation Phase

The maximum predicted cone of influence of mine dewatering extends beneath the Carmichael River within, upstream and downstream of the Project (Mine) site. Given that groundwater discharge to the Carmichael River upstream of the site is thought to help maintain flow in the river during dry periods (along with discharge from Doongmabulla Springs), surface water flows in the river are likely to decline as a result of the predicted reduction in groundwater levels along the river. Groundwater modelling results suggest that groundwater discharges to the Carmichael River upstream of the mine site, will be reduced by up to 200 m^3/d or 5 per cent of pre-development discharge during the operational phase. Predictions also suggest that mining induced drawdown within the mine area will increase observed flow losses across the site by up to 800 m^3/d. Total impacts, through a combination of reduced baseflow upstream and increased losses across the site, are therefore around 1000 m^3/d (or 33 per cent of the long term average pre-development baseflow) at the end of the mine life.

The predicted reductions in baseflow will also affect the duration of low/zero flow periods at the downstream boundary of the site and are likely to cause the zero baseflow point in the Carmichael River to migrate upstream. Model predictions suggest:

- A 10 km migration of the zero baseflow point upstream
- A 5 percent increase in no flow periods at the upstream boundary of the Mine Area
- A 30 percent increase in no flow periods at the downstream boundary of the Mine Area.

No significant impacts on flows in the various ephemeral minor creeks which drain the Project area are anticipated since these water courses are not thought to currently receive any substantial discharges from groundwater.

3.10.5 Base flow impacts – post closure

Total impacts through a combination of reduced baseflow upstream and increased losses across the site are predicted to be around 950 m^3/d (or 31 per cent of the long term average pre-development baseflow) post closure. Predictions also suggest:

- A 10 km migration of the zero baseflow point upstream
- A 5 percent increase in no flow periods at the upstream boundary of the Mine Site
- A 30 percent increase in no flow periods at the downstream boundary of the Mine Site.

This represents a similar level of impact to that predicted during the operational phase.

No significant impacts on flows in the various ephemeral minor creeks which drain the Project area are anticipated since these water courses are not thought to currently receive any substantial discharges from groundwater.

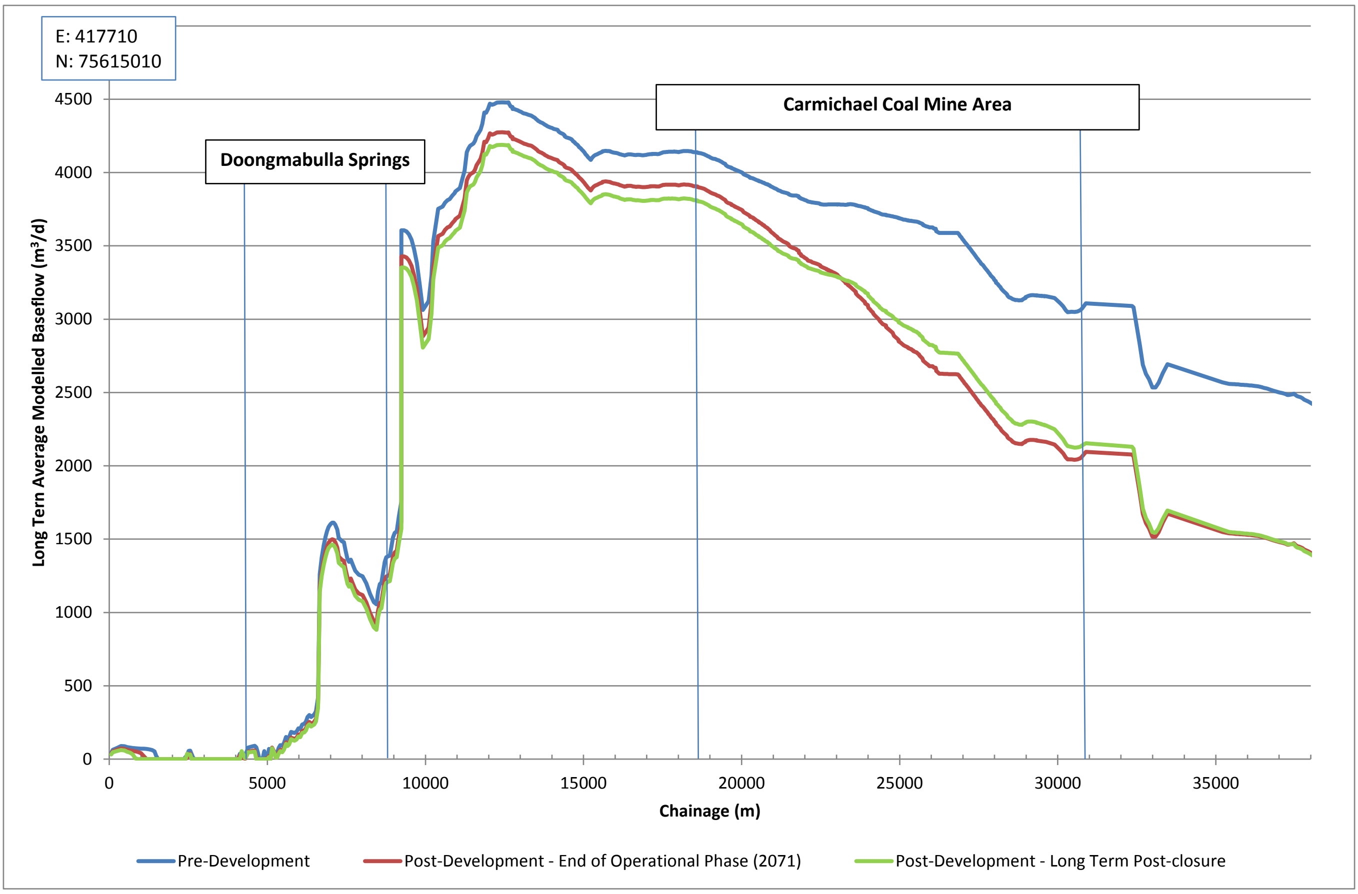
Further information on pre-development flows in the Carmichael River and on discharges from the Doongmabulla Springs is required to confirm these estimated impacts.

Unlike during the operational period there is little opportunity for ‘making good’ any impacts since the mining operations will have been de-commissioned. In the event ongoing monitoring confirms significant impacts during the operational period then Adani Mining Pty Ltd is committed to taking any further steps necessary to reduce the post closure impacts on levels and/or flow in the Carmichael River to acceptable levels. Potential mitigation measures which may reduce and/or mitigate impacts during the post closure phase include:

- Reviewing and revising the extent, location and/or timing of the proposed mine workings
- Backfilling of final voids to above pre-development groundwater levels to prevent ongoing losses due to evaporation
- Offsetting any residual impacts

Predicted post closure base flow impacts on each of the affected local watercourses are shown in Figure 35.

Figure 35 Predicted base flow impacts – Pre and post development



3.11 Total impact Carmichael River surface flow

As a summary of the previous sections the following elements will impact on seasonal surface flow in the Carmichael River.

- Reduced groundwater flows
- Changes to surface runoff
- Site controlled discharges.

The reduction in groundwater flows have been estimated to reduce the Carmichael River base flow by 33% on a long term daily average for the operation life of the mine or approximately 1,000 m^3/d and 31% post closure (950 m^3/d). The change to catchment areas decreases the flow to Carmichael River by 21.5% of local site flows or 1.9% of the total Carmichael River flow at the site (based on 2,133 km^2 upstream catchment used in the flood modelling) or around 5,000 ML per year (based on the MUSIC modelling). The total site discharges from the Central MAW storages into the Carmichael River are expected to be in the order of 100 ML per year (by year 2017) to 7,500 ML per year maximum (refer Figure 24).

While the discharges from the site storages may contribute to mitigating some of the surface flow losses caused by loss of catchment they will not be sufficient to mitigate against the long term loss of base flows in the Carmichael River.

3.12 Geomorphological impact assessment

The baseline geomorphology assessment can be found in Appendix A of this report.

Based on a review of the proposed layout and description of the Project (Mine), the potential key components of the Project (Mine) that could impact on the geomorphology of waterways include:

- Construction of diversion drains
- Construction of flood levees along and a bridge across the Carmichael River
- Subsidence effects of underground mining
- Construction and/or upgrade of temporary and/or permanent waterway vehicular crossings.

The potential impacts and significance of each of the above on waterway geomorphology are discussed in the following sections.

3.12.1 Diversion drains

As detailed in SEIS Appendix K4 Preliminary Flood Mitigation and Creek Diversion Design Report (GHD, 2013), diversion drains have been proposed to direct external catchment flows around open cut pits, subsidence affected areas and spoil dumps at various locations. There is currently no proposal to divert any currently determined watercourses as defined under the *Water Act 2000*. There is however a proposal to divert a tributary of Eight Mile Creek and this waterway has been determined by DNRM in August 2013 as a drainage feature.

It is recognised that many of the existing waterways in the Project (Mine) area display evidence of past and ongoing erosion through gullying and erosion. As a result, the long-term stability of the diversions cannot be assured even where they comply with the DERM (2011) criteria. It is therefore recommended that further consideration for limiting erosion potential be placed on the entire length of the diversions. This will need to consider the erodibility of excavated bounding materials in context with the predicted flow hydraulics and selection of appropriate treatments for stabilising the diversion channels. Nevertheless, the general compliance with the DERM (2011) criteria suggests that 'soft-engineering' approaches to stabilisation such as top-soiling and revegetation are likely to be viable options for stabilisation of a large proportion of the lengths of the diversions.

The diversion discharge points have also been designed to closely mimic existing drainage paths and where possible maintain inflows to downstream waterways to the east of the mine area. This will limit impacts on catchment areas and hydrological regimes and the subsequent potential impacts on downstream sediment transport and scour processes.

In respect to downstream sediment delivery, the effect of the diversions maybe potentially beneficial, particularly if the diversions can be maintained as stable systems with limited erosion. This will effectively replace existing waterways currently undergoing considerable gullying and channelization with stable systems and thereby reduce the existing elevated sediment loads to downstream reaches.

3.12.2 Carmichael River levees and bridge

The key components of the Project (Mine) that could directly impact on the geomorphology of the Carmichael River are:

- The provision of levees either side of the Carmichael River corridor. These extend out from the bunded area to protect additional area for the mine from river flooding and to improve the shaping of the constriction, whilst allow allowing flows to enter the head of the Cabbage Tree Creek effluent flow path.
- The provision of a bridge to allow passage of the haul road and conveyor over the Carmichael River.

In addition, proposed diversion drains will discharge into the Carmichael River where it flows through the Project (Mine) area.

The predicted velocity changes (detailed in section 3.4.3) have the potential to alter patterns of sediment transport, scour and deposition along the Carmichael River through the Project (Mine) area. While the greatest velocity increases will be experienced at the bridge opening and embankment culverts, appropriate scour counter measures will be provided. The extents to which these measures extend upstream and downstream will be considered during the detailed design phase.

Elsewhere, the increases in velocities are not considered to be of sufficient magnitude to result in any significant change in the extent or severity of erosion along the channel of the Carmichael River. Typically flow velocities remain in the same general range under developed conditions as to those under existing conditions. For example, under the 100 Year ARI flow conditions, flow velocities largely range from 1.5 to 3.0 m/s for both existing and developed conditions along the channel in the reach subject to flow constriction by the levees. Hence, the impact of the minor velocity increases is expected to be limited to very localised adjustments in scour patterns under infrequent, higher magnitude events (ie > 50 Year ARI), with no significant impact on the overall morphological form and functioning of the Carmichael River.

The predicted reduction in flow velocities under developed conditions upstream of the bridge crossing structure could result in reduced sediment transport capacity leading to the infilling of any pools and channel aggradation. However, the Carmichael River dominantly transports sediment in suspended load and flow velocities under developed conditions for all events modelled are maintained at above 1.5 m/s within the channel upstream of the bridge. This velocity is capable of retaining fine sand, mud and silt in suspension as well transporting coarse sand and gravel as bedload. Further, the effect of the bridge structure on flow velocities for frequent, lesser magnitude flood events (ie < 10 Year ARI) is almost negligible. Hence, the sediment transport and pool flushing capacity of these events will be maintained. Therefore, the propensity any significant channel aggradation and pool infilling in the channel upstream of the bridge is considered low.

While only localised minor erosion and aggradation is expected along the Carmichael River in response to the proposed development, it is difficult to determine with any high degree of certainty the location, severity and extent of these potential impacts. Hence, it is considered appropriate that these risks be managed through the development and implementation of a morphological monitoring and action response program.

3.12.3 Subsidence effects

Due to subsidence the topography within the mine area above the underground workings will change. Essentially subsidence will result in a series of linear depressions (above the centre of long-walls and ridges (above chain pillars). With this, drainage patterns in the affected areas will change as well. In general, the proposed drainage concept diverts water around the areas of predicted subsidence to reduce the importance of surface water management in these areas.

There are however some areas of predicted subsidence where diversions are not practical and water will pass through these areas generating pools that will rely on either evaporation and infiltration losses to remove it. To address this, a series of low flow connection channels through the ridges are proposed to link depressed areas and provide an outlet at the downslope extent of the subsided affected areas. Without such intervention, under high rainfall events pools in upstream depressions may overtop into downslope depressions resulting in the potential for the uncontrolled erosion of the ridges separating depressions.

Additionally, existing gullying and erosion within subsided affected areas may also result in the erosion of the ridges separating depressions, leading to the uncontrolled passage of water within the subsided area. This will be of particular importance for the far western longwall panels, where the increased gradient of the landscape on the upslope side of the depression may initiate of exacerbate erosion. This may lead to gullying that retreats upslope away from the subsided areas and potentially off the Project (Mine) area. It is recommended that an assessment of the distribution of existing gullying and erosion in relation to the predicted post subsidence landform be undertaken in subsidence affected zones. This will allow targeting of areas that may require monitoring or treatment to limit erosion either prior to or immediately following subsidence.

3.12.4 Vehicular crossings

The Project (Mine) will require the construction of temporary or permanent waterway vehicular crossings for new roads and/or the upgrade of existing waterway vehicular crossings. Construction of waterway road crossings could cause or exacerbate bed and bank instabilities locally.

The potential for initiating bed and bank instabilities can be minimised through adoption of the following recommendations in the design and construction of waterway crossings:

- Wherever possible, waterways should be crossed on a straight portion of the waterway to avoid the risk of erosion. Where this is not possible bank stability works may be implemented
- Avoid impeding flows through selection of an appropriate crossing type. Causeway crossings inset so that they are flush with the channel profile present the best means for crossing small waterways. For culvert crossings, the hydraulic capacity of the culvert should be equivalent to the channel capacity of the waterway, or at least equal to the hydraulic capacity of the waterway below the level of the road surface
- Avoid concentrating or redirecting flow on the outlet of crossings. Where this is not possible, appropriate scour protection measures will need to be provided
- Avoid the need for access of heavy machinery to the bed of the waterways as works should be undertaken from the top of the banks where possible
- Avoid disturbance of surrounding banks by machinery or other construction works
- Vegetation clearance should be avoided where possible to protect soils from erosion. If clearance cannot be avoided, the area of vegetation cleared at any one time should be minimised
- Stabilise disturbed areas and reinstate vegetation as quickly as practicable after construction.

With implementation of the above recommendations, the impact of vehicular crossings on the geomorphology of waterways is considered low.

3.13 Management, mitigation and monitoring activities – operational phase

3.13.1 Recommendations for future design refinement

Levees

The location of the Carmichael River levees used in this SEIS flood study has remained consistent with the location and hence flood study undertaken for the EIS. Whilst there has been some adjustments to the sections of the levees that approach or angle away from the Carmichael River, the levees running parallel to the river remained the same for the flood modelling. As an outcome of the flood modelling process, and as a result of refinements to the Mine Plan and staging, it was identified that the northern levee parallel to the Carmichael River could be moved further from the river channel than it is shown, ensuring that the setback to the river is maintained and hence this is likely to minimise predicted afflux and velocity impacts within this vicinity.

Onsite storages

A hazard assessment for all dams on site will be required during future design stages. Note that for dams without an actual catchment, like the MAW transfer dams, allowing for the DSA will be a matter of increasing the storage depth.

Diversion Drains

It is suggested the following areas require attention in the next stage of the design of the drains.

- Design in Accordance with *Watercourse Diversions Guidelines – Central Queensland Mining Industry (DERM, 2011)* – these guidelines include further design criteria which include:
  - Incorporation of features that mimic the natural stream characteristics to create ‘dynamic equilibrium’
  - Providing a corridor of suitable width to accommodate potential channel meanders
  - Consideration of channel vegetation implementation to stabilise channel banks, terraces and floodplain drainage paths
  - Consideration of the need for fish movement within the channel, or a fish movement exemption notice application.

  To the extent that DNRM has finalised the Manual and Guidelines currently in development pursuant to the new waterway diversion exemption under section 20(4) *Water Act 2000*, Adani will meet their requirements as appropriate.
- *Importance of drainage issues to mine safety* – The reliance on constructed drainage measures to manage surface water and local flooding within the mine site will necessitate careful consideration of drainage design, construction, monitoring and maintenance issues throughout the life of the mine
- *Interfaces with other infrastructure* – Further design of the diversion drains and other infrastructure needs to consider how these elements interface
- *Design of inlets into the diversion drains* – The management of drainage, scour and erosion at the inlets to the diversion drains requires on-going attention as the mine design progresses
- *Design of waterway crossings and culverts* – The design of all waterway crossings and culverts will require on-going revision as the mine design progresses. Note that Adani will comply with the *Guideline - Activities in a watercourse, lake or spring associated with a resource activity or mining operations (version 3), and if there are circumstances where the*se activities cannot be carried out in accordance with the departmental guideline mentioned above, a Riverine Protection Permit will be obtained under section 266 of the *Water Act 2000*. To the extent that any of these vehicle crossings are off the mining lease area, a development permit will be obtained under SPA.
- *Calculation of appropriate channel side slope* – As yet no geotechnical data has been provided for the region underlying the proposed diversion drains. The assumed channel side slopes of 1 vertical to 5 horizontal are for conceptual modelling purposes only and a geotechnical analysis of a stable slope angle both with respect to slumping and scour protection placement capability is required to confirm appropriate channel cross sections
- *Benching of Large Cuts* – The proposed design is based on an assumed channel side slope of 1 vertical to 5 horizontal with no benches. Where deeper cuts are required for diversion drains, benching may be required. The need for benching would be determined on the basis of analysis of geotechnical data and horizontal and vertical profile requirements

- *Potential Erosion at Outlet Gully* – Detailed consideration of the flow velocities at the outlets into the existing natural minor waterway is required, including the need for any erosion protection measures
- *Lining of the Drain* – At this stage the nature of the lining of the drain has not been considered. This aspect will require further attention in the next stage of the design
- *Energy Dissipation Structures* – Based on the case study diversion drain, energy dissipation is likely to be required on a number of diversion drains in order to reduce the 50 year ARI in-channel velocity to the acceptable maximum of 2.5 m/s. Methods of energy dissipation in these areas could include rip-rap lining or rock chutes
- Consideration of final landform and rehabilitation and closure requirements.

Haul Road and Conveyor Crossing

Modelling indicates that there is a substantial head drop across the haul road and conveyor crossing structure which may cause scour of the haul road bank, particularly in combination with the relatively high velocities through the structure. Detailed design of the bridge needs to recognise that these can be overtopped in the floods marginally bigger than the 100 year ARI flood.

Further consideration should also be given to the waterway openings presented in the design, and to whether there are benefits in increasing the size of these openings to reduce the risk of scour damage in a flood.

Water balance modelling

The following items would need to be added to the water balance in the future when more detail is known.

- Boxcuts: No design specifics are available at this stage for the underground access areas (boxcuts). Hence they have not been included in the water balance
- Outcomes of the tailings and rejects study, which are currently unavailable, will potentially lead to changes in water management infrastructure and, if so, should be included in future water balance modelling
- Rehabilitated areas: The water balance does not take into account the exclusion of fully rehabilitated areas
- Climate change: Potential impacts of long term climate change have not been considered
- Offsite infrastructure: Offsite infrastructure is excluded with exception of potable water usage for the camp

The following recommendation is made as part of the water balance study:

- The water balance and proposed site water management infrastructure will undergo refinement during future design stages in order to adequately represent the mine development.

Controlled discharges

It is proposed to discharge from the two central MAW storages (north and south) and from the disturbed area sediment basins.

The potential maximum discharge volume (average flow conditions) to the Carmichael River are estimated in Appendix B of the Water Balance Report. The water balance determined combined potential discharge volumes even for the worst year 2060, less than 30 percent of the estimated potential maximum discharge volumes.

Model results indicate that an increase in the dam sizes will have a relatively limited effect on the reduction of discharges through evaporation, and that effect would be outweighed by increasing total raw water demand requirements as result of evaporation.

Overflows

It is expected that the overburden sediment basins may overflow in response to extreme weather events, but considering the size of the catchments and the volumes of the dams the discharges are considered minimal with the maximum average yearly overflows estimated at 250 ML. Water quality of overflows from these basins is expected to be relatively good, with total dissolved solids (turbidity/sediments) being the critical contaminant.

3.13.2 Management of overburden sediment dams and disturbed area sediment basins

It is expected that a range of small sedimentation basins will be required on site for treatment of small disturbed areas. These basins have not been included in the SEIS as the current design level for the mine has not reached that level of detail.

In order to reduce the overflows from the basins/dams the site operations can increase dust suppression of exposed areas, such as, haul roads. It was found in the water balance modelling that water usage on site is very sensitive to the amount of water used for dust suppression due to the size of the site and its unsealed areas.

In order to reduce the sediment loading and flocculants can be applied to the captured stormwater to increase settlement. Regular clean out of the basin/dams to continually re-establish the settlement and storage zones after the treatment of each rainfall event will also improve the quality of water overflowing from the basin/dam.

3.13.3 Flood harvesting mitigation

The following mitigation measures have been proposed to provide some level of mitigation to the impacts discussed in section 3.9.

Clearing of vegetation

The flood harvesting infrastructure has been located to avoid environmentally significant areas (such as remnant and high value regrowth vegetation) where possible. Further mitigation measures include:

- Restriction of vegetation clearing to the minimum necessary amount
- Construction areas should be located within the pipeline corridor
- Water supply storages will be located within existing cleared, non-remnant or disturbed areas where possible
- Clearly identified clearing area on construction plans
- Supervised vegetation clearing by a suitably qualified professional

- Rehabilitation of cleared areas immediately after construction, to be undertaken in accordance with the Project (Mine) plans for rehabilitation.

Protection of fish and other animals

The intake structure at the Belyando River may suction up fish, and other river life. An intake screen should be installed at the inlet to prevent this from occurring. This screen may include:

- An automatically raked trash screen
- A manually raked trash screen or
- A wedge wire passive screen with air blasting.

Spillages

In order to minimise the risk of a petrochemical spill from the pump station into the river occurring the pump station should be bunded.

Erosion and Scour

Due to changes in the river profile caused by the pump intake structure erosion and scour is expected to occur in order for the river flow to create a new equilibrium. The clearing required to build the intake structure will also contribute to scour and erosion. In order to mitigate this, the extent of potential scour will need to be investigated and scour protection will need to be designed and installed accordingly. Vegetation should also be re-established where possible.

4. Monitoring

A comprehensive monitoring program will be developed as part of the site water management plan. The site water management plan will include the following monitoring measures as outlined in SEIS Volume 4 Section Q1 Environmental Management Plan for the Mine:

- Surface flows will be monitored on an ongoing basis prior to construction, during operation and post operation upstream, downstream and within the Study Area to measure changes
- All regulated water management infrastructures (dams, levees, diversion dams) will be annually inspected at a minimum by a suitably qualified and experienced person. A report will be produced with any recommendations required to ensure the structural integrity, as recommended in the DEHP (2012) guidelines *Structures which are dams or levees constructed as part of environmentally relevant activities (EM634)*
- Dam capacity must be reviewed on 1 November annually to ensure that sufficient capacity exists to meet the design storage allowance as determined by the *Manual for assessing hazard categories and hydraulic performance of dams (EM635)*
- Diversion drains, floodplains and discharge points to downstream waterways will be inspected regularly during the wet season and after any flow event to identify any scouring, instability or erosion. Corrective action will be taken promptly.

5. References

Adani, 2013. *Flood Harvesting_Memo_18072013*

Australian Coal Association Research Program (ACARP), 2002, *Maintenance of Geomorphic Processes in Bowen Basin River Diversions, Stages 1, 2 & 3.*

Department of Environment and Resource Management (DERM), October 2010, *Burdekin Basin Resource Operations Plan Revision 2*

Department of Natural Resources and Mines (DNRM), 2012. *Watermonitoring.derm.qld.gov.au* [accessed 18/07/2013]

Department of Natural Resources and Mines (DNRM), 2007, *Water Resource (Burdekin Basin) Plan 2007*

Department of Natural Resources and Mines (DNRM), 2009, *Burdekin Basin Resource Operations Plan (ROP) 2009*

Department of Natural Resources and Mines (DNRM), 2006, *Water Resource (Great Artesian Basin) Plan 2006*

Department of Natural Resources and Mines (DNRM), 2012, *Great Artesian Basin Resource Operations Plan February 2007 Amended November 2012*

Hyder Consulting, 5 October 2012a, 0046-AA005171-AAR-01 *Carmichael Coal Mine and Railway Project – River Flood Harvesting Water Supply Option*

Hyder Consulting, 22 October 2012a, 0052-AA0055171-AAR-01 *Carmichael Coal Mine and Railway Project – Water Strategy Report*

Hyder Consulting, 13 January 2012c, F001-AA004715-AAR-01 *Carmichael Coal Mine – Water Supply and Water Sourcing Option*s.

IECA, 2008. *Best Practice Erosion & Sediment Control.*

Queensland Government (DERM 2010a), 2010, *Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study report prepared by Department of Environment and Resource Management, Department of Infrastructure and Planning, Local Government Association of Queensland*

Queensland Government (DERM 2010b), 2010, *Increasing Queensland's resilience to inland flooding in a changing climate, Final Scientific Advisory Group (SAG) report—Derivation of a rainfall intensity figure to inform an effective interim policy approach to managing inland flooding risks in a changing climate', report prepared by Department of Environment and Resource Management, Department of Infrastructure and Planning, Local Government Association of Queensland*

Appendices

Appendix A – Carmichael Mine Geomorphology Report

Adani Mining Pty Ltd

adani

Carmichael Coal and Rail Project SEIS

Report for Geomorphological Assessment

14 November 2013

GHD

This Carmichael Coal Mine and Rail Project SEIS: Geomorphological Assessment (the Report) has been prepared by GHD Pty Ltd (GHD) on behalf of and for Adani Mining Pty Ltd (Adani) in accordance with an agreement between GHD and Adani.

The Report may only be used and relied on by Adani for the purpose of informing environmental assessments and planning approvals for the proposed Carmichael Coal Mine and Rail Project (Purpose) and may not be used by, or relied on by any person other than Adani.

The services undertaken by GHD in connection with preparing the Report were limited to those specifically detailed in this Report.

The Report is based on conditions encountered and information reviewed, including assumptions made by GHD, at the time of preparing the Report.

To the maximum extent permitted by law GHD expressly disclaims responsibility for or liability arising from:

- *any error in, or omission in connection with assumptions, or*
- *reliance on the Report by a third party, or use of this Report other than for the Purpose.*

Table of contents

Table index

Plate

Figure index

Appendices

1. Introduction

1.1 Project overview

Adani Mining Pty Ltd (Adani, the Proponent), commenced an Environmental Impact Statement (EIS) process for the Carmichael Coal Mine and Rail Project (the Project) in 2010. On 26 November 2010, the Queensland (Qld) Office of the Coordinator General declared the Project a ‘significant project’ and the Project was referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (referral No. 2010/5736). The Project was assessed to be a controlled action on the 6 January 2011 under section 75 and section 87 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions for the Project include:

- World Heritage properties (sections 12 & 15A)
- National Heritage places (sections 15B & 15C)
- Wetlands (Ramsar) (sections 16 & 17B)
- Listed threatened species and communities (sections 18 & 18A)
- Listed migratory species (sections 20 & 20A)
- The Great Barrier Reef Marine Park (GBRMP) (sections 24B & 24C)
- Protection of water resources (sections 24D & 24E)

The Qld Government’s EIS process has been accredited for the assessment under Part 8 of the EPBC Act 1999 in accordance with the bilateral agreement between the Commonwealth of Australia and the State of Queensland.

The Proponent prepared an EIS in accordance with the Terms of Reference (ToR) issued by the Qld Coordinator-General in May 2011 (Qld Government, 2011). The EIS process is managed under section 26(1) (a) of the *State Development and Public Works Act 1971* (SDPWO Act), which is administered by the Department of State Development, Infrastructure and Planning (DSDIP).

The EIS, submitted in December 2012, assessed the environmental, social and economic impacts associated with developing a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the northern Galilee Basin, approximately 160 kilometres (km) north-west of Clermont, Central Queensland, Australia. Coal from the Project will be transported by rail to the existing Goonyella and Newlands rail systems, operated by Aurizon Operations Limited (Aurizon). The coal will be exported via the Port of Hay Point and the Point of Abbot Point over the 60 year (90 years in the EIS) mine life.

Project components are as follows:

- The Project (Mine): a greenfield coal mine over 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 (the Mine) and the Mine (offsite) infrastructure including a workers accommodation village and associated facilities, a permanent airport site, an industrial area and water supply infrastructure.

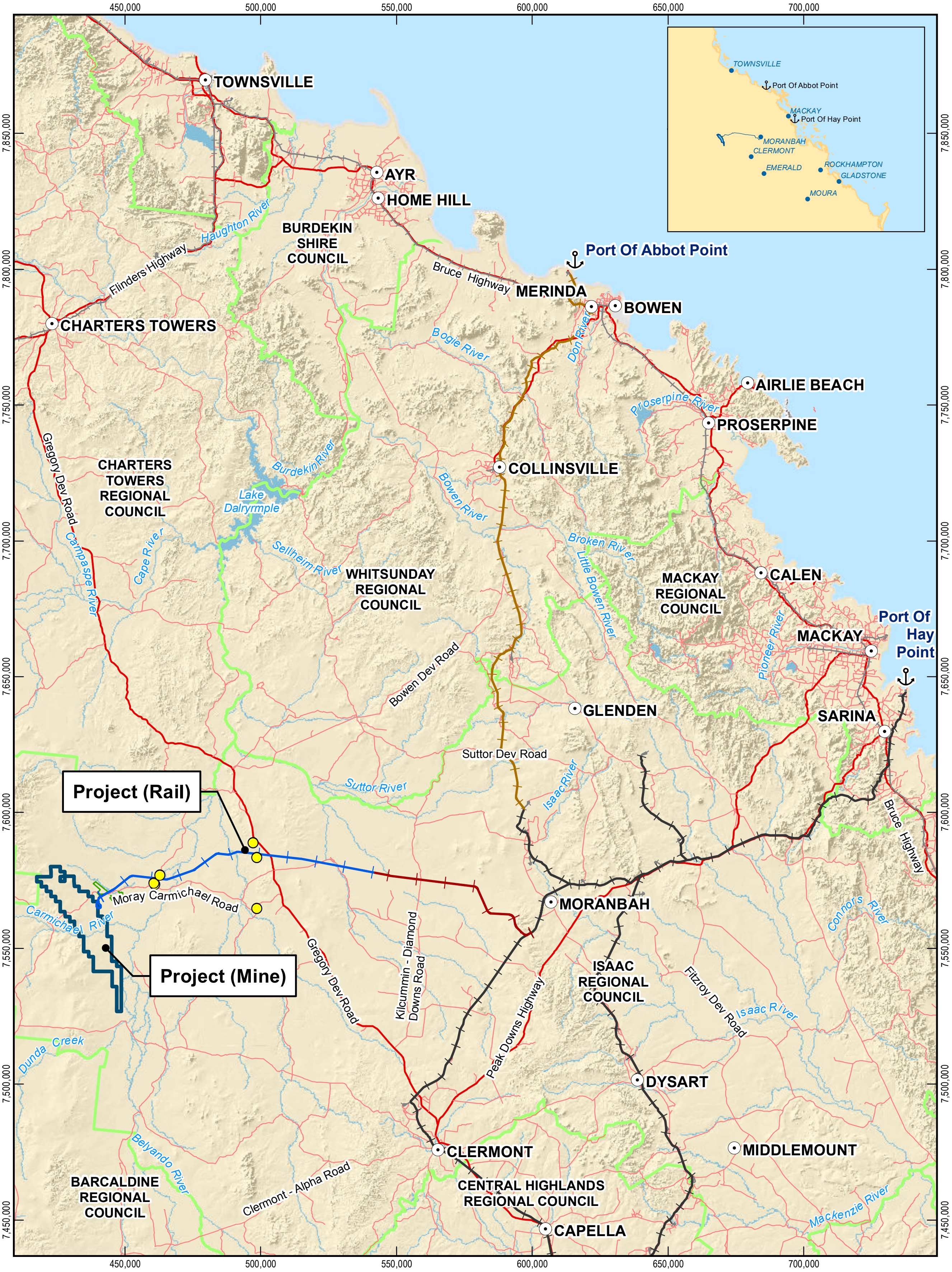
- The Project (Rail): a greenfield rail line connecting to mine to the existing Goonyella and Newlands rail systems to provide for the export of coal via the Port of Hay Point (Dudgeon Point expansion) and the Port of Abbot Point, respectively including:
  – Rail (west): a 120 km dual gauge portion running west from the Mine site east to Diamond Creek
  – Rail (east): a 69 km narrow gauge portion running east from Diamond Creek connecting to the Goonyella rail system south of Moranbah
  – Quarries: The use of five local quarries to extract quarry materials for construction and operational purposes.

Figure 1 shows the project location.

1.2 Assessment and reporting scope

This report provides an assessment of the impacts of the Project (Mine) on stream morphology. The outcomes will be used to inform the Supplementary Environmental Impact Assessment (SEIS) for the Project. A desktop assessment was undertaken to describe the existing stream morphology that may be affected by the Project (Mine).

This assessment focusses on those waterways located within the mine area which have been determined to be watercourses or to potentially be watercourses by DNRM, 2013 (see Appendix A) under the *Water Act 2000*.



LEGEND

- Town
- Major Port
- Other Rail Network
- Goonyella System
- Newlands System
- Local Road
- Watercourse
- Local Government Area
- Project (Rail)
- Rail (West)
- Rail (East)
- Project (Mine)
- Mine (Offsite)
- Quarry

Based on or contains data provided by the State of QLD (DNRM) [2013]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Project Location

Job Number	41-26422
Revision	2
Date	14-10-2013

Figure 1

G:\41\26422\GIS\Maps\MXD\0000_Overview\41-26422_117_rev_2.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

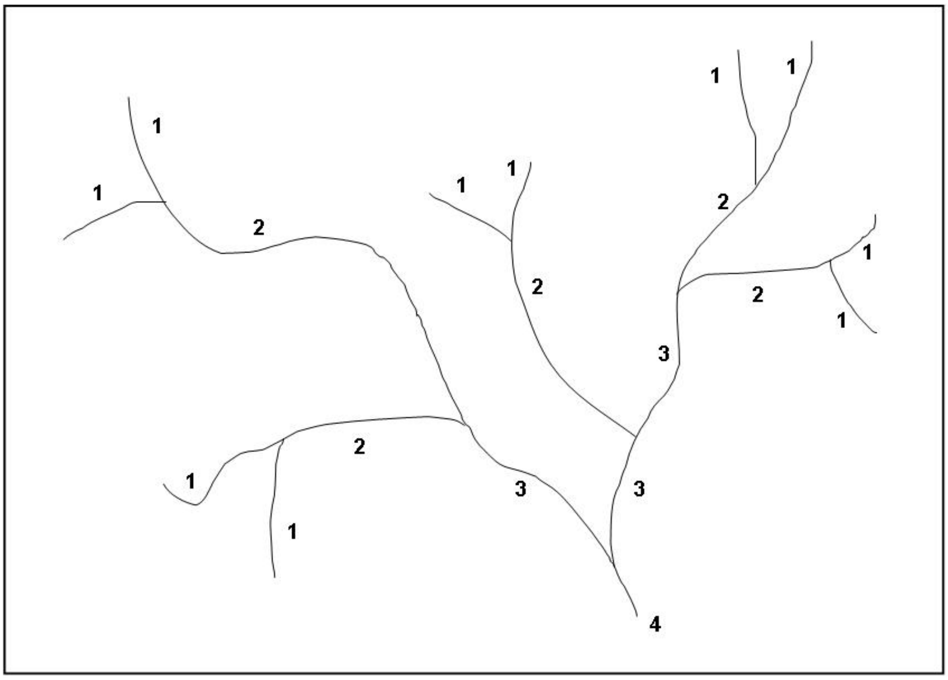
Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DNRM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008);
Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Offsite, Quarry (2013). Created by: MS

2. Methodology

A desktop assessment of existing information (GIS data, aerial imagery and site photographs taken by others) was undertaken to identify waterway types (river style), geomorphic condition and stream order of watercourses in the mine area.

Stream ordering followed the Strahler stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (Strahler, 1952). Figure 2 indicates the Strahler stream ordering process for a generic catchment.

Figure 2 Stream order using Strahler (1952) Method



The assessment of stream physical form and function is broadly based on the methods and principles of the River Styles® framework (Brierley and Fryirs, 2005). Determination of stream types is largely based on the following parameters:

- Degree of valley confinement and bedrock influences
- Presence and continuity of a channel
- Channel planform (number of channels, sinuosity)
- Channel and floodplain geomorphic features
- Nature of channel and floodplain sediments.

The assessment of geomorphic condition was based on Outhet and Cook (2004) who describe a rapid method of condition assessment that frames geomorphic condition in the context of natural and human induced variability. The characteristics of each condition category are described in Table 1. These categories provide an indication of the degree of alteration a reach has experienced from its expected natural form.

Table 1 Geomorphic condition category descriptions

Indicative condition	Characteristics
Good	Geomorphic structure is largely unchanged from the pre-disturbance state such that only minor cases of localised instability occur. Relatively intact and effective vegetation coverage dominated by native species, giving resistance to natural disturbance and accelerated erosion. There is minimal alteration to catchment controls such as sediment supply and the hydrological regime allowing fast recovery from natural disturbance. There is also a high potential for ecological diversity.
Moderate	Geomorphic structure is moderately altered such that a reduced diversity of river features exist and floodplain connectivity is somewhat limited. Localised degradation of river character and behaviour, typically marked by modified patterns of geomorphic units. Patchy effective vegetation coverage allowing some localised accelerated erosion. The river has not fully adjusted to prevailing conditions and is experiencing ongoing changes.
Poor	Considerable geomorphic alteration to the functioning and structure of the system when compared with the pre-disturbance condition. Type, extent and rate of processes are radically altered. Floodplain connectivity may be significantly altered. Abnormal or accelerated geomorphic instability (reaches are prone to accelerated and/or inappropriate patterns or rates of planform change and/or bank and bed erosion). Excessively high volumes of sediment inputs which blanket the bed, reducing flow diversity. Absent or geomorphologically ineffective coverage by vegetation (allowing most locations to have accelerated rates of erosion).

3. Existing conditions

3.1 Watercourse determinations

Watercourses generally flow west to east across the mine area. With the exception of the Carmichael River, most watercourses, crossing the western boundary of the Project (Mine) area have relatively small catchment areas (< 20 km^2).

The Department of Natural Resources and Mines (DNRM) has undertaken a desktop assessment of streamline features in the vicinity of the Project (Mine) to define which of these features are determined to be watercourse as defined in the *Water Act 2000* (DNRM, 2013). This desktop assessment was following by a site inspection in July 2013. The DNRM correspondence relating to the watercourse determination assessment is provided in Appendix A and the results summarised below:

- Features determined to be watercourses:
  - Carmichael River
  - Belyando River
  - Logan Creek
  - Dyllingo Creek
  - Surprise Creek
  - Mistake Creek
  - North Creek [1]
  - Cabbage Tree Creek [2]
- Features which do not exhibit the characteristics of a watercourse as defined in the *Water Act 2000* and are therefore considered to be drainage features:
  - Eight Mile Creek
  - Laguna Creek
  - Pear Gully
  - Obungeena/Ogenbeena Creeks

There are a number of unnamed streamlines within the mine area which have not been explicitly included in the watercourse determination undertaken by DNRM. These are all small catchment, low stream order streamline features (first and second order) and are therefore likely to be considered to be drainage features and not watercourses as defined under the *Water Act 2000*.

---

[1] Between approximate bearings: 21o 55’ 10.7” S 146o 23’ 28.4” E and 21o 55’ 56.4” S 146o 32’ 59.6” E

[2] Between approximate bearings: 22o 06” 24.1” S 146o 23” 57.4” E and 22o 06” 33.0” S 146o 25” 25.7” E 22o 06” 26.3” S 146o 26” 11.6” E and 22o 06” 15.2” S 146o 27” 44.4” E 22o 05” 45.7” S 146o 28” 33.9” E and 22o 05” 58.7” S 146o 29” 33.4” E

3.2 Stream order

A review of the Geosciences Australia 2007 watercourse GIS dataset indicates that most waterways within the mine area are first and second order streamlines. The exception is the Carmichael River which was estimated to be a 5th order watercourse where it runs through the mine area. Cabbage Tree Creek is essentially a distributary anabranch channel of the Carmichael River and is therefore also considered to be a 5th order streamline.

3.3 Waterway types

A total of three different stream types were identified from the desktop assessment of the waterways within the Study Area as follows:

- anabranching, low sinuosity, sand systems
- channelised fill systems
- valley fill systems.

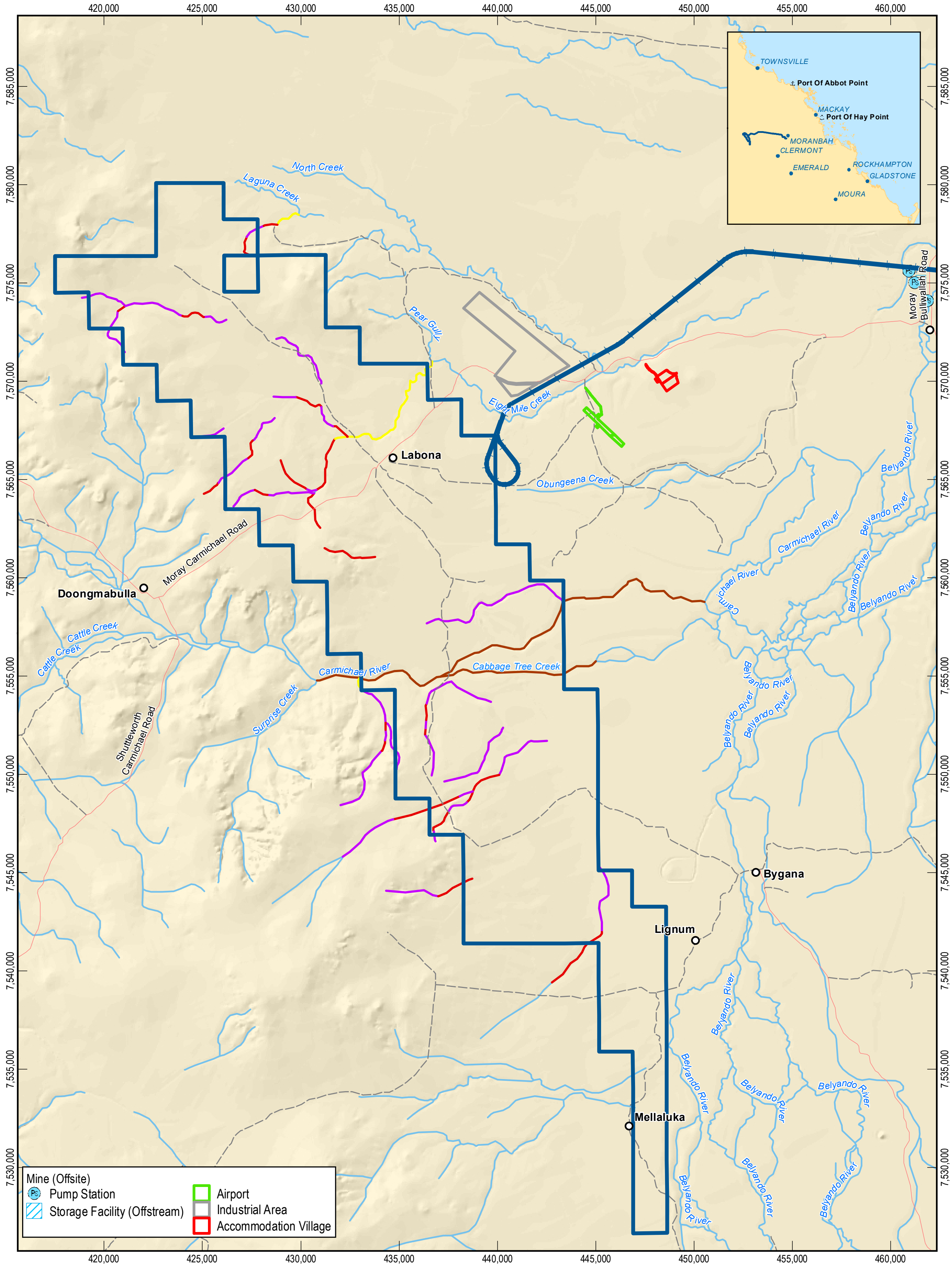
The distribution of stream types within the Study Area is displayed in Figure 3 and their characteristics are described below.

Anabranching, low sinuosity, sand system

This waterway type is characterised by a multiple channel system with broad continuous floodplains. It consists of one primary channel with anabranching channels converging and diverging from the main channel. Fine-grained material and sand dominate the bed and banks of the main channel. Coarser sediment (sand/gravel) is generally transported through the main channel and finer material in the anabranches. Stream power is low due to the low channel gradient and anabranch streams decrease the energy of the main channel through conveying a proportion of the flow in flood events. While the main channel is subject to low rates of lateral migration when well-vegetated, peripheral anabranching channels will become activated during times of high flow and can assume the role of the main channel in the event the primary channel becomes significantly blocked as a result of sedimentation or debris jams.

The anabranching low sinuosity, sand system identified in the mine area encompasses the Carmichael River and its distributary anabranch Cabbage Tree Creek.

The Carmichael River exhibits a low sinuosity channel with wide, continuous floodplains and relatively well-vegetated stable banks composed of cohesive fine-grained material. The channel is of low gradient (approximately 0.001 m/m) and low energy such that sediment transported is predominantly limited to fine sands, silts and clays largely in suspension. The channel generally holds water in isolated pools between flows separated by riffle/bar complexes composed of sand Plate 1). The low capacity channel allows overbank flows to be readily dissipated across the floodplain surfaces, activating anabranches, flood channels and depositing fine grained sediments on the floodplain.



LEGEND

- Homestead
- Local Road
- Track
- Water Supply Pipeline

Type

- Anabranching, Low Sinuosity Sand
- Channelised Fill
- Low Sinuosity Sand
- Valley Fill

- Rail (West)
- Project (Mine)

Based on or contains data provided by the State of QLD (DNRM) [2013]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:275,000 (at A4)

0 1 2 3 4 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

GHD adani

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project SEIS

Job Number 41-26422
Revision B
Date 13-11-2013

Waterway Types

Figure 3

G:\41\26422\GIS\Maps\MXD\0400_Hydrogeology\41-26422_402_rev_b.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC1690 (2010) / EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); GHD: Monitoring Bores (2013); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013). Created by: BW, CA, IH

Cabbage Tree Creek displays a number of long pools separated by relatively short sections of channel with limited geomorphic diversity, existing as a grass-lined depression within the broader floodplains of the Carmichael River. The banks of pools are generally well-vegetated with a range of grasses, shrubs and trees (Plate 2) and stable. However, in areas subject to high frequency stock access, banks exhibit localised erosion as a result of the impacts of stock on banks including trampling, pugging and the suppression of riparian vegetation.

Plate 1 Downstream view of the Carmichael River displaying sand bars and well-vegetated banks

Plate 2 Downstream view of a pool on Cabbage Tree Creek with well-established riparian vegetation

Low sinuosity sand systems

This waterway type exhibits a single channel inset on both sides within wide, continuous floodplains composed of alluvial sediments. The channel is typically symmetrical and has a low sinuosity with generally gentle bends. Inset benches may be present reflecting channel width adjustments potentially in response to changes in sediment load, flow regimes and/or vegetation associations. The bed consists of sand size sediments creating a planar bed with limited hydraulic diversity due to limited variability in bed form and only scattered low width/depth ratio. As a result, there is no defined pool riffle sequence associated with these systems. Minor scour pools are associated with the presence of vegetation growing within the channel or accumulations of large woody debris.

Due to the lack of bedrock control, these systems have the capacity to adjust freely. In particular, channel migration occurs on occasional bends through bank erosion of the outside bend and deposition on the inside bends forming point bars. The banks are composed of sandy silt sediments and are prone to erosion by flows when riparian vegetation is disturbed or removed. Additionally, 'breakaways' (gullying of channel banks) can form within the banks where concentrated flood flows or local run-off drains over the banks into the channels. These systems can also incise if disturbed, causing significant alteration to stream form and releasing sediment to downstream reaches.

Low sinuosity sand systems are located in the eastern section of the mine area along the downstream of the tributaries draining to Laguna and 8 Mile Creeks (Plate 3).

Plate 3 Upstream view of a low sinuosity sand section along the second order tributary of 8 Mile Creek

Channelised fill systems

Channelised fill is characterized by a continuous channel of low sinuosity that has incised within flat and featureless floodplains. These systems are inferred to have generally incised since European settlement due to disturbances such as catchment clearance, road and track crossings and disturbance of riparian vegetation. Headcuts, which are usually the process of the channeling, will progress upstream as a result of disturbances and unprotected banks will erode during times of higher flow (Plate 4). Most channels have incised to a point where all flows are contained within the channel such that the former fill surfaces are rarely inundated. Downstream reaches are subject to the accumulation of sand sourced from the ongoing erosion and incision of channels upstream (Plate 5). As a result, these systems have limited in-channel geomorphic diversity, often exhibiting a planar bed of sand.

The channelised fill systems are found throughout the mine area along first to second order drainage lines.

Plate 4 Upstream view of a channelised fill in the northern part of the mine area

Plate 5 Upstream view of a stable channelised fill section exhibiting evidence of sand accumulation from the release of sediment from ongoing upstream incision processes

Valley Fill Systems

These systems are characterised by a relatively flat, featureless valley floor surface that lacks a continuous, well-defined channel (Plate 6). Substrates are comprised of alluvial sands, silts and muds vertically deposited out of suspension as flow dissipate (Plate 7) and sediment transport competence is lost. Material eroded from the catchment is not transported through the reach resulting in the long-term deposition and storage of sediment. Hence, these stream types act as long term sediment accumulation zones. Degradation of these systems generally occurs through incisional processes such that a continuous channel forms within the valley floor sediments. Once incised, recovery back to an intact valley system is limited.

Valley fill systems are found throughout the mine area along first to second order drainage lines.

Plate 6 Upstream view of a valley fill along a first order tributary of 8 Mile Creek

Plate 7 Downstream view of a valley fill showing dissipation of flow across the flat fill surface

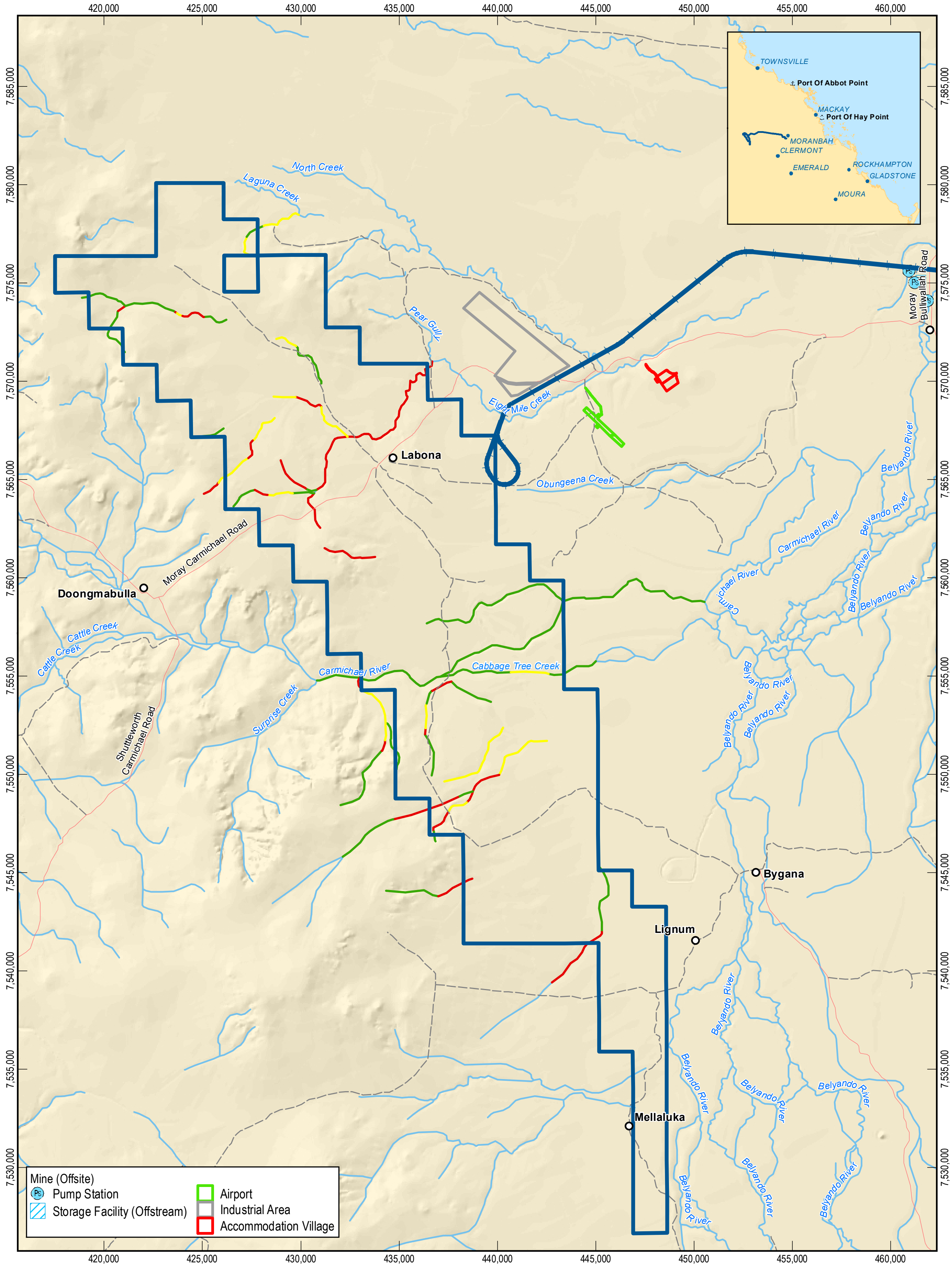
3.4 Geomorphic condition

The geomorphic condition of the assessed streamlines in the mine area is displayed in Figure 4. Poor condition reaches are largely associated with the channelised fill waterway type in the mine area. Headcuts, network gullying (Plate 8) and evidence of past incision is prevalent along these reaches. Downstream reaches are therefore subject to the accumulation of largely sand sediment sourced from the ongoing erosion and incision of channels upstream.

Plate 8 Aerial view of network gullying in the northern section of the mine area

Of the first to second order streamlines, good condition reaches are largely associated with the valley fill waterway types. However, several of these reaches are under threat of incision as gully heads progress upstream.

The Carmichael River through the mine area is also considered to be in good condition displaying limited evidence of erosion and a wide, continuous well-structured riparian zone. Cabbage Tree Creek is also considered to be in largely good condition, with a 2 km reach in moderate condition where bed and bank erosion is evident.



LEGEND

- Homestead
- Local Road
- Track
- Water Supply Pipeline

Condition
- Good
- Moderate
- Poor

- Rail (West)
- Project (Mine)

Based on or contains data provided by the State of QLD (DNRM) [2013]. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for marketing or be used in breach of the privacy laws.

1:275,000 (at A4)
0 1 2 3 4 5
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project SEIS

Job Number	41-26422
Revision	B
Date	13-11-2013

Geomorphic condition of waterways

Figure 4

G:\41\26422\GIS\Maps\MXD\0400_Hydrogeology\41-26422_403_rev_b.mxd

Level 9, 145 Ann St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DME: EPC1690 (2010) / EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); GHD: Monitoring Bores (2013); Adani: Project Rail 1 (Opt11 Rev2) & 2 (Opt9 Rev3), Facilities (2013). Created by: BW, CA, IH

4. Impact Assessment

4.1 Overview

Based on a review of the proposed layout and description of the Project (Mine), the potential key components of the Project (Mine) that could impact on the geomorphology of waterways include:

- Construction of diversion drains
- Construction of flood levees along and a bridge across the Carmichael River
- Subsidence effects of underground mining
- Construction and/or upgrade of temporary and/or permanent waterway vehicular crossings.

The potential impacts and significance of each of the above on waterway geomorphology are discussed in the following sections.

4.2 Diversion drains

As detailed in the Conceptual Flood Mitigation and Creek Diversion Design (GHD, 2013), diversion drains have been proposed to direct external catchment flows around open cut pits, subsidence affected areas and spoil dumps at various locations. There is currently no proposal to divert any determined watercourses as defined under the *Water Act 2000*.

Diversion drain design criteria have included:

- Drains to carry 100 year ARI capacity
- Drain banks to have 1 to 3 slope batters
- Drain to have a minimum grade of 0.2 percent
- Hydraulic constraints as described in the departmental regional guideline entitled Central West Water Management and Use Regional Guideline: Watercourse Diversions – Central Queensland Mining Industry Version 5 (DEHP, 2011), namely:
  - A reach average channel flow velocity that does not exceed 2.5 m/s in the 1 in 50 Year ARI.
  - A reach average shear stress that does not exceed 80 N/m^2 in the 1 in 50 Year ARI

As part of the conceptual design of the diversions, HEC-RAS hydraulic modelling was undertaken for 100 Year ARI flow conditions. The results of this modelling are provided in the Conceptual Flood Mitigation and Creek Diversion Design (GHD, 2013) and indicate that the diversions generally meet the DERM (2011) criteria. In instances where the criteria are exceeded, recommendations are provided for refinement of the diversions for consideration during detailed design. These recommendations include provision of drop structures and/or scour protection measures, implying that the diversions could be constructed and maintained as stable systems.

However, it is recognised that many of the existing waterways in the mine area display evidence of past and ongoing erosion through gullying and erosion. As a result, the long-term stability of the diversions cannot be assured even where they comply with the DERM (2011) criteria. It is therefore recommended that further consideration for limiting erosion potential be placed on the entire length of the diversions. This will need to consider the erodibility of the natural bounding materials that channels would be excavated into in context with the predicted flow hydraulics allowing selection of appropriate treatments for stabilising the diversion channels. Nevertheless, the general compliance with the DERM (2011) criteria suggests that 'soft-engineering' approaches to stabilisation such as top-soiling and revegetation are likely to be viable options for stabilisation of a large proportion of the lengths of the diversions.

The diversion discharge points have also been designed to closely mimic existing drainage paths and where possible maintain inflows to downstream waterways to the east of the mine area. This will limit impacts on catchment areas and hydrological regimes and the subsequent potential impacts on downstream sediment transport and scour processes.

In respect to downstream sediment delivery, the effect of the diversions may be potentially beneficial, particularly if the diversions can be maintained as stable systems with limited erosion. This will effectively replace existing waterways currently undergoing considerable gullying and channelisation with stable systems and thereby reduce the existing elevated sediment loads to downstream reaches.

4.3 Carmichael River levees and bridge

The key components of the Project (Mine) that could directly impact on the geomorphology of the Carmichael River are:

- The provision of levees either side of the Carmichael River corridor. These extend out from the bunded area to protect additional area for the mine from river flooding and to improve the shaping of the constriction, whilst allow allowing flows to enter the head of the Cabbage Tree Creek effluent flow path.
- The provision of a bridge to allow passage of the haul road and conveyor over the Carmichael River.

In addition, proposed diversion drains will discharge into the Carmichael River where it flows through the Project (Mine) area.

The combined effect of the above on hydraulic conditions along the Carmichael River has been modelled for the 10, 50, 100 and 1,000 year ARI design flows. The results of this modelling are outlined in the supporting information "Preliminary Flood Mitigation and Creek Diversion Design" and indicate the following velocity changes along the Carmichael River between existing and developed conditions:

- In terms of velocity afflux, the results show that the proposed mine infrastructure will generally reduce or cause only a minor increase (less than 0.1 m/s) in the velocity throughout the model, except in some localised areas. The areas of increase are generally along the proposed diversion drains (and/or upstream of the proposed top soil spoil piles), through the crossings (bridge and culverts) under the haul road, and immediately downstream of the crossings (especially along the Carmichael River). The most significant change in terms of magnitude is along the diversion drains, which generally show increases in excess of 0.5 m/s, and the biggest change in terms of area is at and downstream of the Carmichael River bridge (which generally shows an increase of between 0.1 and 0.5 m/s).

- The velocity afflux in the 50 year ARI event shows a similar trend to the 10 year ARI event, with an increase in the magnitude of the changes in velocity in the localised areas of increase. At the Carmichael River Bridge, the velocities increase by up to 0.9 m/s. This event also identifies two additional areas of increased velocities, one immediately upstream of the haul road crossing along Drain 8 and one just downstream of the point of greatest constriction between the Carmichael River levees.
- The velocity afflux in the 100 year ARI event shows the same general areas of change as the 50 year ARI event with an increase in the magnitude of the velocity changes in these localised areas. The largest increases are as follows:
  - At the Carmichael River bridge and culverts, which show a velocity increase of up to 1.5 m/s and in excess of 2 m/s respectively
  - Just downstream of the point of greatest constriction between the Carmichael River levees.

  These results also identify an additional area of increased velocities where flow bypasses the modelled haul road via the marginally lower terrain between Drain 5 and the Carmichael River.
- The velocity afflux in the 100 year ARI event shows the same general areas of change as the 50 year ARI with an increase in the magnitude of the velocity changes in these localised areas. The largest increases are as follows:
  - At the Carmichael River bridge and culverts, which show a velocity increase of up to 1.5 m/s and in excess of 2 m/s respectively
  - Just downstream of the point of greatest constriction between the Carmichael River levees.

These results also identify an additional area of increased velocities where flow bypasses the modelled haul road via the marginally lower terrain between Drain 5 and the Carmichael River.

The predicted velocity changes have the potential to alter patterns of sediment transport, scour and deposition along the Carmichael River through the mine area. While the greatest velocity increases will be experienced at the bridge opening and embankment culverts, appropriate scour counter measures will be provided. The extents to which these measures extend upstream and downstream will be considered during the detailed design phase.

Elsewhere, the increases in velocities are not considered to be of sufficient magnitude to result in any significant change in the extent or severity of erosion along the channel of the Carmichael River. Typically flow velocities remain in the same general range under developed conditions as to those under existing conditions. For example, under the 100 Year ARI flow conditions, flow velocities largely range from 1.5 to 3.0 m/s for both existing and developed conditions along the channel in the reach subject to flow constriction by the levees. Given velocities under developed conditions do not increase beyond the range of those for existing, it is expected that any impacts will be limited to very localised adjustments in scour patterns under infrequent, higher magnitude events (i.e. > 50 Year ARI), with no significant impact on the overall morphological form and functioning of the Carmichael River.

The predicted reduction in flow velocities under developed conditions upstream of the bridge crossing structure could result in reduced sediment transport capacity leading to the infilling of any pools and channel aggradation. However, the Carmichael River dominantly transports sediment in suspended load and flow velocities under developed conditions for all events modelled are maintained at above 1.5 m/s within the channel upstream of the bridge. This velocity is capable of retaining fine sand, mud and silt in suspension as well transporting coarse sand and gravel as bedload. Further, the effect of the bridge structure beyond the immediate area of the opening on flow velocities for frequent, lesser magnitude flood events (i.e. < 10 Year ARI) is almost negligible. Hence, the sediment transport and pool flushing capacity of these events will be maintained. Therefore, the propensity for any significant channel aggradation and pool infilling in the channel upstream of the bridge is considered low.

Only localised minor erosion and aggradation is expected along the Carmichael River in response to the proposed development, with the greatest impact in the vicinity of the bridge structure. Further, the location of the Carmichael River levees used in this SEIS flood study has remained consistent with the location and previous flood study undertaken for the EIS. Whilst there has been some adjustments to the sections of the levees that approach or angle away from the Carmichael River, the levees running parallel to the river remained the same for the EIS flood modelling. As an outcome of the SEIS flood modelling process, and as a result of refinements to the Mine Plan and staging, it was identified that the northern levee parallel to the Carmichael River could be moved further from the river channel, ensuring that the setback to the river is increased. Hence this is likely to minimise predicted afflux and velocity impacts within this vicinity.

Given potential impacts on the morphology of the Carmichael River are expected to be low, it is considered appropriate that these risks be managed through the development and implementation of a morphological monitoring and action response program. .

4.4 Subsidence effects

Due to subsidence the topography within the mine area above the underground workings will change. Essentially subsidence will result in a series of linear depressions (above the centre of long-walls and ridges (above chain pillars). With this drainage patterns in the affected areas will change as well. In general, the proposed drainage concept diverts as much water around the areas of predicted subsidence to reduce the importance of surface water management in these areas.

There is however some areas of predicted subsidence where diversions are not practical and water will pass through these areas generating pools that will rely on either evaporation or infiltration losses. To address this, a series of low flow connection channels through the ridges are proposed to link depressed areas and provide an outlet at the downslope extent of the subsided affected areas. Without mitigation, under high rainfall events pools in upstream depressions could overtop into downslope depressions resulting in the potential for the uncontrolled erosion of the ridges separating depressions.

Additionally, existing gullying and erosion within subsided affected areas could also result in the erosion of the ridges separating depressions, leading to the uncontrolled passage of water within the subsided area. This will be of particular importance on the upslope most subsidence trough overlying the far western longwall panels, where the increased gradient of the landscape on the upslope side of the depression may initiate of exacerbate erosion. This may lead to gullying that retreats upslope away from the subsided areas and potentially off the mine area. It is recommended that an assessment of the distribution of existing gullying and erosion in relation to the predicted post subsidence landform be undertaken in subsidence affected zones.

This will allow targeting of areas that may require monitoring or treatment to limit erosion either prior to or immediately following subsidence.

4.5 Vehicular crossings

The Project (Mine) will require the construction of temporary or permanent waterway vehicular crossings for new roads and/or the upgrade of existing waterway vehicular crossings. Construction of waterway road crossings could cause or exacerbate local bed and bank interferences.

The potential for initiating bed and bank instabilities can be minimised through adoption of the following recommendations in the design and construction of waterway crossings:

- Wherever possible, waterways should be crossed on a straight portion of the waterway to avoid the risk of erosion. Where this is not possible bank stability works may be implemented
- Avoid impeding flows through selection of an appropriate crossing type. Causeway crossings inset so that they are flush with the channel profile present the best means for crossing small waterways. For culvert crossings, the hydraulic capacity of the culvert should be equivalent to the channel capacity of the waterway, or at least equal to the hydraulic capacity of the waterway below the level of the road surface
- Avoid concentrating or redirecting flow on the outlet of crossings. Where this is not possible, appropriate scour protection measures will need to be provided
- Avoid the need for access of heavy machinery to the bed of the waterways as works should be undertaken from the top of the banks where possible
- Avoid disturbance of surrounding banks by machinery or other construction works. Vegetation clearance should be avoided where possible to protect soils from erosion. If clearance cannot be avoided, the area of vegetation cleared at any one time should be minimised
- Stabilise disturbed areas and reinstate vegetation as quickly as practicable after construction.

With implementation of the above recommendations, the impact of vehicular crossings on the geomorphology of waterways is considered low.

5. Summary and recommendations

5.1 Existing environment

Most waterways within the mine area are first and second order streamlines. The exceptions are the Carmichael River and Cabbage Tree Creek which are both considered 5th order streamlines.

A total of four different stream types were identified during the desktop and field assessment of the waterways within the study area as follows:

- Anabranching, low sinuosity, sand systems
- Low sinuosity, sand systems
- Channelised fill systems
- Valley fill systems

These stream types are low to moderate energy systems reflective of the relatively gentle gradients and intermittent flow regimes of the waterways. As a result, the waterways transport sediment largely in suspended load and are generally stable. However, it is evident that active erosional processes (gully head retreat and sidewall erosion) is continuing along first and second streamlines (channelised fill systems) in the mine area.

5.2 Impacts and recommendations

The potential key components of the Project (Mine) that could impact on the geomorphology of waterways include:

- Construction of diversion drains.
- Construction of flood levees along and a bridge across the Carmichael River.
- Subsidence effects of underground mining.

This assessment has determined that the on-site and downstream significance of these potential impacts will be negligible to low with implementation of the following recommendations:

- During the detailed design of the diversion drains the erodibility of natural bounding materials of excavated channels in context with the predicted flow hydraulics will need to be considered for selection of appropriate treatments for stabilising the diversion channels
- An assessment of the distribution of existing gullying and erosion in relation to the predicted post subsidence landform is recommended to be undertaken in subsidence affected zones. This will allow targeting of areas that may require monitoring or treatment to limit erosion either prior to or immediately following subsidence
- Develop and implement a morphological monitoring and action response program for the Carmichael River and Cabbage Tree Creek within the mine area
- As an outcome of the flood modelling process, and as a result of the Mine Plan and staging, it was identified that the northern levee parallel to the Carmichael River could be moved further from the river channel than is currently shown. This measure is likely to reduce the predicted afflux and velocity impacts in the Carmichael River.

- The potential for initiating bed and bank instabilities at waterway crossings can be minimised through adoption of the proposed mitigation measures.

6. References

ACARP, 2000. Maintenance of Geomporphic Processes in Bowen Basin River Diversions, Project C8030.

ACARP, 2001. Monitoring and Evaluation Program for Bowen Basin River Diversions. Project CP9068.

Brierley G and Fryirs K (2005). Geomorphology and River Management: Applications of the River Styles Framework. Blackwell Publishing, Oxford, UK, 398pp

DERM, 2011. Central West Water Management and Use Regional Guideline, Watercourse Diversions – Central Queensland Mining Industry.

DNRM, 2013. Watercourse Determinations for the Carmichael Coal Mine Project Area, Offsite Infrastructure Area and Rail Project Area

Geosciences Australia, 2007. Spatial dataset. Data source – Watercourse.

GHD, 2013. Preliminary Flood Mitigation and Creek Diversion Design

Outhet, D. and Cook, N. (2004). “Definitions of Geomorphic Condition Categories for Streams” Unpublished internal draft paper for use throughout NSW by the Department of Infrastructure, Planning and Natural Resources

Strahler, A. N., 1952. "Hypsometric (area-altitude) analysis of erosional topology", Geological Society of America Bulletin 63 (11): 1117–1142

Appendices

Appendix A – DNRM Desktop Study Watercourse Determinations

Author: Kylie Cronk
File number: EME/650/006
Unit: Major Development Projects
Phone: 07 4987 9302

Queensland Government

17 May 2013

Hamish Manzi
General Manager - Environment and Sustainability
Adani Mining Pty Ltd
GPO Box 2569
BRISBANE QLD 4001

Dear Mr Manzi,

Watercourse Determinations for the Carmichael Coal Mine Project Area, Offsite Infrastructure Area and Rail Project Area

Two watercourse determination requests were provided to the Department of Natural Resources and Mines (the department) via email on 11 April 2013 in relation to the above. It is to be noted that one of the requirements of a watercourse determination request, is that the request must be made by an owner of land, an acknowledged representative of the owner the land (i.e. legal representative or consultant), or if not made by the owner or owner's representative the request is to be accompanied by the owner's consent. Under the *Water Act 2000* (the Water Act), an owner includes an applicant for, or the holder of, a mineral development licence (MDL) or mining lease (ML) under the Mineral Resources Act 1989.

Therefore, a watercourse determination desktop assessment was completed for the features requested and within land in which Adani Mining Pty Ltd owns i.e. Mining Lease application (MLA) 70441, MLA 70490, MLA 70487 and the "Moray Downs" property. The object of the assessment was to determine which features specified in the request are considered watercourses as defined under the Water Act.

The department included two additional features in the watercourse determination assessment which were not included in the request. These two unnamed features were the topic of previous discussions and were therefore included as part of this watercourse determination assessment.

The department reviews the implementation of legislation under the Water Act to reflect current opinion, legal advice and decisions of the Land Court. A watercourse as defined under the Water Act must have certain characteristics of a channel of a river, creek or other stream between the outer banks laterally and between upstream and downstream limits longitudinally. It does not include a drainage feature and must have flow that persists after

Department of Natural Resources and Mines

State Government Building
99 Hospital Road
PO Box 19
EMERALD QLD 4720

Telephone (07) 4987 9300
Facsimile (07) 4987 9333
Website www.dnrm.qld.gov.au
ABN 59 020 847 551

rain has ceased. The determination has been made in accordance with current legislation and departmental guidelines.

Following the desktop assessment and taking the above into consideration, the subsequent determinations have been made.

The following features, specified in the request and within the area of interest have been previously determined watercourses as defined in the Water Act.

- Carmichael River
- Belyando River
- Logan Creek

It was determined that the following features, specified in the request and within the area of interest, exhibit the characteristics of a watercourse as defined in the Water Act.

- Dyllingo Creek
- Surprise Creek
- Mistake Creek

It was determined that the following features, specified in the request and within the area of interest, do not exhibit the characteristics of a watercourse as defined in the Water Act and are therefore considered to be drainage features that facilitate overland flow.

- Laguna Creek
- Pear Gully
- Obungeena/Ogenbeena Creeks

It was determined that the following features, which were not specified in the request but have been the topic of previous discussions and are within the area of interest, do not exhibit the characteristics of a watercourse as defined in the Water Act and are therefore considered to be drainage features that facilitate overland flow (refer to the attached map showing the location of these drainage features).

- unnamed feature located to the south of MLA70441
- unnamed feature located to the north of MLA70441

A conclusive watercourse determination for the following features was unable to be made during the desktop assessment. It is recommended that a delegated officer under the Water Act complete a site inspection to finalise the determination of these features.

- Cabbage Tree Creek
- Eight Mile Creek
- North Creek

Please note, while Cattle Creek, Gowrie Creek and Grosvenor Creek were requested to be determined, they were not included in the watercourse determination desktop assessment, as they are located on land where Adani Mining Pty Ltd are not considered to be the owners of that land. As the watercourse determinations for Gowrie Creek and Grosvenor Creek are associated with the construction of the rail, it is advised that you read the guideline - activities in a watercourse, lake or spring associated with a resource activity or mining operations - WAM/2008/3435 and where the guideline cannot be complied with in these locations, then future watercourse determinations may be required to determine legislative requirements. The guideline can be downloaded from the internet at http://www.derm.qld.gov.au/about/policy/documents/3435/attachments/guideline-3435-act-wls-assoc-mining-v3-20120712.pdf. If a watercourse determination is still required for Cattle Creek, please ensure the request is accompanied by the owner's consent.

Any proposed take of, or interference with water or any proposed activity within the abovementioned watercourses must be in accordance with the provisions of the Water Act and associated subordinate legislation. Any capture of overland flow must be in accordance with the provisions of the relevant Water Resource Plan.

It is requested that Adani Mining Pty Ltd acknowledge receipt of this decision and advice.

Please contact me at the Emerald Office on 4987 9302 to organise a site inspection by a delegated officer of the Water Act to assist in completing the watercourse determinations of Cabbage Tree Creek, Eight Mile Creek and North Creek, or if you require anything further regarding the watercourse determinations.

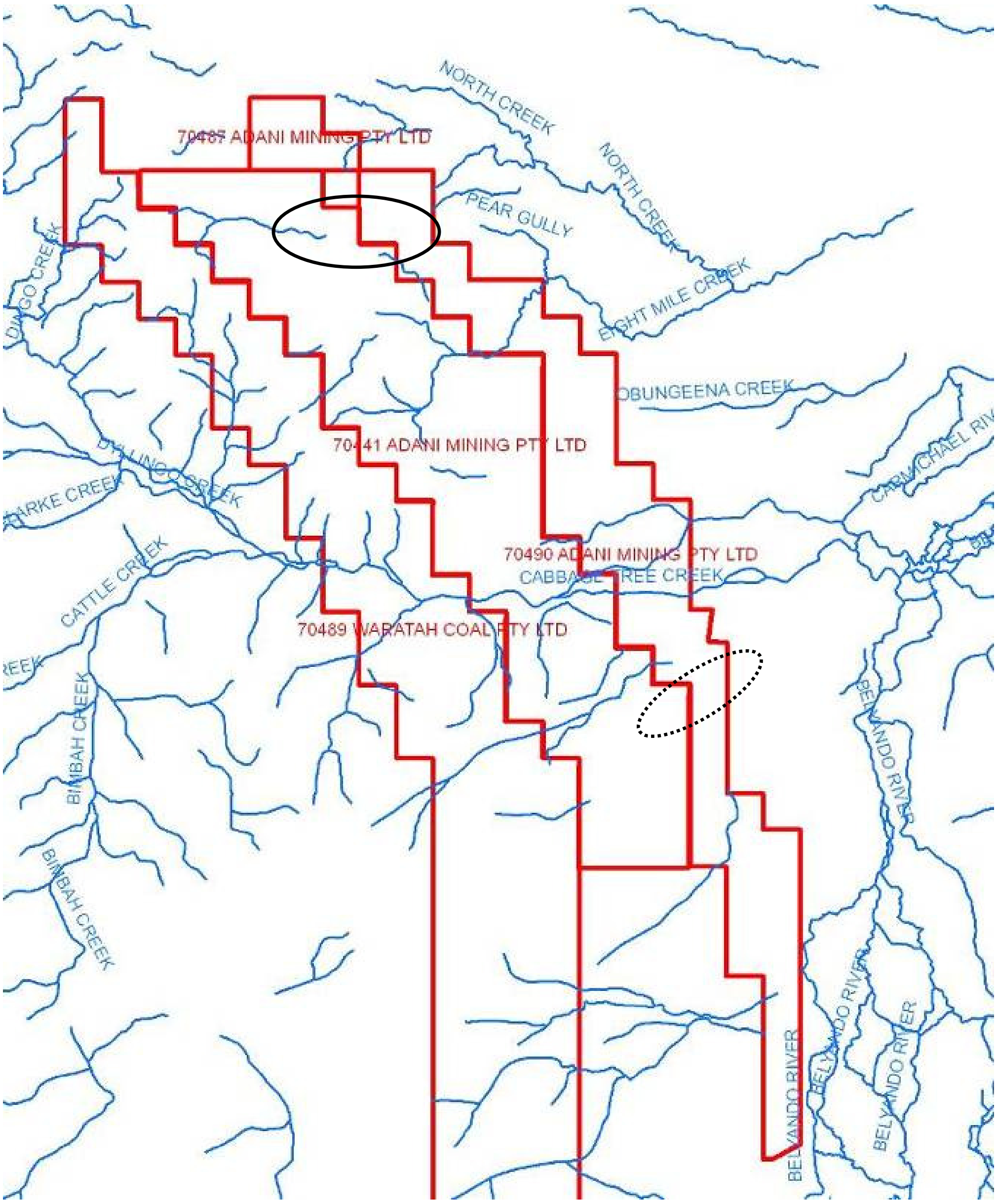
Yours Sincerely

Kylie Cronk
SENIOR ADVISOR REGULATORY SERVICES
CENTRAL REGION

Attachments:

- Attachment 1 - Statement of Reasons
- Attachment 2 - Map showing the location of the unnamed feature located to the south of MLA70441 and the unnamed feature located to the north of MLA70441

Attachment 2 Map showing the location of the unnamed feature located to the south of MLA70441 (within the dotted black circle) and the unnamed feature located to the north of MLA70441 (within the bold black circle)



Author: Lenny Cummings
File number: EME/650/006
Unit: Water Management & Use
Phone: 07 4987 9310

Queensland Government

8 August 2013

Hamish Manzi
General Manager - Environment and Sustainability
Adani Mining Pty Ltd
GPO Box 2569
BRISBANE QLD 4001

Dear Mr Manzi,

Watercourse Determinations for the Carmichael Coal Mine Project Area, Offsite Infrastructure Area and Rail Project Area

Two watercourse determination requests were provided to the Department of Natural Resources and Mines (the department) via email on 11 April 2013 in relation to the above.

A desktop assessment was completed by a departmental officer on 7 May 2013, and a letter and statement of reasons was forwarded to you on 17 May 2013, regarding the outcome of the desktop assessment. The letter advised that a conclusive watercourse determination for Cabbage Tree Creek, North Creek and Eight Mile Creek was unable to be made during the desktop assessment. It was recommended that a delegated officer under the *Water Act 2000* (Water Act) complete a site inspection to finalise the determination of these features.

A delegated officer under the Water Act completed a site inspection on 24 July 2013. This letter and attached statement of reasons advises on the decision made on the watercourse determinations for Cabbage Tree Creek, North Creek and Eight Mile Creek, and the reasons for the decision.

The department reviews the implementation of legislation under the Water Act to reflect current opinion, legal advice and decisions of the Land Court. A watercourse as defined under the Water Act must have certain characteristics of a channel of a river, creek or other stream between the outer banks laterally and between upstream and downstream limits longitudinally. It does not include a drainage feature and must have flow that persists after rain has ceased. The determination has been made in accordance with current legislation and departmental guidelines.

Department of Natural Resources and Mines

State Government Building
99 Hospital Road
PO Box 19
EMERALD QLD 4720

Telephone (07) 4987 9300
Facsimile (07) 4987 9333
Website www.dnrm.qld.gov.au
ABN 59 020 847 551

As a result of the site inspection and taking the above into consideration, it has been determined that the following features exhibit the characteristics of a watercourse as defined in the Water Act.

- North Creek between approximate bearings:
  21° 55’ 10.7” S 146° 23’ 28.4” E and 21° 55’ 56.4” S 146° 32’ 59.6” E

- Cabbage Tree Creek between approximate bearings:
  22° 06” 24.1” S 146° 23” 57.4” E and 22° 06” 33.0” S 146° 25” 25.7” E
  22° 06” 26.3” S 146° 26” 11.6” E and 22° 06” 15.2” S 146° 27” 44.4” E
  22° 05” 45.7” S 146° 28” 33.9” E and 22° 05” 58.7” S 146° 29” 33.4” E

While Cabbage Tree Creek ceases to exist in parts it does possess 3 significant features along its extremity, which can be described as waterholes. It is at these locations where the feature is a watercourse as defined in the Act as they have bed and banks and a degree of permanency within them.

It was determined that the following feature does not exhibit the characteristics of a watercourse as defined in the Water Act and is therefore considered to be a drainage feature that facilitates overland flow.

- Eight Mile Creek

Any proposed take of, or interference with water or any proposed activity within the abovementioned watercourses must be in accordance with the provisions of the Water Act and associated subordinate legislation. Any capture of overland flow must be in accordance with the provisions of the relevant Water Resource Plan.

It is requested that Adani Mining Pty Ltd acknowledge receipt of this decision and advice.

Please contact me at the Emerald Office on 4987 9302 if you require anything further regarding the watercourse determinations, or if you require further information on associated regulatory requirements.

Yours Sincerely

Kylie Cronk
SENIOR ADVISOR REGULATORY SERVICES
CENTRAL REGION

Attachments:
- Attachment 1: Statement of Reasons

Attachment 1

Statement of Reasons

Under the *Water Act 2000* (Water Act) all rights to the use, flow and control of all water in Queensland are vested in the State. An important part of administrating the Water Act is determining the State's jurisdiction over water.

Request for watercourse determination – Carmichael Coal Mine Project Area, Offsite Infrastructure Area and Rail Project Area

On 11 April 2013 the Department of Natural Resources and Mines (the department) received two requests by Hamish Manzi from Adani Mining Pty Ltd to complete watercourse determinations on features within the proposed Carmichael Coal Mine Project Area, Offsite Infrastructure Area and Rail Project Area.

A desk top assessment was carried out by departmental officers and some of the requested features were assessed and determined. However, a conclusive watercourse determination for Cabbage Tree Creek, North Creek and Eight Mile Creek was unable to be made during the desktop assessment and it was recommended that a delegated officer under the Water Act complete a site inspection to finalise the determination of these features.

A delegated officer under the Water Act completed a site inspection of the abovementioned features on 24 July 2013.

This Statement of Reasons is given in accordance with the Water Act in respect of the decisions made in response to the above requests and the corresponding site inspection.

Decision

The department delegates officers to exercise the power of the chief executive to make decisions about requests for the determination of watercourses for the purposes of the Water Act.

As a delegated officer of the chief executive, I have decided that the following.

As a result of the site inspection, it has been determined that the following features exhibit the characteristics of a watercourse as defined in the Water Act.

- North Creek between approximate bearings:
  21° 55' 10.7" S 146° 23' 28.4" E and 21° 55' 56.4" S 146° 32' 59.6" E

- Cabbage Tree Creek between approximate bearings:
  22° 06" 24.1" S 146° 23" 57.4" E and 22° 06" 33.0" S 146° 25" 25.7" E
  22° 06" 26.3" S 146° 26" 11.6" E and 22° 06" 15.2" S 146° 27" 44.4" E
  22° 05" 45.7" S 146° 28" 33.9" E and 22° 05" 58.7" S 146° 29" 33.4" E

As a result of the site inspection, it has been determined that the following feature does not exhibit the characteristics of a watercourse as defined in the Water Act and is therefore considered to be a drainage feature that facilitates overland flow.

- Eight Mile Creek

This Statement of Reasons is advice of my decision and the reasons for the decision.

Evidence on which those findings were based (material considered)

In making my decision, I had regard to the following material:

- The requests for a watercourse determination made on 11 April 2013 by Hamish Manzi, General Manager - Environment and Sustainability, Adani Mining Pty Ltd
- The Water Act Section 5;
- The Water Act, Schedule 4 – Dictionary;
- The Water Regulation 2002, Section 3A;
- Desktop investigation completed by departmental officer, Sandra Grinter, on 7 May 2013;
- Site inspection completed by departmental officer, Lenny Cummings, on 31 July 2013;
- Site inspection report completed by departmental officer, Lenny Cummings, on 1 August 2013;
- Aerial imagery obtained from the departmental SPOT 2009 imagery, aerial photographs and Google Earth;
- Maps: 100K Topo Map, 250K Geology Map, digitised layers of cadastral boundaries (DCDB layer), 100K and 250K drainage layer, Regional Ecosystem v.6.0 and HVR Maps;
- A search of the Water Management Systems (WMS) and WERD database for existing water entitlements and works;
- Previous watercourse determinations;
- *Carmichael Coal Mine and Rail Project: Mine Technical Report - Mine Aquatic Ecology Report 23244-D-RP-0025* 16 November 2012 Revision 1 by GHD for Adani Mining Pty Ltd – Volume 4 Report O1 for the Adani EIS; and
- An investigation report sent to departmental officer Kylie Cronk on 30 April 2013 *Water Act 2000 Watercourse Determination & Riverine Protection Permit Review for Carmichael Coal Project (Rail) Separable Portion 1* dated 22 March 2013 by Saunders Havill for Adani Mining Pty Ltd.

Findings on material questions of fact

In making my decision, I made the following findings of fact:

- The requests for a watercourse determination made on 11 April 2013 by Hamish Manzi, General Manager - Environment and Sustainability, Adani Mining Pty Ltd.
- Parts of North Creek and Cabbage Tree Creek (waterholes) exhibit the characteristics of a watercourse as defined in the Water Act.
- Eight Mile Creek is considered to be drainage feature that facilitates overland flow.
- Previous watercourse determinations have been considered in making the decision.
- The watercourse determinations do not have an impact on any existing entitlement holders.
- The watercourse determinations do not have an impact on any existing infrastructure, as it is located off the main channel.
- Information from the two reports, *Carmichael Coal Mine and Rail Project: Mine Technical Report - Mine Aquatic Ecology Report 23244-D-RP-0025* 16 November 2012 Revision 1 by GHD for Adani Mining Pty Ltd – Volume 4 Report O1 and *Water Act 2000 Watercourse Determination & Riverine Protection Permit Review for Carmichael Coal Project (Rail) Separable Portion 1* dated 22 March 2013 by Saunders Havill for Adani Mining Pty Ltd has been considered in making the decision.

Reasons for the Decision

- I made the decision to determine that there are reaches of North Creek and Cabbage Tree Creek (waterholes) that exhibit the characteristics of a watercourse as defined in the Water Act.
- I made the decision to determine that Eight Mile Creek does not exhibit the characteristics of a watercourse as defined in the Water Act.
- The decision is in accordance with the definition provided in the Water Act and is consistent with departmental work practices.

Kylie Cronk
Senior Advisor Regulatory Services
Central Region

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000 F: (07) 3316 3333 E: bnemail@ghd.com

G:\41\26422\Tech\Water Resources\Geomorphology\450550 Draft Mine geomorphology report Appendix A_13112013.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	G Lampert	S. Hein	DRAFT	J Keane	DRAFT	26/07/2013
0	G Lambert	S Hein	On file	J Keane	On file	31/07/2013
1	M Goodall	J Keane	On file	J Keane	On file	22/10/2013
2	J Keane	J Keane		J Keane		14/11/2013

GHD

145 Ann Street Brisbane QLD 4000
GPO Box 668 Brisbane QLD 4001
T: (07) 3316 3000   F: (07) 3316 3333   E: bnemail@ghd.com

G:\41\26422\WP\449771.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	N Webb	S Hein	DRAFT	J Keane	DRAFT	27/07/2013
B	N Webb	S Hein	DRAFT	J Keane	DRAFT	31/07/2013
0	N Webb	S Hein	On file	J Keane	On file	01/08/2013
1	S Hein	J Keane	On file	J Keane	On file	22/10/2013
2	J Keane	J Keane		J Keane		14/11/2013

www.ghd.com