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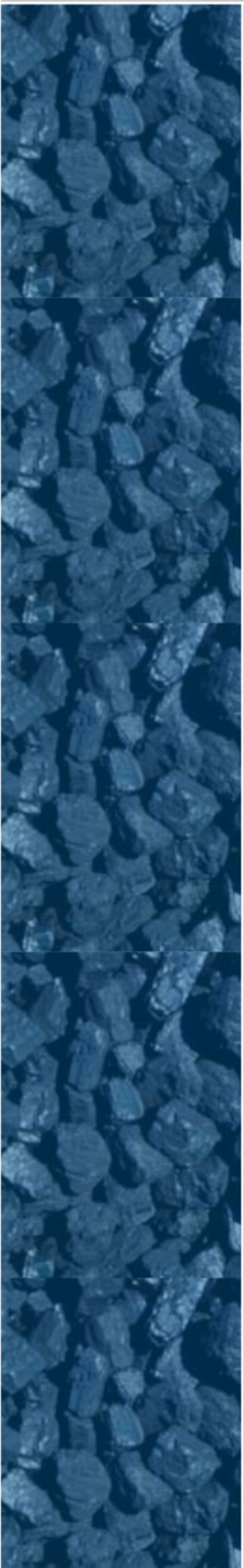

Adani Mining Pty Ltd

Report for Carmichael Coal Mine and Rail Project

Hydrology Report 25215-D-RP-0021

18 September 2012

Revision 2

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Abbreviations and Glossary

Project Specific Terminology	
Abbreviation/ Term	**Definition**
the EIS	Carmichael Coal Mine and Rail Project Environmental Impact Statement
the Proponent	Adani Mining Pty Ltd
the Project (Mine)	Carmichael Coal Mine and Rail Project: Mine Component
the Project (Rail)	Carmichael Coal Mine and Rail Project: Rail Component
Generic Terminology	
Abbreviation/ Term	**Definition**
AHD	Australian Height Datum
ARI	Average Recurrence Interval
Afflux	Afflux is the rise level at a defined point due to a particular set of engineering works.
Base flow	The component of stream flow that can be attributed to ground-water discharge
Brigalow	*Acacia harpophylla* a species of silvery wattle that is the dominant native tree species of the upper catchments of the Burdekin River in Queensland.
Bund	A modest earthen embankment often formed to redirect surface water.
Causeway	A raised path or road, as across wet ground or water.
Culvert	A covered channel of relatively short length designed to pass water through an embankment (e.g. road, railway, dam).
DERM	Former Department of Environment and Resource Management
Design flood	This is a derived or calculated flow value or hydrograph that is usually assigned a statistical probability such as the 100 year ARI flood, and is used for the purposes of designing engineering works, or determines flood levels.
Diversion	An engineering work that redirects surface water away from where it would naturally flow. Can also mean an abstraction of water from a river.
Drainage density	The total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream channels.
Ephemeral	A creek that does not flow all year round

Flood frequency	The statistical determination of the probability of getting a flood of a particular size based on the historic flood record
Floodplain	Wider channel of a waterway that accommodates flood flows.
Ford	A shallow place in a river or stream that can be crossed on foot or in a vehicle
Groundwater	Water that is underground
Headwaters	The place from which the water in a river or stream originates.
Hydraulic capacity	Measure of the ability of a channel/culvert/etc to convey water.
Hydraulics	The study of flows. In particular the science used to determine the flood level for a particular flood flow rate.
Hydrograph	A hydrograph is a time series set of data showing how the flow in a waterway changes over time. Typically a hydrograph shows how a flood rises and falls.
Hydrology	The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere
Hydrometric data	Recoded data relating to flow in a creek or river, such as flow, water level height
Impervious	A surface through which surface water and rainfall is unable to infiltrate (such as a roof, sealed road or concrete hard stand area).
Intensity Frequency Duration (IFD)	Time based statistical measure of the rate of rainfall expressed in mm/hr or mm of accumulated depth.
Inundation	Inundation means the land is flooded, or covered in flood water, usually temporarily when in a flood context.
Kandosol	A fine sandy soil which has low to moderate agricultural potential with moderate chemical fertility and water-holding capacity.
Low flow	A term to describe flow in a waterway that is generally small by comparison to the average flow for that waterway.
Mainstem	The principal channel of a waterway
MUSIC	Software that provides for designing stormwater quality treatment measures such as infiltration strips and sediment basins.
Peak discharge	The maximum flow rate of a flood
Potable water	Water treated to standard sufficient for drinking.
Raw water	Water taken from the environment, and is subsequently treated or purified to produce potable water.
Strahler stream order	A method devised by AN Strahler to define the size and relative significance of perennial (a stream with water in its bed continuously throughout the year) and recurring (a stream with water in its bed only part of the year) streams.

Sub-catchments	A sub-catchment is a part of a catchment, usually associated with a tributary of the main catchment and therefor defined by the terrain.
Surface water	Any natural flowing water usually in creeks and rivers, i.e. not groundwater
Trigger flow	The specific flow rate usually in a waterway, which when exceeded, allows for the discharge of stored water into the waterway.
Turbidity	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye
Vertosol	A clay soil, is highly dispersive, and has shrink-swell properties that exhibit strong cracking when dry.
Water balance	A model that is used to describe the flow of water in and out of a system.
Weir	A weir is a small overflow dam used to alter the flow characteristics of a river or stream.

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Executive Summary

This report is the Rail Hydrology Report for the Carmichael Coal Mine and Rail Project Environmental Impact Statement. The emphasis of this report is the effects the Project (Rail) on the surface water aspects of 12 major waterway crossings. The majority of these crossings occur over the Belyando River, making it the most significant waterway.

Existing Conditions

This report describes the catchments and rivers that are traversed by the Project (Rail). Key aspects of the existing conditions are:

- Rainfall, and hence typical flows in the rivers, with the wet season from December to April
- A dry season, in which only the larger rivers experience a base flow
- Substantially varying annual rainfall and river flows
- Droughts that can persist for several years
- Extreme flood events, notably the Cyclone Helen floods in January 2008
- Use of existing water resources, generally limited to stock and farm water
- Restricted access to sections of properties and access roads during minor rainfall events, with access cut off for weeks during major rainfall

The environmental values against which the effects of the Project (Rail) are reported are:

- Stock watering and farm use
- Aquatic ecosystems
- Other values (floodplain)

Flood Hydrology

An important aspect of the Project (Rail) is the flood immunity standard adopted for the design (a 100 year ARI flood), the acceptable level of rise in flood level (called “afflux’) and the lengths of waterway structures (bridge and culverts) required to achieve acceptable afflux.

Early flood modelling comprised the initial preparation of preliminary 100 year average recurrence interval (ARI) flood estimates at all the watercourse crossings. These estimates were based on the regression method of analysis for the major waterways (catchment areas greater than 100 square kilometres) and the rational method of analysis for the minor waterways (catchment areas less than 100 square kilometres).

For each of the large waterway crossings analysed, three opening length scenarios were identified and modelled. Afflux results for each option are presented at several distances upstream of the crossing. The peak afflux is also reported.

The early flood modelling data is being used as a baseline for ongoing modelling that is currently being carried out as part of the base engineering design. This modelling is utilising additional detailed survey data and afflux limits based on current industry practice and afflux levels for approved projects in the region taking into account the significance of the increased flooding. The floodplains traversed by the Project (Rail) are rural with limited constructed assets (e.g. roads, buildings, fences, farm tracks, etc.). The more detailed flood modelling being completed as part of the base engineering design will further assess potential flood impacts as part of the progression of the detailed design of the Project (Rail) and opening/crossing design and lengths are refined. This is an iterative process and will continue through the design phase.

Key Construction Phase Potential Impacts

The key construction phase potential impacts and mitigation measures are:

- Construction works in the floodplain may lead to a deterioration of water quality and hence aquatic ecosystems
- Mitigation measures include the implementation of comprehensive erosion and sediment control measures, and undertaking floodplain works in the drier periods as far as is possible

Key Operational Phase Potential Impacts

The key operational phase potential impacts include:

- The Project (Rail) will potentially lead to higher flood levels (afflux) upstream of the railway line
- The higher flood levels will potentially reduce the extent of grazing land during a flood
- Higher flood levels may potentially affect farm buildings, roads and farm tracks that may be impassable for longer

Mitigation measures include:

- Adopting bridge and culvert sizes (length in the rail direction) that limit the afflux to acceptable and practical levels
- Preparing a catalogue of the floodplain assets and the afflux for each asset with a view to demonstrating that the effects are acceptable

It is acknowledged that the hydraulic modelling completed and reported on to date is preliminary. More detailed modelling currently being carried out as part of the base engineering design along with further detailed modelling and iterations will be required through the Project (Rail) design development phase to produce afflux models with a high level of accuracy, further limit flood extents and establish afflux acceptable to stakeholders. Afflux modelling methodology, preliminary results and limitations are outlined in Section 3.5.

1. Introduction

1.1 Project Overview

Adani is proposing to develop a 60 million tonne (product) per annum (Mtpa) thermal coal mine in the north Galilee Basin approximately 160 kilometres (km) north-west of the town of Clermont, Central Queensland. All coal will be railed via a privately owned rail line connecting to the existing QR National rail infrastructure, and shipped through coal terminal facilities at the Port of Abbot Point and the Port of Hay Point (Dudgeon Point expansion). The Carmichael Coal Mine and Rail Project (the Project) will have an operating life of approximately 90 years.

The Project comprises of two major components:

- The Project (Mine): a greenfield coal mine over EPC1690 and the eastern portion of EPC1080, 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
  - Water supply infrastructure
- The Project (Rail): a greenfield rail line connecting the 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 from the Mine site running west to 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

The Project has been declared a ‘significant project’ under the *State Development and Public Works Organisation Act 1971* (SDPWO Act) and as such, an Environmental Impact Statement (EIS) is required for the Project. The Project is also a ‘controlled action’ and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Project EIS has been developed with the objective of avoiding or mitigating all potential adverse impacts to environmental, social and economic values and enhancing positive impacts. Detailed descriptions of the Project are provided in Volume 2 Section 2 Project Description (Mine) and Volume 3 Section 2 Project Description (Rail).

Figure 1-1 shows the Project location.

LEGEND

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

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.

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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

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Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	L
Date	28-08-2012

Project Location

Figure: 1-1

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Data Source: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA, (2011), Hillshade (2009); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012);
DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (2012). Created by: BW, JVC

1.2 Purpose of this Report

This report specifically addresses the criteria of the terms of reference for the Project EIS outlined in Section 3.4 Water Resources, relating to the Project (Rail). Section 3.4 requires assessment of Water Resources, which includes both surface water and groundwater. The surface drainage patterns including flood levels, flooding extent and frequency are included in the terms of reference of this report. Compliance with the terms of reference of the Project EIS is presented in Appendix A and summarised in Table 1-1. A separate groundwater assessment has been undertaken (refer Volume 4 Appendix AC Rail Hydrogeology Report).

Table 1-1 Terms of Reference Cross Reference

Terms of Reference Requirement/Section Number	Cross-reference
Climate, Natural Hazards and Climate Change	
3.1.1 Flood Plain Management Due to the site location, a comprehensive flood study should be included in the EIS, including: ◗ quantification of flood impacts on properties surrounding and external to the project site from redirection or concentration of flows ◗ identification of likely increased flood levels, increased flow velocities or increased time of flood inundation as a result of the development	Section 1.5.3 and Section 5.4
The flood study should address any requirements of local or regional planning schemes for flood affected areas.	Volume 4 Appendix D Project Approvals and Planning Assessment
The study report should include details of all calculations along with descriptions of base data, any potential for loss of flood plain storage, and triangulated surface meshes produced in terrain modelling software.	Section 1.5
Refer to any studies undertaken by the local council in relation to flooding.	N/A (none)
Provide details on: ◗ potential impacts of floods at a range of flood intervals, including the probable maximum flood event ◗ potential impacts of flooding on environmental values due to the identified likely increased flood levels, increased flow velocities or increased time of flood inundation as a result of the project ◗ impacts and mitigation measures for flooding. Describe the construction of any flood protection levees with regards to construction material, design and methods	Section 1.5.3 and Section 4 and 5
Water Resources	
3.4.1 Description of Environmental Values Describe the existing water resources that may be affected	Section 2.1
Describe present and potential users and uses of water in areas potentially affected by the project	Section 2.2

Terms of Reference Requirement/Section Number	Cross-reference
Provide a detailed description quality and quantity of the surface and groundwater resources, describe: ◗ Existing surface and groundwater in terms of physical, chemical and biological characteristics ◗ Existing surface drainage patterns, flows, history of flooding including extent, levels and frequency and present water uses	Section 2
Describe the surface water and ground water quality considering seasonal variations in depth and flow. Parameters should include: Electrical conductivity; Major cations and anions; Dissolved metals; Minor ions; Hydrocarbons; Any other potential toxic or harmful substances; Turbidity; Suspended sediments; and pH.	Volume 2 Section 6[1]
Investigate the relationship between groundwater and surface water to assess the nature of any interaction between the two, and any implications of the proposed mine that would affect the interaction	Volume 2 Section 6
Describe the environmental values of the surface waterways and groundwater of the affected area in terms of: values identified in the EPP; Physical integrity, fluvial processes and morphology; Any impoundments; Hydrology of waterways and groundwater; Sustainability (quality and quantity); Dependent ecosystems; Existing and other potential surface and groundwater users; Details of any proposed buffer widths between project activities and waterways; Any water resource plans relevant to the affected catchments	Section 2
If the project is likely to use or affect local sources, describe: A comprehensive hydrogeological description covering: the coal seams and surrounding aquifers, both artesian and sub-artesian; inter-aquifer connectivity; flow of water; recharge and discharge mechanisms; and hydrogeological processes at work:	Volume 2 Section 6
Define and describe the objectives and practical measures for protecting or enhancing water resource	Section 4 and Section 5
Address and describe (including provision of maps): ◗ Potential impacts on the flow and quality of surface and groundwater from all phases of the project	 Section 4 and Section 5
◗ All likely impacts on groundwater depletion or recharge regimes	Volume 4 Appendix AC
◗ Likely volume of groundwater to be dewatered during the operations	Volume 4 Appendix AC
◗ The impacts on groundwater resources in each aquifer	Volume 4 Appendix R
◗ How extracted groundwater will be managed in the surface water management system	Volume 4 Appendix P and Appendix R

[1] This part of the ToR is not considered to be applicable to the Project (Rail) as the rail construction and operation is not expected to impact on electrical conductivity etc. This is therefore addressed in Volume 2 Section 6 for the Project (Mine).

Terms of Reference Requirement/Section Number	Cross-reference
◗ Measures to prevent, mitigate and remediate any impacts on existing users or groundwater dependent ecosystems	Volume 4 Appendix AC Volume 4 Appendix R
◗ Potential environmental impact caused by the project to local ground water resources	Volume 4 Appendix AC
◗ Response of the groundwater resource to the progression and cessation of the proposal	Volume 4 Appendix R
◗ Impact on the local groundwater regime caused by the altered porosity and permeability of any land disturbance	Volume 4 Appendix R
◗ Any potential for the project to impact on groundwater-dependent vegetation	Volume 4 Appendix R
◗ Potential impacts of surface water flow on existing infrastructure	Section 4.3 section 5.4
◗ Chemical and physical properties of any wastewater	Volume 2 Section 10
◗ How contaminants and waste are avoided, minimised, treated and managed	Volume 2 Section 10
◗ Environmental monitoring to check the effectiveness of mitigation measures	Section 4.3
◗ Potential impacts on other downstream receiving environments	Section 4.3
◗ Mitigation measures for water treatment if proposed to discharge water into riverine system	Volume 4 Appendix P and Appendix R
◗ Results of a risk assessment for uncontrolled releases	Volume 4 Appendix P and Appendix R
◗ Potential to contaminate surface and groundwater resources and measures to prevent, mitigate and remediate such contamination	Section 4.3
Outline impacts on all surface water resources by describing: ◗ Local overland flow catchment characteristics and estimated change to mean and median (50th percentile) annual run off from local overland flow catchments ◗ Change to flows including mean and median (50th percentile) annual flow, in watercourses immediately downstream of the site	Section 2
Describe the option for supplying water to the project, and assess the consequential impacts.	Section 2
Reference the properties of the land disturbed and processing liquid wastes, the technology for settling suspended clays from contaminated water and the techniques to be employed to ensure contaminated water is contained and successfully treated on site.	Volume 2 Sections 6 and 10
Describe management strategies in adequate detail to demonstrate best practice management and environmental values of receiving waters will be maintained to nominated water quality objectives.	Sections 4.2.2, 4.3.2, 4.4.2, 5.2.1, 0 and 5.4.2

1.3 Aims and Objectives

Consistent with Section 3.4 of the terms of reference (relevant to water resources), this surface water assessment aims to identify and assess the potential Project (Rail) impacts upon the following:

- Hydrology of waterways including any impoundments (dams)
- Values identified in the Environmental Protection (Water) Policy 2009 (EPP Water)
- Aquatic ecosystems
- Farm use and stock watering
- Floodplain, with reference to flood levels, extent of flooding and flood frequency

1.4 Assumptions and Data Limitations

The description of the surface water hydrology in this report is comprised of a desktop study and many of the data sources are internet based. These data sources are supplemented by:

- The Carmichael Rail Line Concept Design (Aarvee Associates, 2011 and 2012), i.e. the Project Description.
- Visual observations gained during a site visit undertaken in August 2011 comprising an inspection of the general vicinity of the proposed rail corridor from the western (Labona) terminus to Cassiopeia Station along the Elgin Moray Road.
- The results of hydraulic modelling conducted by Golder Associates (2011), as presented in Appendix B.

As at 23 December 2011, modelling results for the following major crossings were available: Grosvenor Creek, Diamond Creek, Gowrie Creek, Mistake Creek, Belyando River (which includes in the one hydraulic model the East Tributary of the Belyando River, Ogenbeena Creek (lower crossing) and Ogenbeena Creek), North Creek and Eight Mile Creek.

Logan Creek and the unidentified watercourse at Chainage 93.1 km have not been modelled due to limited survey data being available at the time of writing, however they are discussed in section 3 of the report and in Appendix B and comparisons are made to similar modelled watercourses. Survey data has now been completed for these two watercourses and more detailed modelling is currently being completed; this will be reported in the Supplementary EIS.

Hydrometric data collection utilises rainfall and flow gauging (water level) stations in the vicinity of settlements, station homesteads and major road crossings. Although the record lengths at the road crossings are reasonable for the purposes of describing the water resource availability, the record lengths are inadequate for determining the 100 year, and more extreme, flood flows from flood frequency analysis. Flood estimates are further limited by source data (i.e. recorded peak flood flows) being regarded as having large confidence limits, and the record lengths tend to be relatively short for the purpose of estimating the 100 year ARI flood.

Published flow data for the rivers in the Study Area are based upon recorded water levels and a relevant rating curve for conversion of the recorded level to a flow rate. The rating curves are not considered highly reliable due to the challenges associated with measuring the flows during flood events. These flood flow measurements inform the rating curve. Challenges arise due to, in general, the lack of bridges and the broad floodplains.

Event based data collection is limited to significant summer cyclone events that document peak levels, rainfall depths and flood extents gained from aerial and satellite imagery.

Despite these limitations, the consistency of the data records in time and space across the affected catchments, and the similarity of their landscapes and soils, have been sufficient to:

- Prepare an adequate description of the hydrology of the railway alignment and its immediate context
- Assess the likely environmental impacts of the railway crossings on the surface water hydrology of the waterways crossed by the railway

It is noted that an important design issue for railways that cross floodplains, as this one does, is the number and size of the culverts and bridges (i.e. the waterway area) under the railway embankment, and how the waterway area affects the rise in flood level upstream of the railway embankment. Providing a large waterway area is more costly, but the rise in flood level (called "afflux") is less, and visa-versa.

The concept design parameters relating to flood immunity of the railway were defined as 50 years ARI flood immunity at formation level and 100 years ARI flood immunity at rail level. The immunity has, however, been revised further for detailed design to 50 years plus 300 mm freeboard for a 50 year ARI (formation level). The 100 year ARI flood immunity (rail level) remains unchanged for the detailed design phase.

1.5 Methodology

1.5.1 Approach

The approach adopted for the preparation of this report is reflected by the following broad steps:

- Step 1: describe the catchments, beds, banks, water column and environmental values associated with waterways crossed by the Project (Rail)
- Step 2: identify the environmental values against which the effects will be reported
- Step 3: assess the potential adverse effects on the nominated surface water environmental values from the construction and operation of the railway, and identify suitable management and mitigation measures to reduce the risk of any such adverse effects to an acceptable level.

1.5.2 Legislative Framework

The description of the surface water environment and how it may be affected by the Project (Rail) has been conducted in the context of the environmental values defined in such documents as the:

- *Water Act 2000* (Qld)
- *Environmental Protection Act 1994* (Qld) (EP Act)
- Environmental Protection (Water) Policy 2009 (EPP (Water))
- ANZECC (2000) Water Quality Guidelines
- Queensland Water Quality Guidelines(DERM, 2009)
- Water Resource (Burdekin River Basin) Plan 2007

- Burdekin Dry Tropics Natural Resource Management Plan (2005–2010)
- Social, Economic, Cultural and Environmental Values of Streams and Wetlands in the Burdekin Dry Tropics Region (Greiner and Hall, 2006)
- Environmental Protection (Water) Policy 2009 Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin (DERM, 2011a)
- National Land and Water Resource Audit 2000-2002 as part of the Australian Water Resources Assessment 2000 (Australian Natural Resource Atlas (ANRA) 2009)

Volume 4 Appendix D Project Approvals and Assessment provides further detail.

1.5.3 Flood Flow and Flood Level Analysis

The methodology adopted for the flood flow and flood level assessments was based on preliminary concept level design and relied upon modelling and reports prepared by Golder Associates (2011), provided in Volume 4, Appendix AB Rail Hydrology Report. The following methodology was applied:

- Design flows were derived using flood frequency regression analysis applied to local or regional historic stream flow data for the larger named waterways such as the Belyando River and Mistake Creek. Flood estimates for the 2, 10, 50, 100 and 500 year Average Return Interval (ARI) events were determined.
- The Rational Method was used to estimate flood flows for minor watercourses using time of concentration calculated according to the Bransby Williams formula and runoff coefficients from DERM (2005) assuming medium density bushland with low permeability soils.
- At the time of the preliminary hydrology modelling no guidelines or current acceptable afflux limitations for similar infrastructure in the Project (Rail) region were available. As a result the afflux at the major waterway crossings (as listed in Table 1-2) was simulated for several scenarios of discharge and crossing length using a 2D XP SWMM/TUFLOW model. The only exceptions to this were the crossings at Logan Creek and an unnamed waterway (at 90.2 km east-west) where qualitative comparisons were made to the other modelled crossings.

Mitigation strategies were formulated for the potential adverse impacts of the construction and operation of the Project (Rail) on environmental values identified at a collective workshop held for that purpose.

Table 1-2 Waterway Crossings – Major Waterways

Waterway Name	Rail Corridor Chainage (km)	Crossing Type
Grosvenor Creek	18.5	Multi span bridge
Diamond Creek	62.7	Major drainage structure
Logan Creek	82.7	Multi span bridge
Unnamed	90.2	Major drainage structure
Gowrie Creek	113.5	Multi span bridge + drainage structure
Mistake Creek	120.8	Multi span bridge + drainage structure

Waterway Name	Rail Corridor Chainage (km)	Crossing Type
Belyando River (East Branch)	139.2	Major drainage structure
Belyando River (Anabranch)	149.0	Multi span bridge + drainage structure
Ogenbeena Creek (Lower Crossing)	150.6	Multi span bridge + drainage structure
Ogenbeena Creek	153.0	Multi span bridge + drainage structure
North Creek	170.4	Multi span bridge + drainage structure
Eight Mile Creek	176.2	Multi span bridge + drainage structure

*Direction east to west.

Minor waterways and overland flow paths are those with catchment areas less than 100 km^2. Minor bridge structures and minor drainage structures are likely to be reinforced concrete box culverts and pipe culverts respectively. It is estimated that eight minor bridge structures and 68 minor drainage structures will be installed for the Project (Rail).

The methodologies and results of the preliminary modelling are currently being utilised as a base for further development and modelling during the engineering design that is currently taking place. Detailed engineering design will incorporate identified design criteria including acceptable afflux and criteria for passage of flows through the proposed railway line and embankment as well as 100 year ARI flood immunity required for the railway line.

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2. Existing Environment

2.1 Description of the Rail Corridor

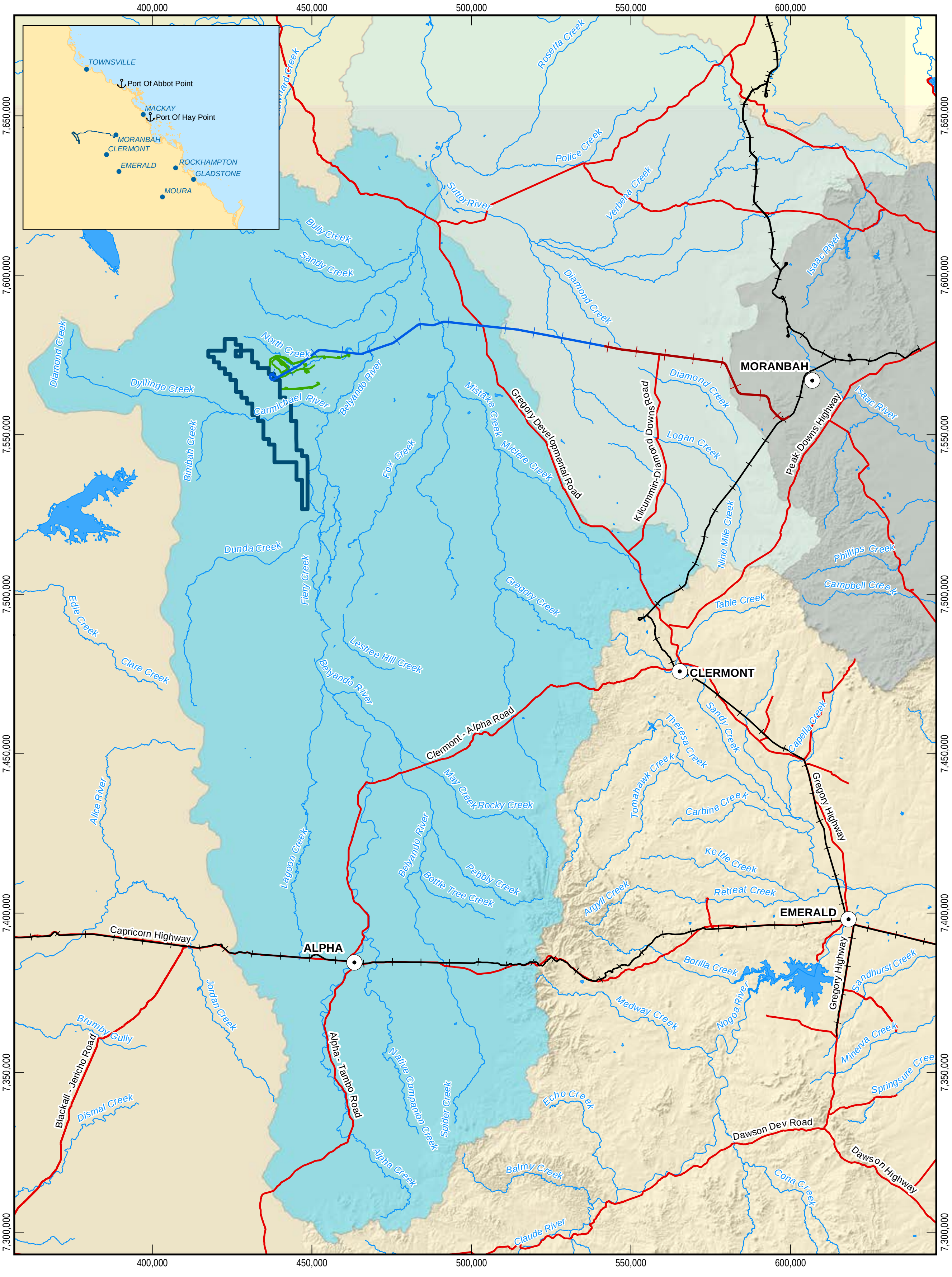
2.1.1 Overview

The landscape of the rail corridor is characterised by flat floodplains dominated by a number of rivers and creeks which have reasonably well defined channels but with wide floodplains that are inundated during flood events. The vegetation within the corridor comprises dry savannah grassland under depleted second growth remnants of formerly extensive dry forests that are understood to have been cleared from the 1950s to the 1980s. Cattle grazing dominates the land use of the area. The railway alignment is located predominantly within the Belyando River / Suttor River sub-catchments of the Burdekin River Catchment. The first 40 km of the railway alignment (from the eastern extent) is located within the Grosvenor Creek sub-catchment of the Isaac River, which is a tributary of the Fitzroy River (142,665 km^2 catchment). The Project (Rail) location with respect to catchments and watercourses is shown in Figure 2-1.

The Belyando River / Suttor River sub-catchments comprise the southern headwaters of the Burdekin River (and 60 per cent of its 130,000 km^2 catchment area). Along with the Cape River and Upper Burdekin River, these catchments are the main contributors to the Burdekin Falls Dam, which lies 60 km downstream of the Project (Rail) corridor. This dam has no backwater influence on the flood levels of the Belyando or Suttor Rivers in the vicinity of the rail corridor. It is noted that, with respect to the hydraulic modelling of the crossings (Golder Associates, 2011), it is often the case that the flood waters of two adjacent crossings merge in a 100 year ARI flood event. In these situations more than one crossing is covered by a single hydraulics model. This situation can lead to confusion in relation to the number and names of the major crossings. Major waterway crossings are listed in Table 2-1. There are also 76 minor waterway crossings. Minor crossings have catchment areas of less than 100 km^2.

The last 30 years of forest clearance for cattle grazing has resulted in altered hydrological regimes and resultant negative impacts on the morphological character of many of the waterways crossed by the Project (Rail). The research of Pettit (2002) shows that catchment responses to this land clearance include increased runoff, increased drainage density, and increased erosion and sediment yields within the catchment. In response to altered hydrological regimes, channel morphology changes can occur as the result of bank erosion, channel incision and floodplain scour. These effects are increasingly pronounced with distance downstream from the ephemeral headwaters to the main creek and river channels.

This is illustrated in Plate 2-1 which shows a channel of Eight Mile Creek near the Mine Site. Plate 2-2 shows the Belyando River and Plate 2-3 shows the eastern channel of the Belyando River and Mistake Creek with their slumped highly eroded banks and beds choked with loose sediment. This material is mobilised readily once there is appreciable flow. In the relatively flat topography, floodplains can be a kilometre or more wide in some localities about the main stem of the rivers.



LEGEND

- Town
- State Road
- Other Rail Network
- Rail (West)
- Rail (East)
- Mine (Onsite)
- Mine (Offsite)
- Watercourse
- Waterbody
- River Basins
  - Belyando River
  - Suttor River
  - Isaac River

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1:1,700,000 (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

Project (Rail)
Catchments and Watercourses

Job Number	41-25215
Revision	C
Date	05-09-2012

Figure 2-1

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: River Basin (2009), State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

Table 2-1 Major Waterways Traversed by the Project (Rail)

Number*	River Catchment	Waterway Name	Rail Corridor Distance (km)*	Catchment upstream of Project (Rail) (km^2)
1	Isaac River	Grosvenor Creek	18.5	128
2	Suttor River	Diamond Creek	62.7	1,000
3	Suttor River	Logan Creek	82.7	2,900
4	Suttor River	Unnamed Creek	90.2	110
5	Belyando River	Gowrie Creek	113.5	210
6	Belyando River	Mistake Creek	120.8	7,900
7	Belyando River	Belyando River (East Branch)	139.2	210
8	Belyando River	Belyando River (Anabranch)	149.0	22,000
9	Belyando River	Ogenbeena Creek (Lower Crossing)	150.6	870
10	Belyando River	Ogenbeena Creek	153.0	850
11	Belyando River	North Creek	170.4	300
12	Belyando River	Eight Mile Creek	176.2	180

* Direction east to west.

Plate 2-1 Eight Mile Creek

Source: GHD, August 2011. Location 10 Mile Road, Labona (S21° 59.878 E146°20.765).

Plate 2-2 Belyando River at Moray Downs Station

Source: GHD, August 2011 (S21°56.163 E146°37.869)

Plate 2-3 Mistake Creek at Elgin Downs Crossing

Source: GHD, August 2011 (S21°59.659 E146°55.623)

Almost all of the waterways within the Project (Rail) area are ephemeral. Under normal conditions the main stem of the Belyando River maintains a small base flow during the dry season. Once storm flow reaches the rivers and creeks, they rapidly fill and overflow into floodplains where flooding can persist for several days and sometimes weeks at a time as illustrated in Plate 2-4. After the flooding recedes, the majority of waterway main channels become a series of waterholes sustained by a slow base flow. Farm dams (refer to Plate 2-5) are often dry by the beginning of the next wet season, unless maintained by pumped groundwater.

Plate 2-4 Belyando River Anabranch in Flood

October 2010, Moray Downs Station (S21°56.163 E146°37.869)

Plate 2-5 Farm Dam on Grosvenor Creek -

Rugby Run Station (S22°7.860 E147°54.889)

2.1.2 Belyando River and Suttor River

There is currently no regulation of the Belyando/Suttor Surface Water Management Area (SWMA) under the Water Resources (Burdekin River Basin) Plan 2007. The Water Resource Plan focuses on water extraction for the irrigated farmlands in the lower Burdekin and Houghton River sub-catchments. The unreliability of the surface water resource in the Belyando and Suttor River catchments is principally due to the rainfall patterns and presents a problem for setting sustainable takes in these catchments (North Queensland Dry Tropics, 2001b).

Furthermore, the program for scheduling environment values and water quality objectives (WQOs) for the catchments of the Dry Tropics including the Belyando River is not due for completion before December 2013 (North Queensland Dry Tropics, 2011b). However, a list of draft environmental values has been proposed for the Belyando and Suttor Rivers by Greiner and Hall, 2006.

2.1.3 Grosvenor Creek in the Isaac River Catchment

The Grosvenor Creek drains to the Isaac River catchment, which is a tributary of the Fitzroy River. All of the other creeks and rivers crossed by the railway ultimately drain to the Burdekin River. The land use in the Grosvenor Creek sub-catchment in the vicinity of the Project (Rail) is beef cattle grazing. Mining, dryland cropping and production forestry are also significant in the wider catchment of the Isaac River. The water and remnant riparian vegetation of Grosvenor Creek is also recognised as habitat for native animals and plants.

Moranbah will soon supplement its domestic water supply from the Burdekin catchment via pipelines across the catchment divide from Burdekin Falls Dam and Eungella Dam. On the Isaac River, water for coal mining in the Goonyella area is supplied from two existing water storages:

- Burton Gorge Dam
- Teviot Dam

Teviot Dam is located in the upper catchment, approximately 40 km north of Moranbah and 30 km to the northeast of the Project (Rail). These privately owned and operated dams supply 1,700 ML/a and 1,500 ML/a respectively. According to DERM (2005), demand from coal mining is set to increase as the substantial reserves in the area are developed over time.

Grosvenor Creek is located within the Isaac Western Upland Tributaries sub-catchment for the setting of scheduled environmental values under the EPP (Water) for the Fitzroy River (DERM, 2011a). For the purposes of this report, the significant environmental values scheduled for this sub-catchment are:

- Stock water
- Farm supply/use

  Stock water and farm supplies are consumed directly from the rivers in the wet season and for the rest of the year by residual natural waterholes or constructed impoundments of wet season runoff such as dams
- Aquatic ecosystems
- Grosvenor Creek in the Isaac Western Upland Tributaries is to be managed as moderately disturbed aquatic habitat for which a list of water quality objectives has been set

2.2 Environmental Values

2.2.1 Overview

The EPP (Water) and the Environmental Protection (Water) Amendment Policy (No. 1) 2008 (EPP Water Amendment), are intended to protect Queensland's waterways while allowing for development that is ecologically sustainable through:

- Identifying environmental values for aquatic ecosystems and for human uses (e.g. water for drinking, farm supply, agriculture, industry and recreational use)
- Determining Water Quality Guidelines (WQGs) and WQOs to enhance or protect the environmental values

It is noted in Section 3.4.1 of the terms of reference that it is required to describe “existing surface drainage patterns, flows, and history of flooding including extent, levels and frequency and present water users.” The Project (Rail) will affect drainage patterns where the rail crosses creeks, rivers and floodplains. In this regard, the impact of the Project (Rail) is to the floodplain, i.e. the extent, depth and duration of inundation may increase or decrease. However, the floodplain, which is generally used for grazing, is not nominated as an environmental value in the above references.

In this section of the report, the description of the significant environmental values for the Project (Rail) is separately identified for the:

- Belyando River and Suttor River
- Grosvenor Creek

The environmental values are described in terms of the following elements:

- Stock water and farm supply
- Aquatic ecosystems
- Other values (floodplain)

The significant environmental values for the Belyando River and Suttor Rivers are discussed below.

2.2.2 Aquatic Ecosystems

The Mistake Creek sub-catchment contains two areas that have been identified as containing High Ecological Value (HEV) waters by the Burdekin Water Quality Improvement Plan ecological values technical panel. These correspond to: (i) Nairana National Park in the bottom of the sub-catchment; and (ii) Narrien Range National Park in the south-west of the sub-catchment. Spring-fed creeks are thought to originate in the Narrien Range and provide a very important source of water in an otherwise dry landscape. These areas are in excess of 160 km south-west of the Project (Rail).

The aquatic ecosystem values of Logan Creek and the remaining other parts of the Belyando/Suttor Rivers sub-catchment are considered to be Slightly to Moderately disturbed (SMD) as a consequence of the surrounding land use for cattle grazing. The extent of this was revealed by a vegetation assessment conducted by Kinsey-Henderson, et al 2007 that shows that as much as half of the entire Belyando River/ Suttor River sub-catchment has less than 50 per cent ground cover.

2.2.3 Farm Use (Stock watering and Irrigation)

Stock water is supplied directly from the rivers in the wet season and for the rest of the year by residual natural waterholes or constructed impoundments of wet season runoff such as 10 Mile Road Waterhole (Plate 2-6) on Eight Mile Creek in Moray Downs Station on the true left of the lower Belyando River.

Data supplied by DERM contained in Appendix C records 26 licensed surface water “takes” (diversions or abstractions) in the Belyando River catchment that includes various impoundments, direct pumped takes and irrigation (650 hectares) for domestic supply, stock water and crop irrigation. The list does not include any of the properties that accommodate the Project (Rail). In addition there are an unknown number of unregulated takes constructed by local farmers to take advantage of the wet season surplus and any base flow. It is estimated by Burdekin Dry Tropics Board (2005) that around 6,400 ha of cotton and grain crops are irrigated in the Belyando River catchment with about half of this in the Mistake Creek sub-catchment. Irrigated land tends to be concentrated in areas with suitable alluvial plains adjacent to the mainstems of the river and its larger tributaries. No irrigated lands or cotton cultivation occurs in the vicinity of the Project (Rail).

Within farmland under irrigation, cotton was once the most common crop, but its popularity has decreased in recent years. Forage, maize, cereal crop and pasture (including lucerne) are currently the most common irrigated crops. While there is some pressure to expand irrigated agriculture, financial constraints within the farming industry may inhibit such development. Further land suitability, agro-economic assessments and water resource assessments will be necessary to define the true agricultural potential of the region (BDTNRMP, 2005).

Plate 2-6 10 Mile Road Waterhole

Source: GHD, October 2010, impoundment of wet season flow on Eight Mile Creek (S21°59.346 E146°19.977)

2.2.4 Other Values (Floodplain)

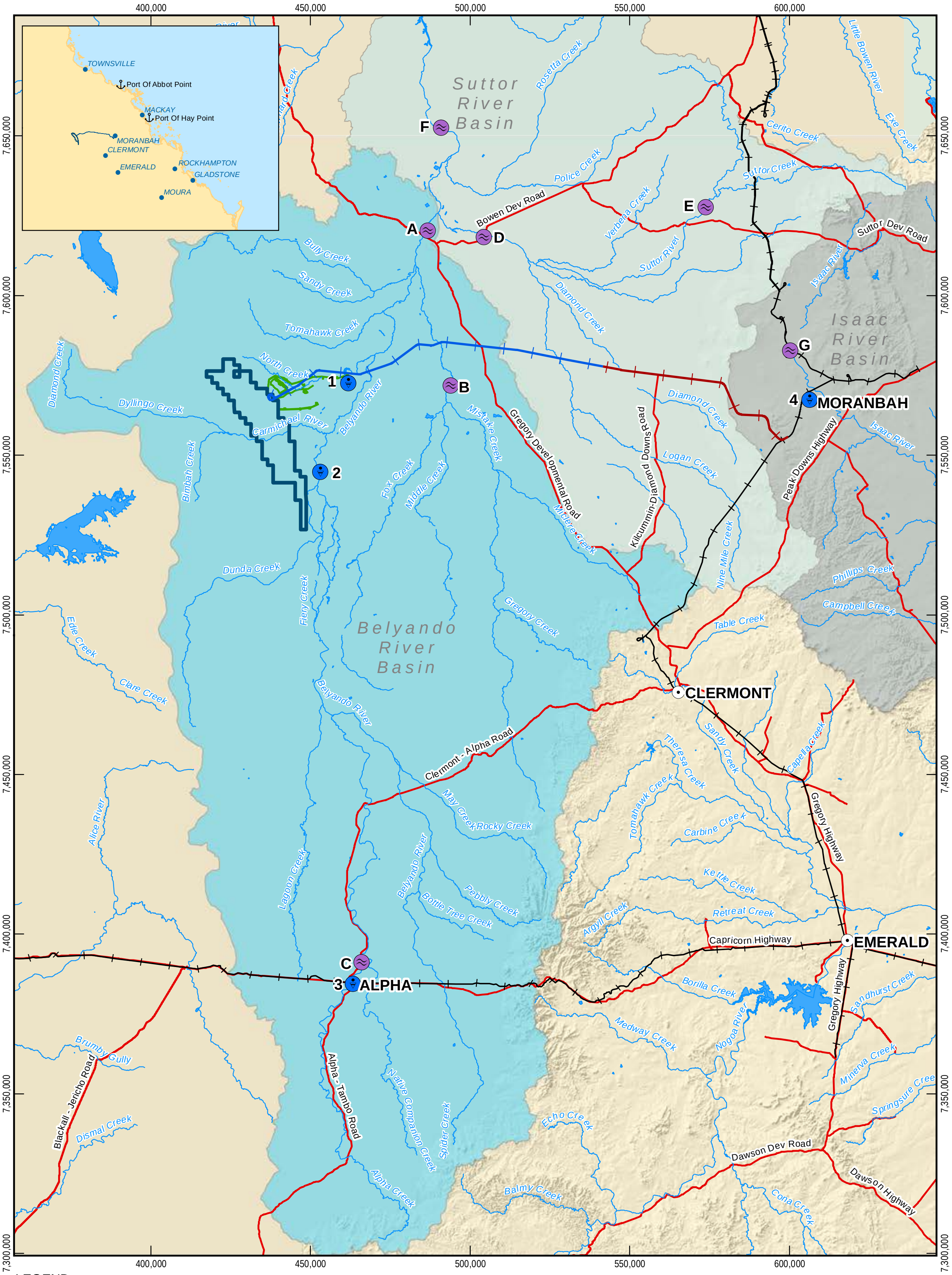
The floodplains generally within the Study Area are used for grazing beef cattle. An exotic grass species *Cenhrus ciliaris* (buffel grass) is a common species of grazing land pasture in the Dry Tropics. Five days of full inundation can kill the species. A major consequence of the widespread buffel grass death caused by weeks of flooding in the Belyando River associated with Cyclone Helen in 2008 was an invasion of the toxic pest herb *Parthenium hysterophorus* (parthenium).

Land use and other infrastructure present within the Project (Rail) area are discussed in detail in Volume 4 Appendix Z Rail Land Use Report and Volume 4 Appendix AG Rail Transport Report. In the order of 70 roads, stock crossings and private tracks and crossings are present.

2.3 Stream Flow

The description of the existing condition flows, or hydrology, is informed by data published by the Bureau of Meteorology (BOM). As described in Section 1.4, due to the challenges associated with flow measurement, the BOM data while not regarded as highly accurate, is considered adequate to present broad scale descriptions of the hydrology of the Project (Rail) area.

There are three BOM flow depth recording sites, also referred to as river gauges, in the Belyando River, Suttor River and Isaac River. The locations of these river gauges are presented in Figure 2-2. Recorded water levels at these sites have been converted to flows based on a rating table that has benefited from actual flood flow gauging. Data obtained from these sources is presented in Table 2-2.



LEGEND

Town	State Road	Mine (Onsite)	River Basins
Rain Gauge	Other Rail Network	Mine (Offsite)	Belyando River
River Gauge	Rail (West)	Watercourse	Suttor River
	Rail (East)	Waterbody	Isaac River

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

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Job Number 41-25215
Revision C
Date 05-09-2012

Flow Gauging Sites and Rain Gauges
(after NQ Dry Tropics 2011b)

Figure: 2-2

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: River Basin (2009), State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

Table 2-2 DERM River Gauging Sites

Map label#	Gauge and DERM site Code	Location	Catchment Area Served km^2	Distance from Rail Corridor*	Record Start Date and Record Length
A	Belyando at Gregory Development Road 120301B	S21° 32.044' E146° 51.612'	35,411	35 km d/s	Aug 1976 36 years
B	Mistake Creek at Twin Hills 120309	S 21°59.642' E146° 55.605'	8,048	12 km u/s	Aug 1976 36 years
C	Native Companion Creek at Alpha 120305A	S 23° 35.198' E146° 40.598'	4,065	180 km u/s	Dec 1967 45 years
D	Suttor at Bowen Development Road Weir 120310A,	S21°31.15' E147°2.32	10,758	50 km d/s	Dec 2006 5 years
E	Suttor at Eaglefield 120304A	S21°27.1' E147°42.51'	1,915	N/A	Dec 1967 45 years
F	Suttor/ Belyando at St Annes 120303A	S21°13.45' E146°54.48'	50,291	65 km d/s	Aug 1967 45 years
G	Isaac at Goonyella 130414A	S21°51.24' E147°58.18'	1,214	N/A	May 1983 28 years

Notes: # Refer Figure 2-2; * d/s (downstream); u/s (upstream)

In the Belyando River, the nearest river gauge to the Project (Rail) is at the Gregory Developmental Road crossing, which is shown below in Plate 2-7 (refer river gauge A on Figure 2-2). There are no river gauges on Logan Creek, which has a catchment area of 3,372 km^2.

There are two river gauges on the Suttor River, one at Bowen Development Road Weir, and the other upstream at Eaglefield. There are no river gauges on Grosvenor Creek. On the Isaac River, the nearest gauge to the Project (Rail) is at Goonyella Creek, 30 km to the north of Moranbah.

Derived daily flow records at the Gregory Developmental Road (river gauge A on the Belyando River), Twin Hills (river gauge B on Mistake Creek), Eaglefield (river gauge E on the Suttor River) and Goonyella (river gauge G on the Isaac River) river gauges are presented in Figure 2-3, Figure 2-4, Figure 2-5 and Figure 2-6, respectively. The derived daily flows provide an overview of the flow regimes in the relevant catchments. It should be noted it is not intended that these plots represent the flow at the intersection with the Project (Rail). Rather, they indicate typical patterns of flow in the Study Area. Of particular note is that, even though the catchment areas at the gauges are large (in the range 1,214 to 35,411 km^2), recorded base flow is often zero or minimal. Although the normal pattern is for lowest flows to occur in the winter months, and for the highest flows to be dominated by substantial events (floods), the rivers can record zero flow in any month of the year.

Plate 2-7 Belyando River at Gregory Developmental Road Bridge

January 2003

Figure 2-3 Daily Flows in the Belyando River at Gregory Developmental Road Bridge

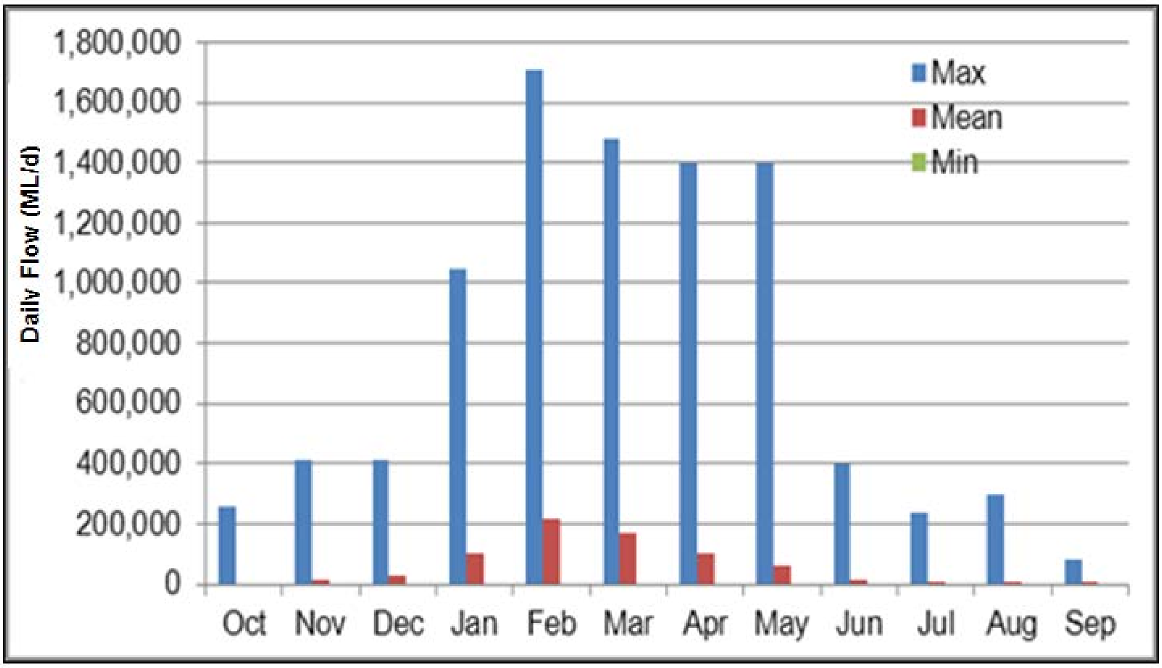


Figure 2-4 Daily Flows in Mistake Creek at Twin Hills

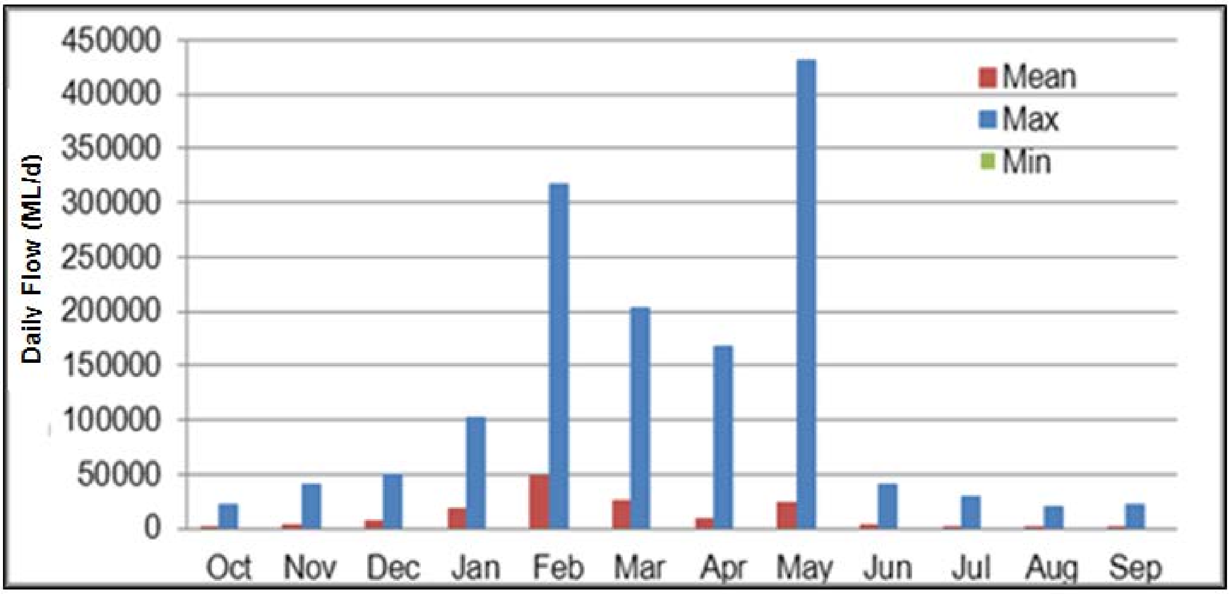


Figure 2-5 Daily Flows in the Suttor River at Eaglefield

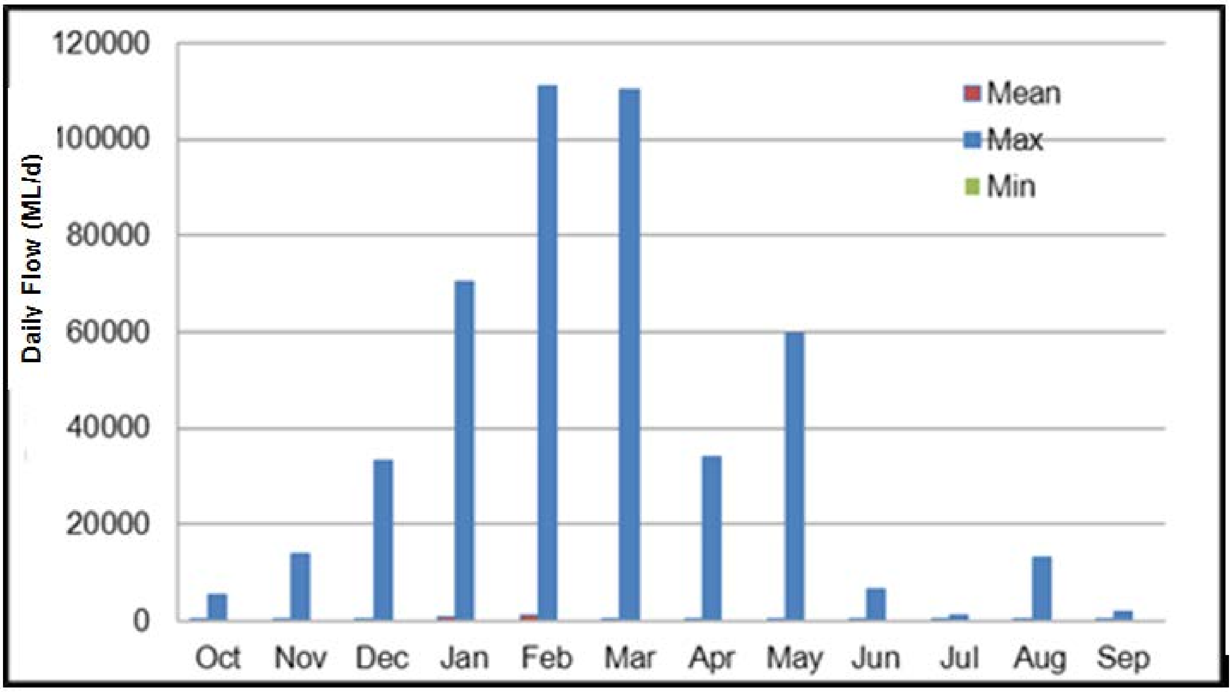
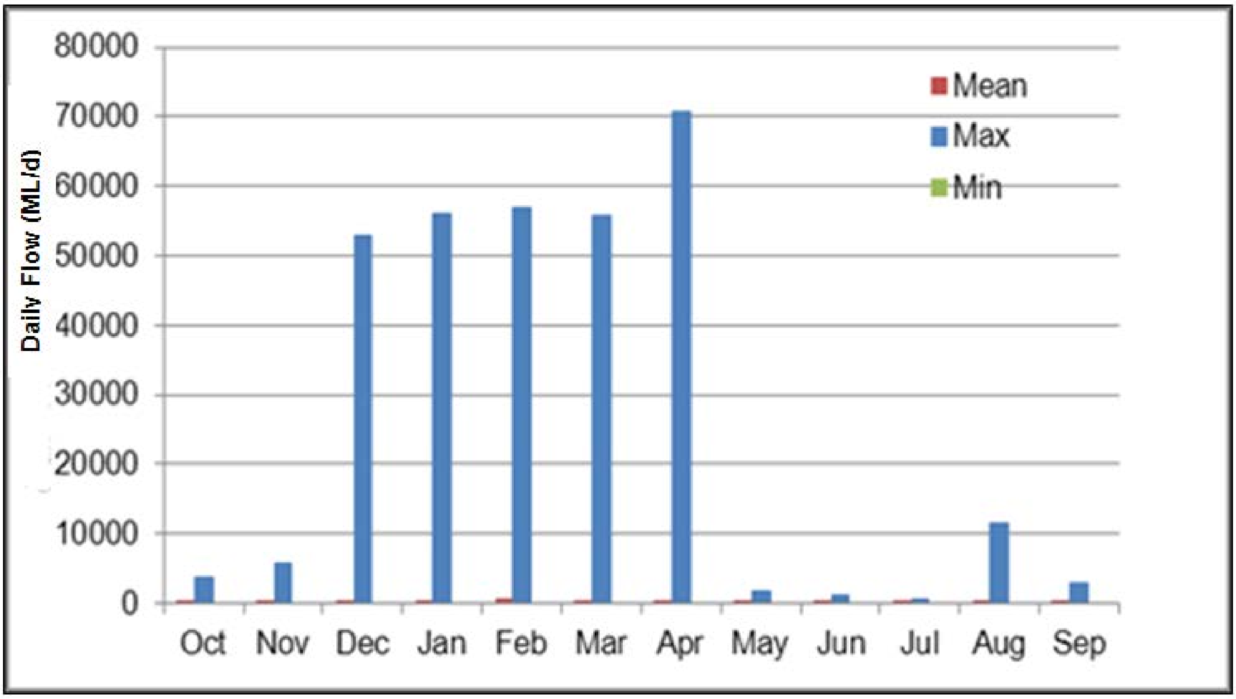


Figure 2-6 Daily Flows in the Isaac River at Goonyella



In addition to the pronounced monthly fluctuation, there is also variability from year to year. The variation in annual discharge volumes is presented in Figure 2-7 which plots the annual flow volumes recorded at St Annes (river gauge F) combining the Belyando and Suttor Rivers. The Isaac River at Goonyella shows a similar variation (refer to Figure 2-8), that is a series of high flow years is often followed by a series of low flow years.

Although the length of dry periods is unpredictable, they have a high frequency and it is the large short duration flood events, which can occur anytime from November to May, that dominate the discharge regime and long term averages. The influence of such episodic, but short-lived phenomena tend to mask the summer seasonality of flows.

Figure 2-7 Annual Discharges at St Annes (Belyando/Suttor Rivers) (1967-2006)

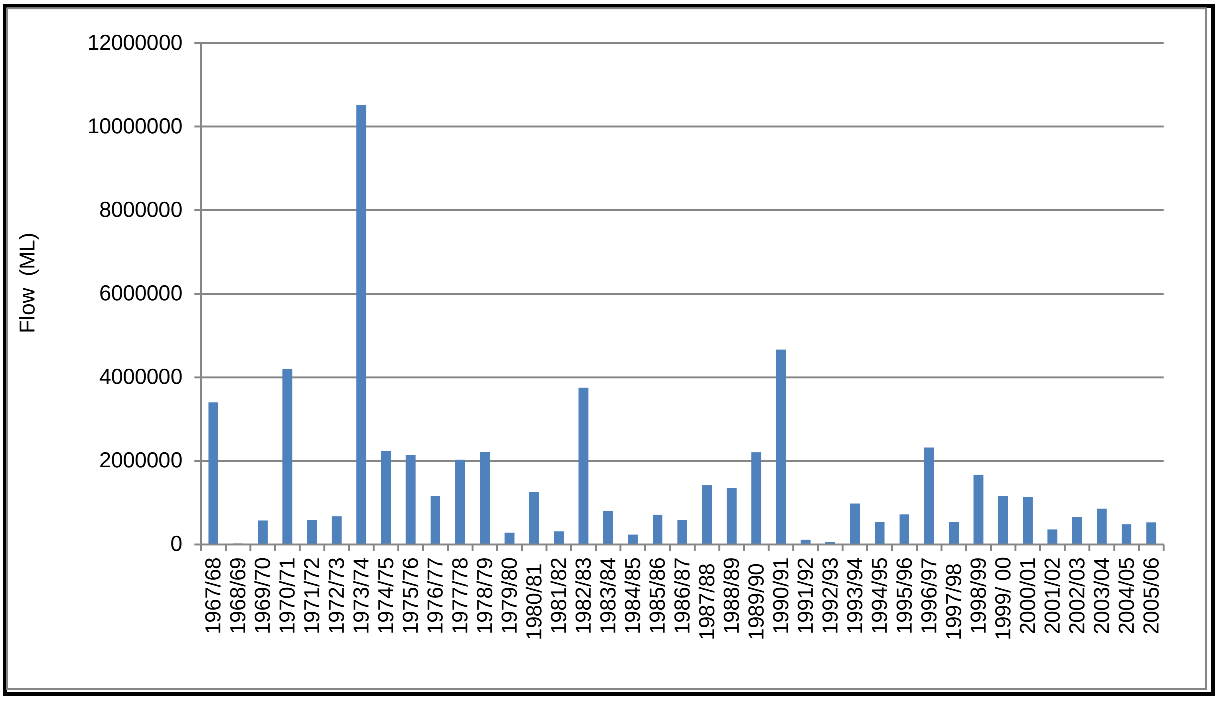
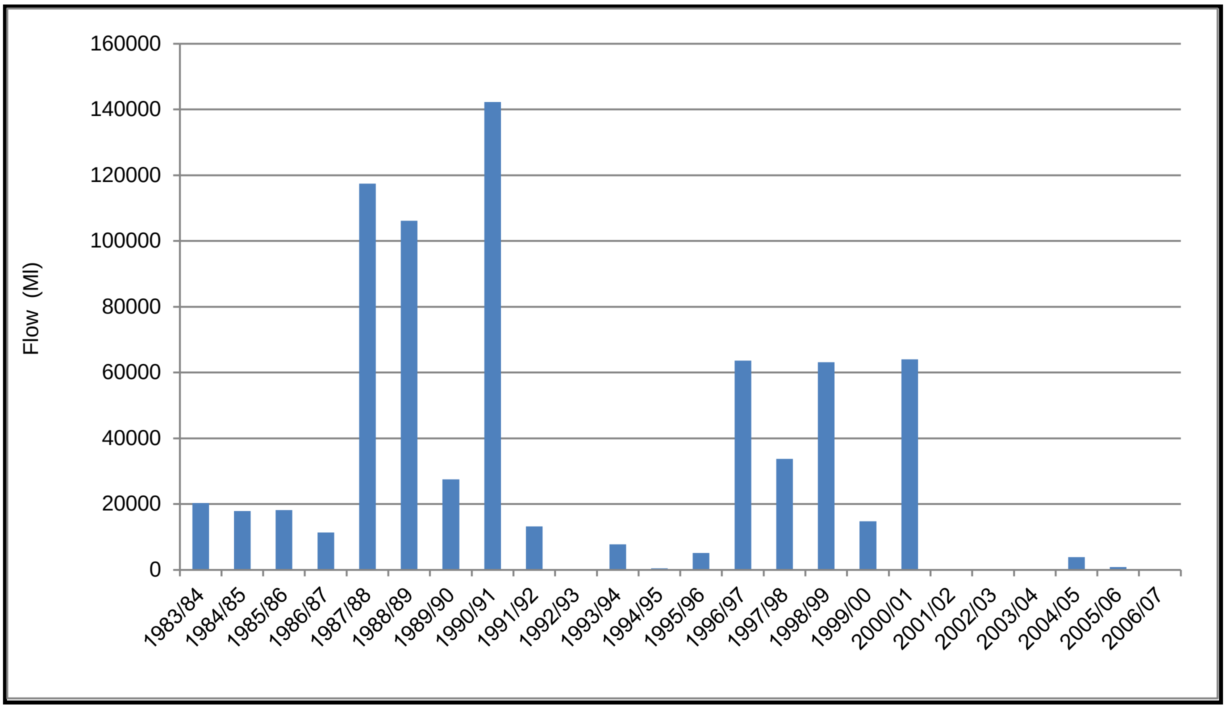


Figure 2-8 Annual Discharges at Goonyella (Isaac River) (1976-2010)



In Table 2-3 it can be seen that this variability contributes to the Belyando River and the Suttor River contributing comparatively less to the discharge of the Burdekin River at Clare (flow gauge 120006 S19°46' E147°18', 40 km west of the mouth of the Burdekin River where it flows to the Coral Sea) than would otherwise be expected given their combined proportion of the total area of the river system. In contrast, more than half the total Burdekin River flow comes from the Upper Burdekin sub-catchment, (although it only represents about 28 per cent of the basin area) while 13 per cent of the flow comes from the Bowen/Broken sub-catchment, representing only seven per cent of the Burdekin River catchment.

Table 2-3 Average Catchment Contributions to the Burdekin River at Clare

Sub-catchment Area (km^2)	Area of Burdekin Basin above Clare (%)	Sub-catchment annual contribution (ML/a)	Contribution to total flow (%)
Upper Burdekin (36,181)	28	4,067,000	52
Belyando/Suttor (73,828)	57	2,554,500	33
Bowen/Broken (9,413)	7	1,021,760	13
Lower Burdekin (10,028)	8	132,700	2
Total at Clare (129,450)	100	7,775,960	100

Source: Burrows, 1999.

2.4 Rainfall

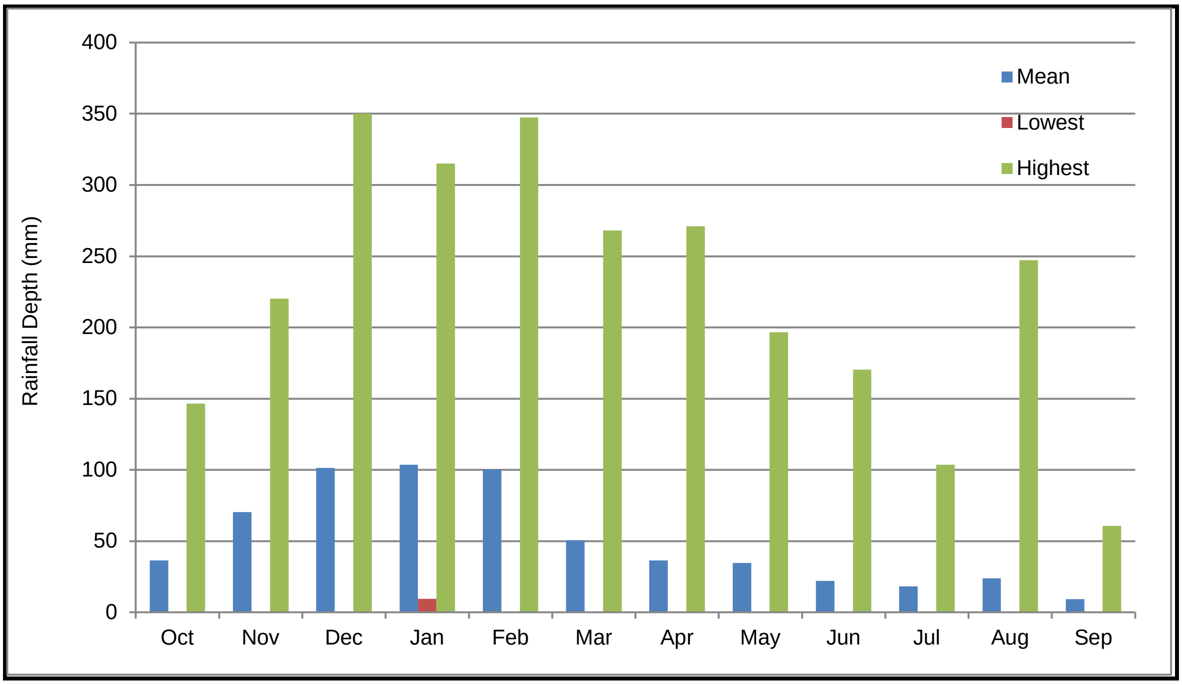
The main influence on the hydrology of the waterways crossed by the Project (Rail) is the rainfall patterns. The catchment areas of these waterways comprise over 35,000 km^2. Monthly rainfall data has been plotted from the records at Moranbah (Figure 2-9), Alpha (Figure 2-10) and Moray Downs (Figure 2-11). The locations of these rainfall gauges are shown on Figure 2-2.

From Figure 2-9, Figure 2-10 and Figure 2-11 it can be seen that:

- Rainfall patterns, in terms of summer maxima, winter minima and annual totals are broadly similar across this relatively large area. The annual total depths for the three rain gauges are 588 mm, 559 mm and 521 mm. These totals are consistent with the BOM regional average of 550 mm.
- In any month of the year, there can be zero rainfall.

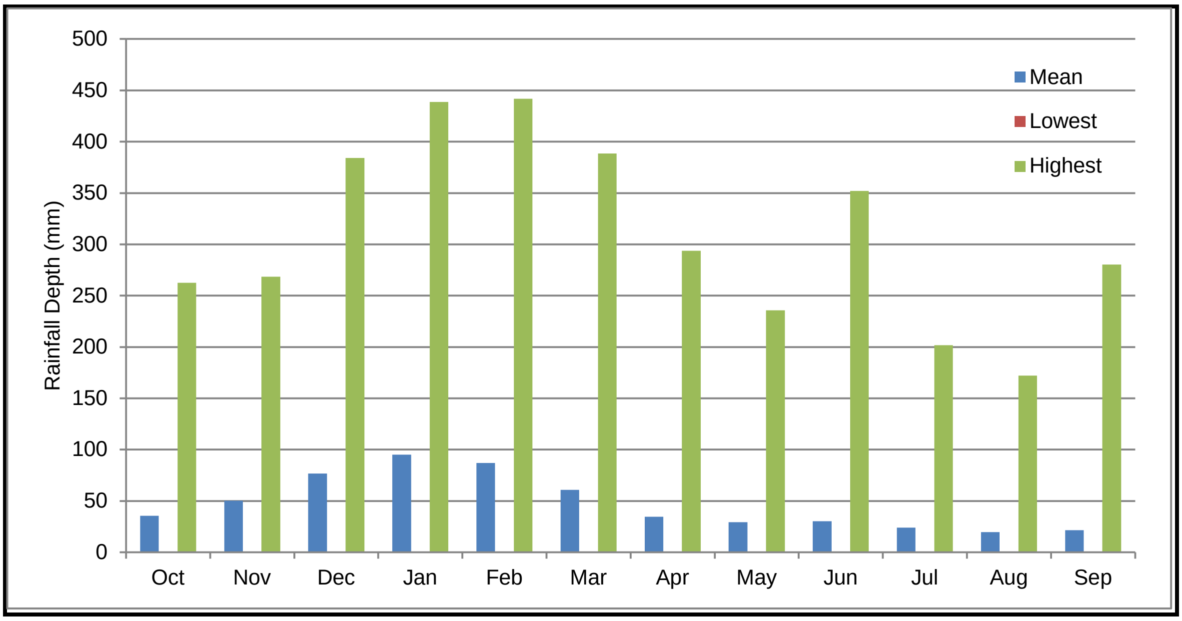
The monthly rainfall trends described above are reflected in the gauged daily river flows seen in Figure 2-3, Figure 2-4, Figure 2-5 and Figure 2-6 (refer Section 2.3). Similarly, the pronounced annual variations in rainfall, including the persistence of both dry years and wet years, affects the annual discharges at St Annes (Belyando / Suttor Rivers) and Goonyella (Isaac River), i.e. the flow pattern is similar to the rainfall pattern. Annual rainfall totals for several relevant rain gauges are presented in Figure 2-12, Figure 2-13 and Figure 2-14.

Figure 2-9 Rainfall - Moranbah



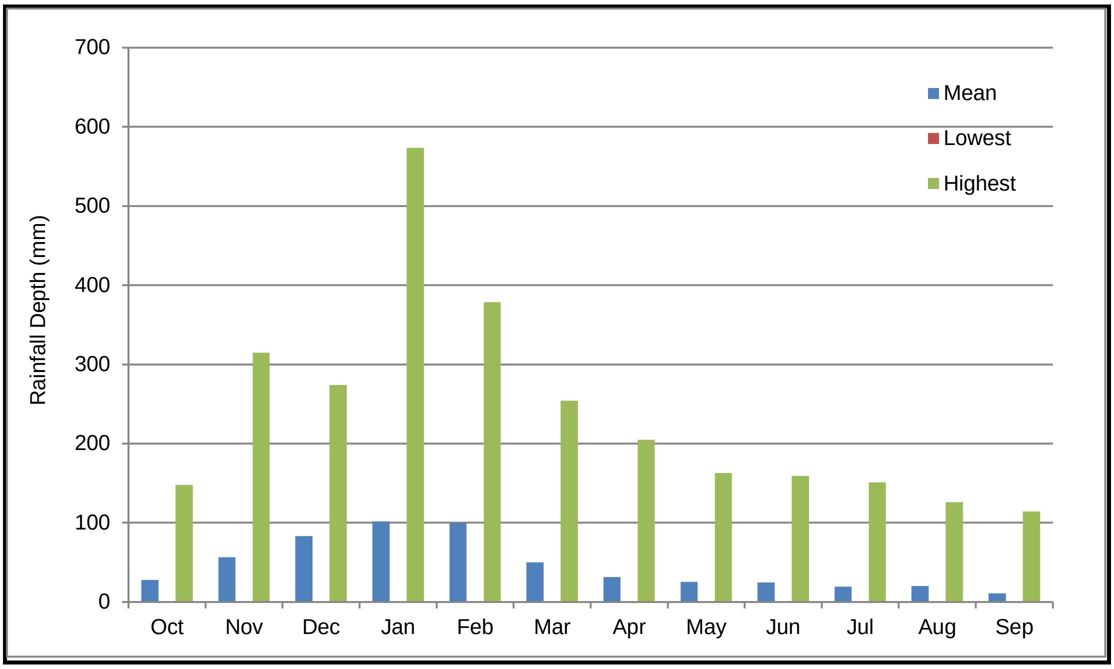
Location 34038 (S21°59.754' E148°01.832'). Elevation: 260 m

Figure 2-10 Rainfall - Alpha Post Office



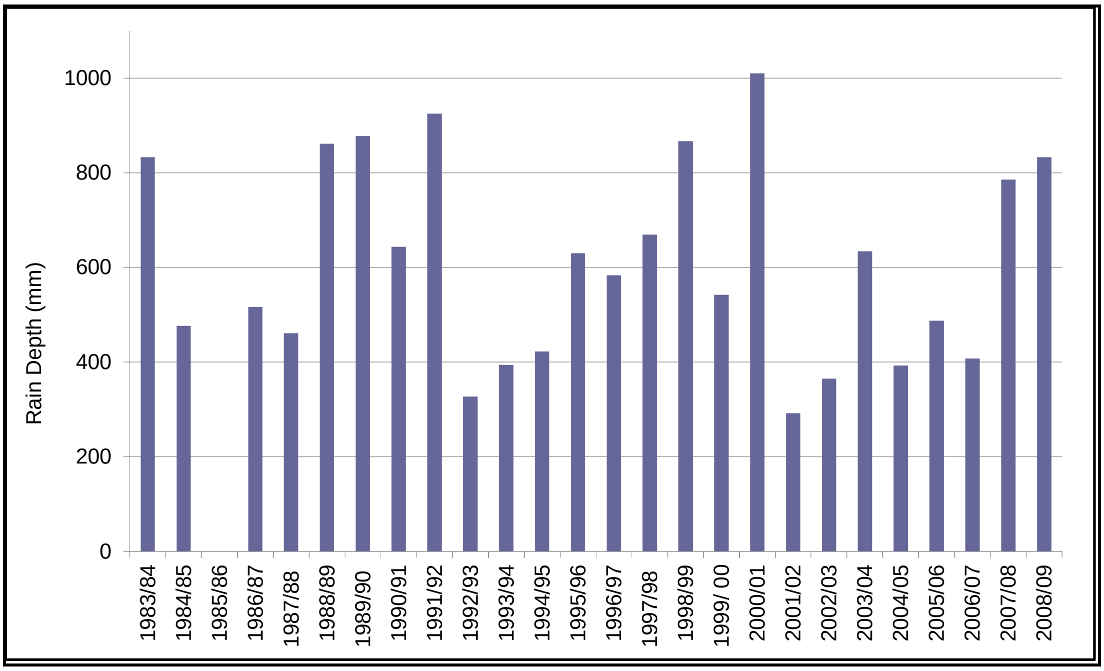
Location 35000 (S23°39.015' E146°39.009'). Elevation 355 m

Figure 2-11 Rainfall - Moray Downs



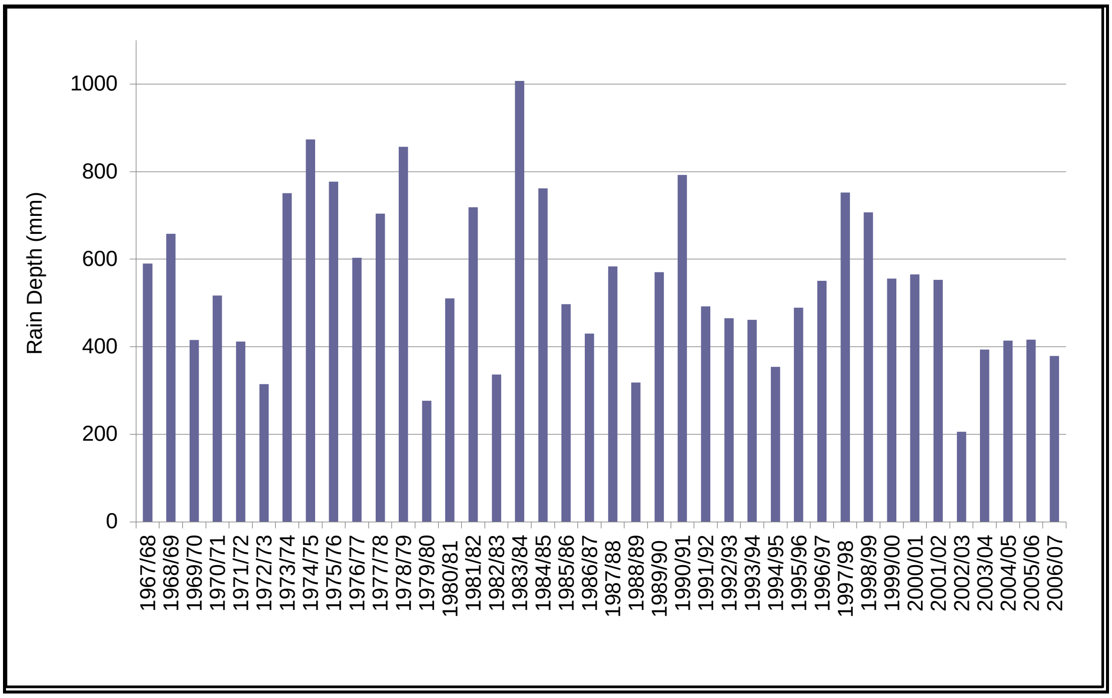
Location 36071 (S21°56.99' E146°37.799'). Elevation 195 m

Figure 2-12 Annual rainfall depths - Moranbah



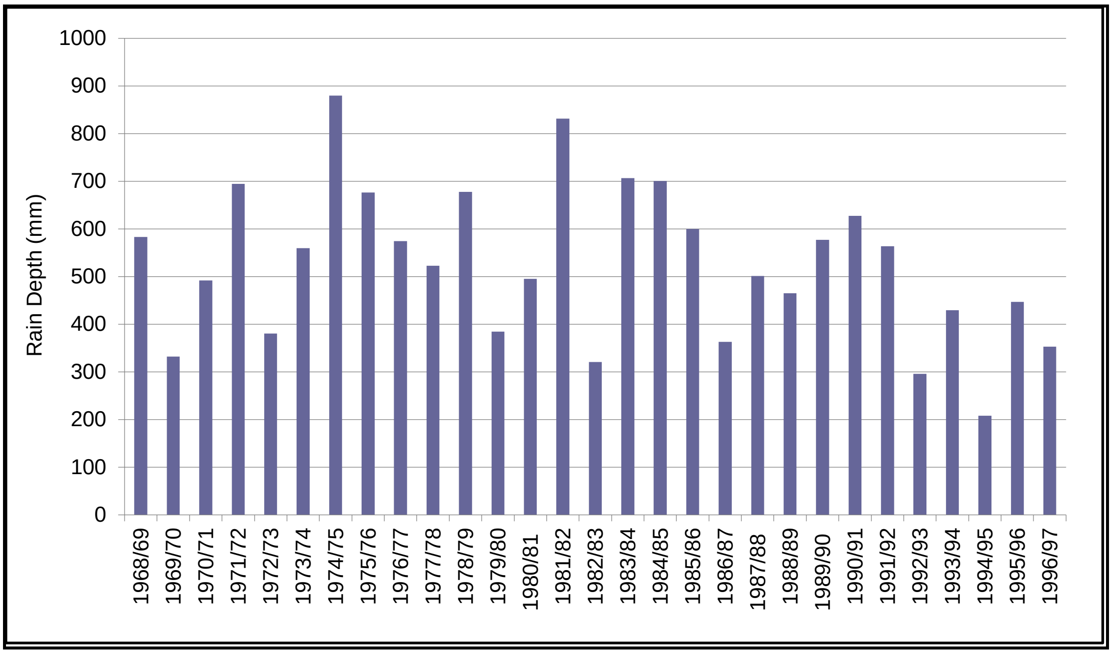
Location 34038 (S21°59.754' E148°01.832'). Elevation: 260 m

Figure 2-13 Annual rainfall depths - Alpha Post Office



Location 35000 (S23°39.015' E146°39.009'). Elevation: 355 m

Figure 2-14 Annual rainfall depths - Moray Downs



Location 36071 (S21°56.99' E146°37.799'). Elevation: 195 m

2.5 Weather Systems

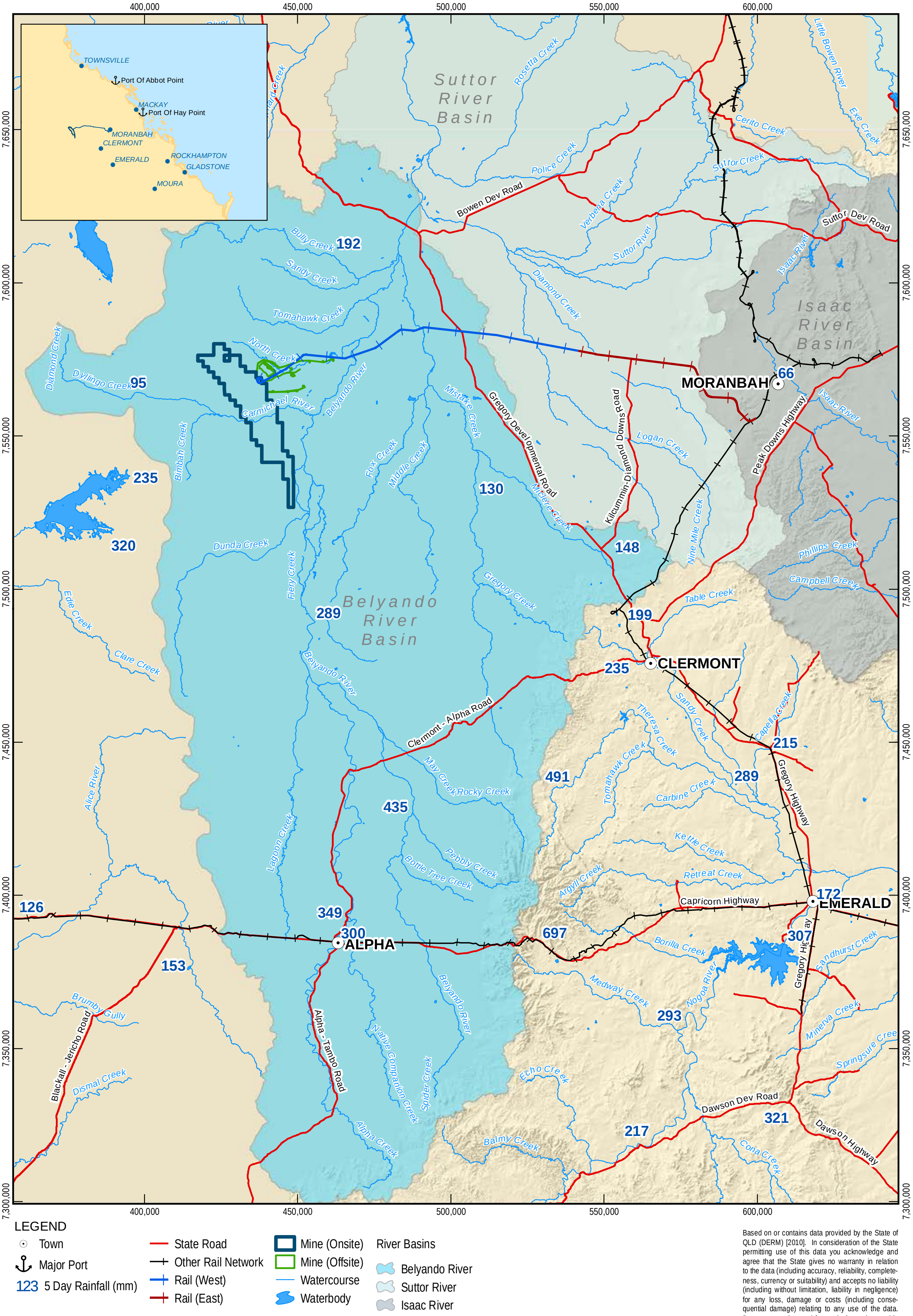
The summer rainfall maxima arise from prolonged eastward travelling monsoon depressions and intense short-term contributions from predominantly westward travelling tropical cyclones. According to Sturman and Tapper (2006), Australian tropical cyclones commonly originate in the Gulf of Carpentaria and out into the Coral Sea between 9-19^{o} south.

An average of ten tropical cyclones per year develop over Australian waters, of which six cross the coast, mostly over north-western Australia and northeast Queensland. According to Watkins (2011), the frequency of cyclones in eastern Queensland is significantly correlated to the fluctuations in the El Niño-Southern Oscillation (ENSO), which is driven by variability on sea surface temperatures in the Pacific Ocean. A strong La Nina phase of the ENSO (cooler sea surface temperatures off eastern Australia) saw four tropical cyclones crossing Queensland over the 2010/11 summer including Cyclone Yasi on 2 February 2011.

Rainfall associated with monsoons and tropical cyclones in North Queensland is often of extreme intensity and while as much as 1,000 millimetres can fall in a few days at the coast, depths of 200 to 300 mm are more common inland as shown by the rain depths associated with Cyclone Helen (8 January to 19 January 2008) as shown in Figure 2-15.

Although the Belyando River catchment appeared to miss the rainfalls of comparable depth over the summer of 2010/11, relatively high totals were still recorded including 92.1 mm at Moranbah and 196 mm at Barcaldine over the period 20 December to 27 December 2010. The extensive flooding in the Belyando River associated with this rainfall is discussed in BOM 2011.

The winter minima coincide with the stalling of large stable anticyclones over central Australia that cause cool dry west to southwesterly airflow to predominate over Queensland. Rainfall in this season is associated with short southerly fronts originating in the southern oceans that affect the southern and eastern coasts of Australia.



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1:1,700,000 (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

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision C
Date 05-09-2012

Cyclone Helen - Peak 5-Day Rain Depths to 20 January 2008

Figure: 2-15

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Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: BOM: Cyclone Helen 5 Day Rainfall (2008); DERM: River Basin (2009), State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

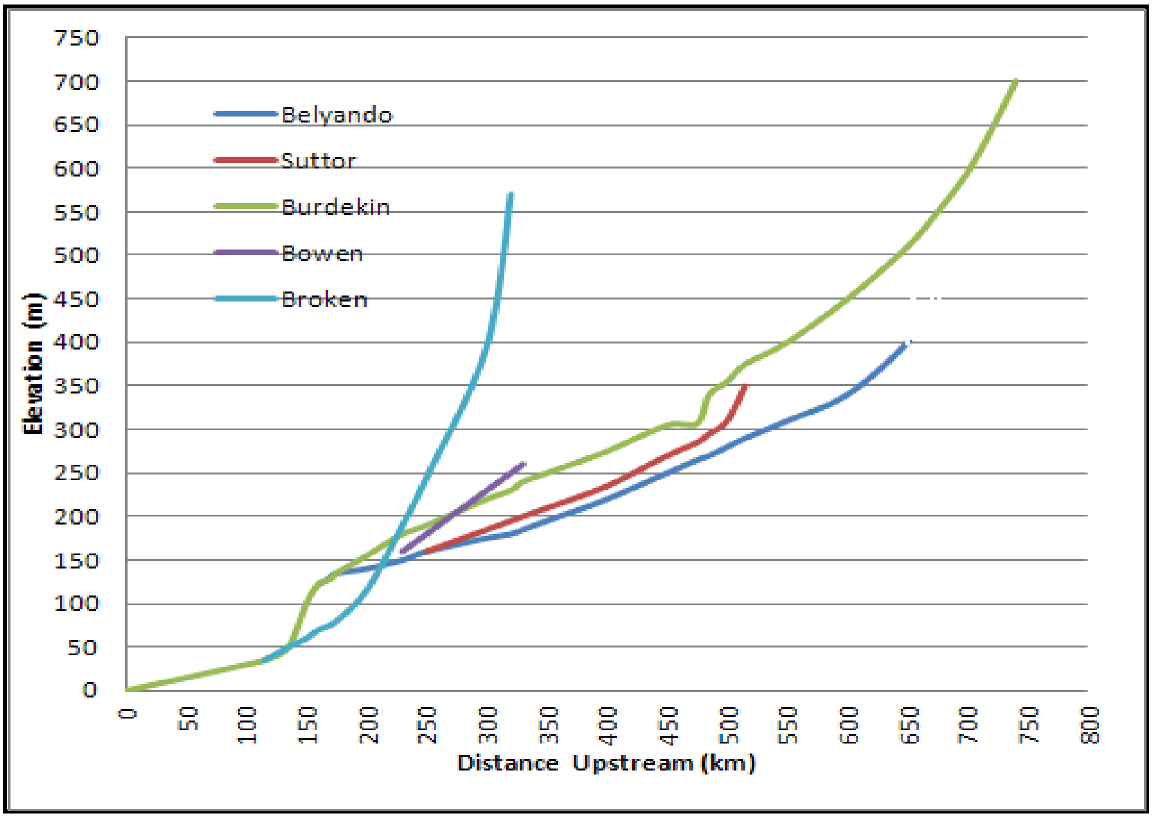
2.6 Catchment Morphology

There is little significant topography in the 300 km plus lengths of the Belyando and Suttor catchments. They occupy a long eroded plain sloping south to north with a few uplands and minor isolated hills rising no more than a further 200 m above the average elevation of the plain, which is approximately 200 m AHD. These rivers and most of their tributary waterways have small low flow channels and broad shallow floodplains often covered in light scrub. Figure 2-16 shows that the channel slopes of the Belyando River and Suttor River are also the shallowest of the Burdekin River tributaries. Average channel slopes of watercourses in the vicinity of the Project (Rail) are as follows:

- 1 in 1,750 for the Belyando River
- 1 in 1,650 for Mistake Creek
- 1 in 1,400 for Logan Creek
- 1 in 375 for Grosvenor Creek

The long flat catchments of the Belyando River, Mistake Creek and Logan Creek, with their shallow channel gradients means that although peak discharges can be very high, velocities are slow. Flood waves take a long time to travel through the catchment leading to an extended duration of flooding. By inference, flow velocities should be higher and floods of shorter duration in the Grosvenor Creek catchment.

Figure 2-16 Burdekin River Tributaries - Bed Profiles



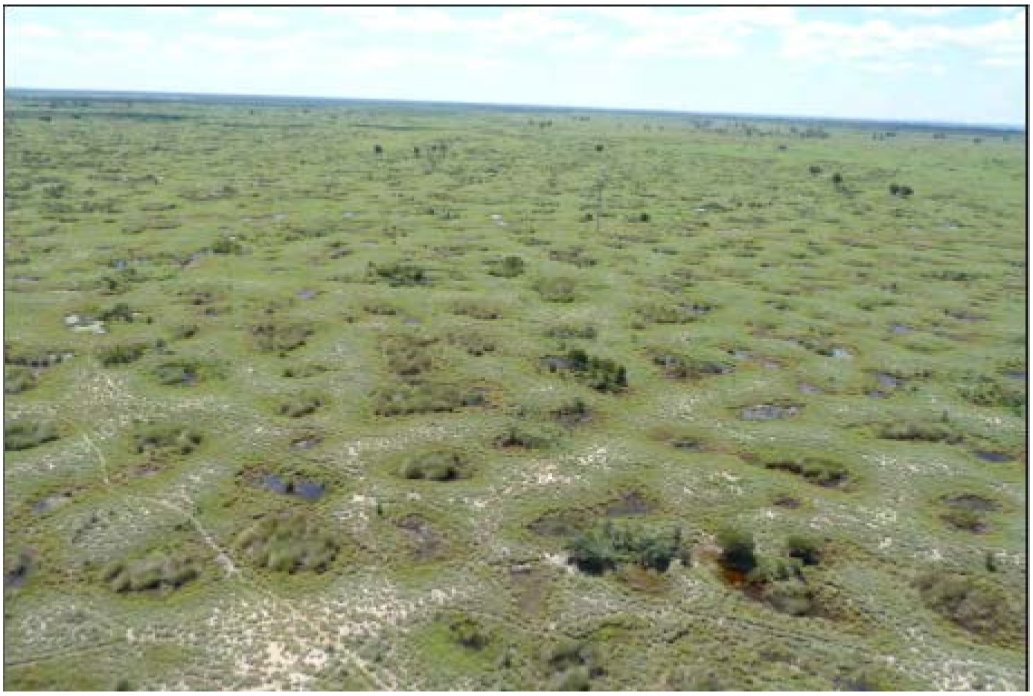
Source: after Pusey and Arthington (1996).

2.7 Soil

The other significant factor in the local hydrology apart from the rainfall patterns is the predominance of Vertosols (cracking clays) in local soils. For most of the year these soils shrink, opening deep cracks to as much as a metre underground. During the rainy season, the soils swell closing the cracks and water collects on the surface in the characteristic gilgai pattern (Plate 2-8) and saturated infiltration rates decline to near zero.

Substantial rainfall is thus absorbed and ponded before runoff and stream flow commences. (Mckenzie *et al*, 2004). These initial losses further explain why the Belyando/Suttor sub-catchment under contributes to the total flow of the Burdekin River when considering its proportion of the larger river catchment despite substantial seasonal rainfall events.

Plate 2-8 Gilgai plain in grazing land - Belyando River catchment



2.8 Historic Floods

The frequency of flooding as shown in Figure 2-17 for the available record (no data from 1972 to 1976 or from 2006 to 2010) from the Gregory Developmental Road gauge on the Belyando River mirrors the frequency of summer monsoonal and cyclonic rain events. Note the severity (as demonstrated by the annual maximum flood plotted in Figure 2-18) is likely to depend upon the level to which antecedent wetness has closed up the soil cracking as much as it does the amount of rainfall.

Figure 2-17 Flood Frequency on the Belyando River at Gregory Developmental Road Gauge (1949-2006)

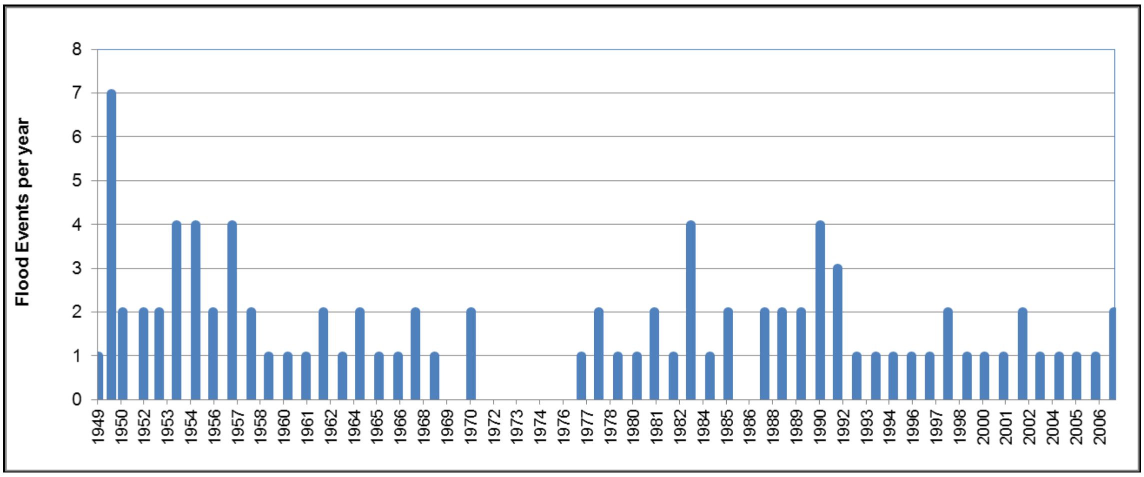
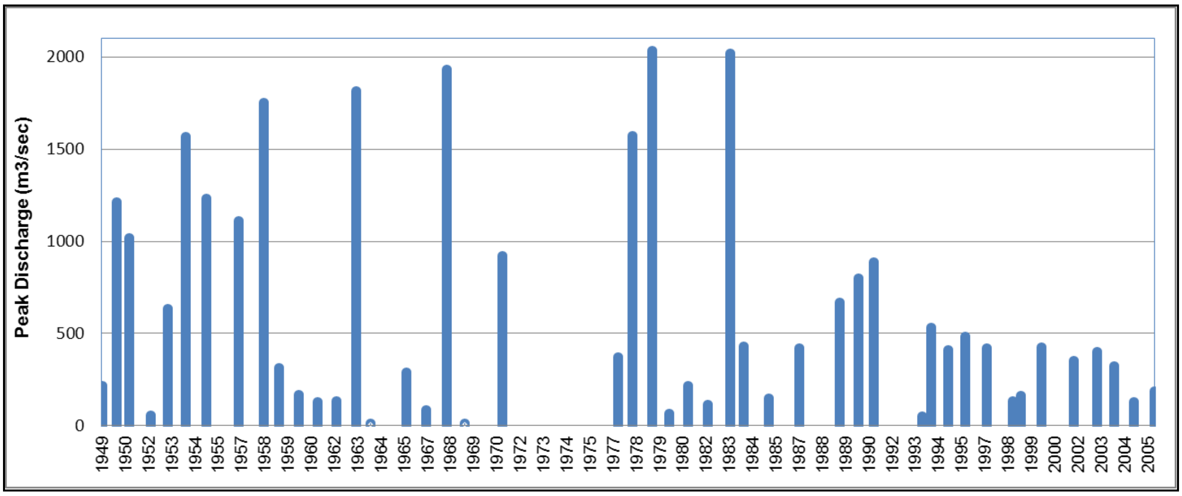


Figure 2-18 Annual Maximum Flood recorded on the Belyando River at the Gregory Developmental Road Gauge



There have been two recent cyclones that are noteworthy, namely Cyclone Yasi in December 2010 and Cyclone Helen in January 2008. Although the bulk of rainfall during Cyclone Yasi fell to the north of the Belyando River catchment, river levels still reached a peak of 3.2 m on 27 December 2010 at the Gregory Developmental Road gauge. Concurrent BOM (Bureau station number: 035229) flood heights recorded at the Alpha gauge (70 km to the south of the Mine Site and 140 km to the east of Barcaldine) were the third highest on record and only one metre lower than the record peak of April 1990.

The best documented flood of recent times in the Belyando River is associated with the slow moving tropical Cyclone Helen between 8 January and 19 January 2008. The 162 mm rain depth recorded at the Alpha rain gauge on 17 January 2008 is the highest recorded, and occurred within a six day total of 225 mm. This is illustrated by the concurrent hydrographs/rainfall plots from the Alpha and Gregory Developmental Road gauges shown in Figure 2-19 and the peak flood heights in Figure 2-17.

Flood frequency analysis (provided in Appendix D) shows that the 9.9 m recorded at Gregory Developmental Road was a 1 in 100 year event. The plots in Figure 2-19 are taken directly from BOM (2008). It is noted that the flood levels rise, fall modestly and then reach a plateau for more than two weeks. It is not known if this represents a persistence of flooding, or perhaps a malfunction of the gauge, such as a stuck recorder. Peak flood heights are shown in Table 2-4. The lateral extent of this flooding is shown in Figure 2-20.

During this event, 380,000 hectares and 59 properties were inundated and at Bygana Station on the true right of the Belyando River, 60 km up river from Project (Rail) corridor, 50 per cent of the property remained under water 32 days after the rain ceased. Plate 2-9 shows the extent of the flooding at Laglan Station, 30 km upstream of Bygana Station.

Figure 2-19 Cyclone Helen (January 2008) - Water Level and Rainfall Intensity

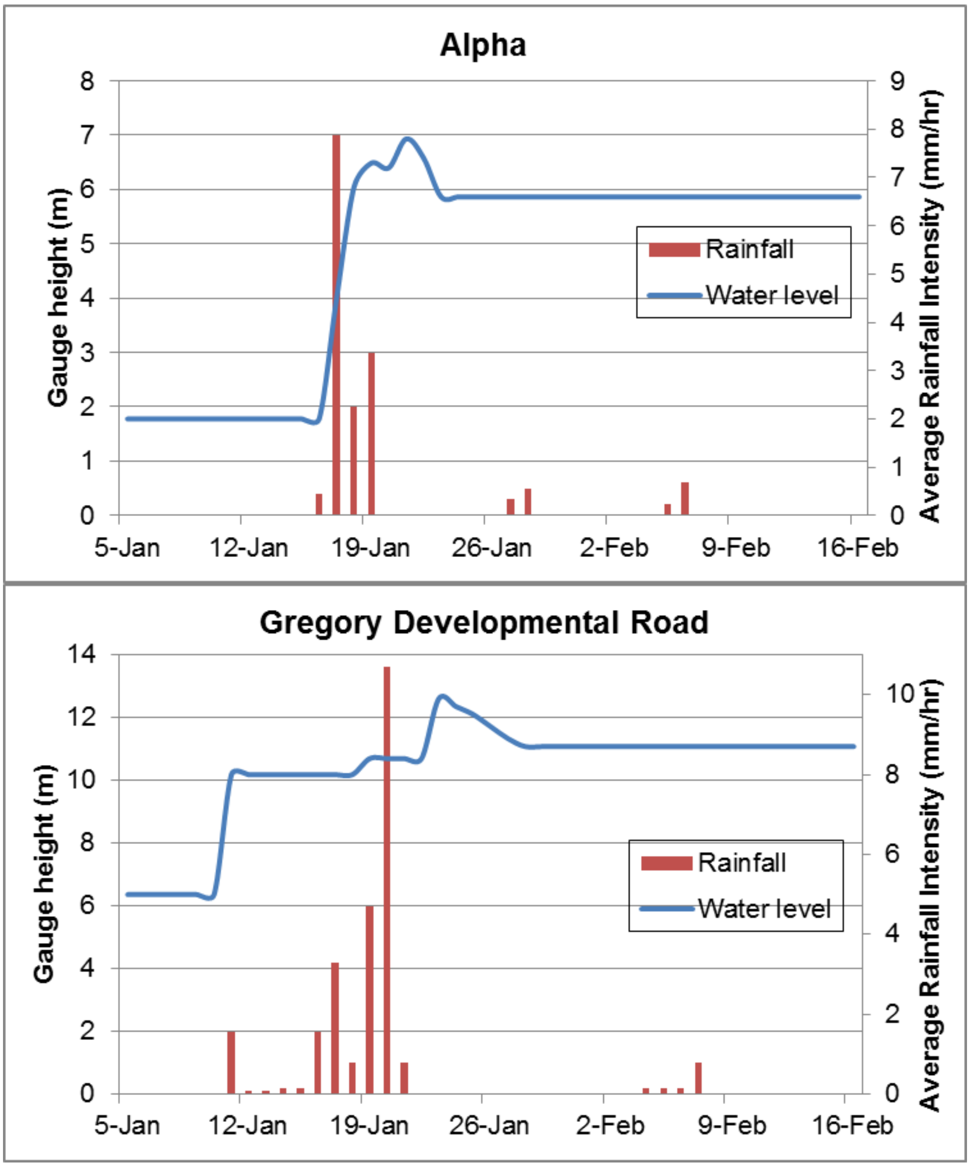
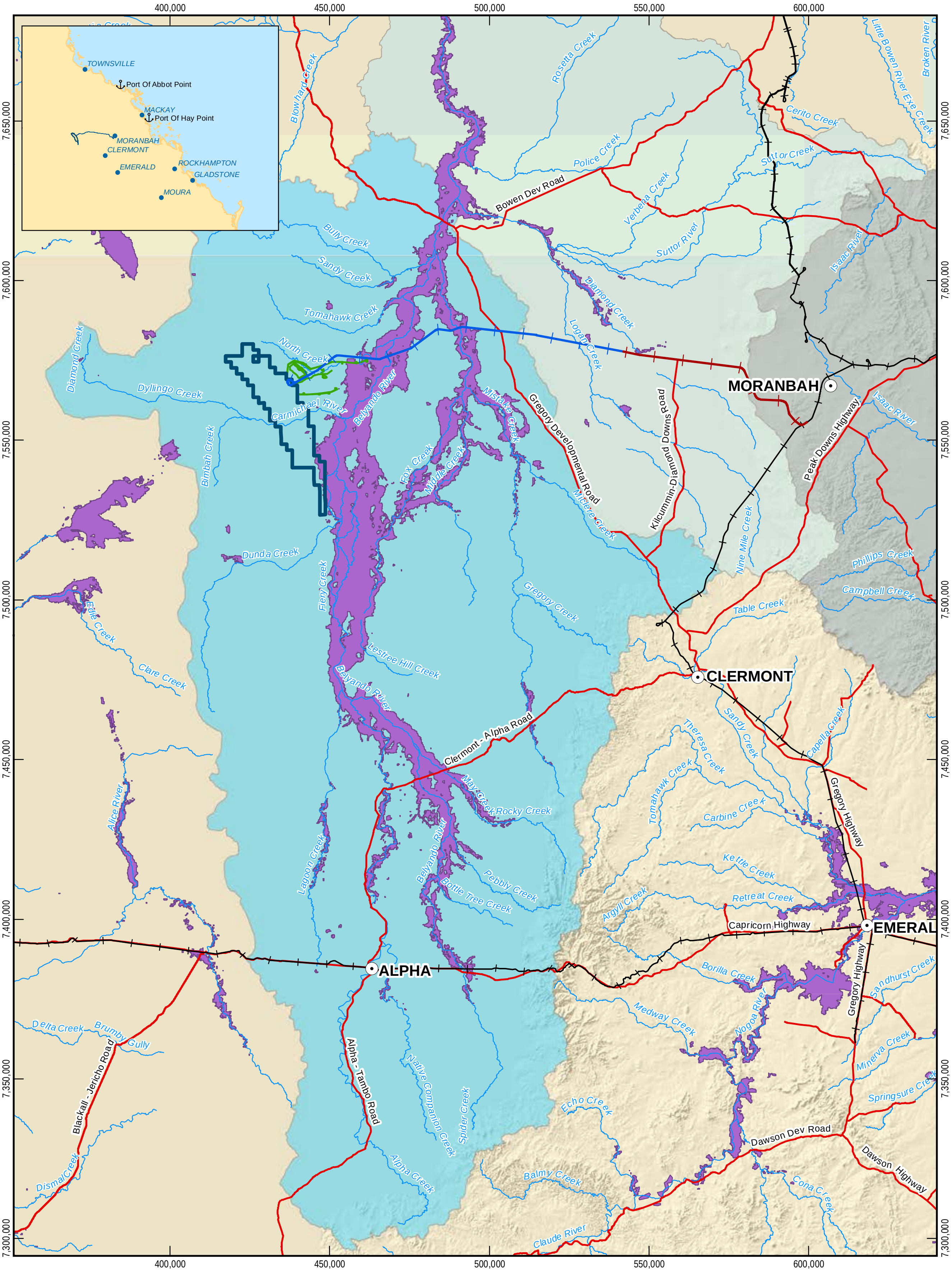


Table 2-4 Cyclone Helen (January 2008) - Peak Flood Heights for the Belyando River at Alpha and Gregory Developmental Road Gauges

Station No.	Station Name	Date	Height (metres)	Flood Class
35229	Alpha	18/01/2008 22:00	7.3	Minor
35229	Alpha	20/01/2008 04:00	7.7	Moderate
536007	Gregory Developmental Road	23/01/2008 07:30	9.1	Moderate
536007	Gregory Developmental Road	23/01/2008 16:00	9.9	Major

Source: BOM (2011)

Plate 2-9 Cyclone Helen (January 2008) - Flooding of the Belyando River at Laglan Station



LEGEND

Town	Rail (West)	Watercourse
State Road	Rail (East)	Cyclone Helen Flood Extent (2008)
Other Rail Network	Mine (Onsite)	
	Mine (Offsite)	

River Basins

- Belyando River
- Suttor River
- Isaac River

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.

1:1,700,000 (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

Job Number 41-25215
Revision C
Date 05-09-2012

Cyclone Helen Flood Extent
Belyando River 20 Jan 2008

Figure: 2-20

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Data Source: Dartmouth Flood Observatory: Cyclone Helen Flood Extent (2008); DERM: River Basin (2009), State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

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3. Flood Hydrology and Hydraulics of River and Creek Crossings

3.1 Introduction

The following is a summary of the outcomes of the preliminary modelling carried out by Golder Associates (2011). The report of this modelling, including all assumptions, is contained in Appendix B.

3.2 Design Flood Flow Estimates

Design flows for the major waterway crossings were derived using flood frequency regression analysis applied to local or regional historic streamflow data. Flood estimates for the 2, 10, 50, 100 and 500 year Average Return Interval (ARI) events were determined. Flood modelling proceeded with the 100 year ARI flood flows.

Flood flow estimates for the 12 major waterway crossings are presented in Table 3-1.

The Rational Method was used for the 76 minor waterways. The times of concentration adopted for the Rational Method estimations were calculated using the Bransby-Williams Formula in accordance with the recommendations in the Queensland Urban Drainage Manual (DNRW 2007). Runoff coefficients were estimated using methods in DNRW (2005). It was assumed that the soils have low permeability and that the vegetation is light to medium bush and grass cover. Table 3-2 summarises the results of the Rational Method flood estimates.

Table 3-1 Estimated Peak Flows for Major Waterways within the Project (Rail)

	Peak Flow m^3/sec		
Waterway	**50 yr ARI**	**100 yr ARI**	**500 yr ARI**
Grosvenor Creek	240	341	490
Diamond Creek	460	682	1100
Logan Creek	1000	1452	2100
Gowrie Creek	350	488	660
Mistake Creek	640	3022	800
Belyando River (East Branch)	310	443	630
Belyando River (Anabranch)	2600	3727	5400
Ogenbeena Creek (Lower Crossing)	550	799	1200
Ogenbeena Creek	550	791	1200
Combined branches of Belyando River and Ogenbeena Creek	2600	3400	5500

	Peak Flow m³/sec		
Waterway	**50 yr ARI**	**100 yr ARI**	**500 yr ARI**
North Creek	370	522	740
Eight Mile Creek	230	338	530

Table 3-2 Summary of Design Flows for Minor Waterways within the Project (Rail)

	Catchment Area (ha)	50 yr ARI Design Flow (m^3/sec)	100 yr ARI Design Flow (m^3/sec)
Minimum	0.11	4	4.7
Average	9	39	44
Maximum	110	300	336

3.3 Historic Floods and Estimates of Flow at Rail Corridor

Table 3-3 shows the results of the interpolation of ARI for the peak flows recorded in the Belyando River at Gregory Developmental Road gauge (120301B) and Mistake Creek at the Twin Hills gauge (120309A) during three historic floods. The peak discharges at the Project (Rail) were then derived from a pro-rata increase/decrease in catchment area between the crossing and the gauges.

Table 3-3 Historic and Estimated Peak Flood Flows

	Belyando River	Mistake Creek
May 1983 (Cyclone Naomi)	**3 May**	**3 May**
Estimated ARI (Years)	20	10
Recorded Peak Flow at gauge (m^3/sec)	2,018	425
Estimated Flow at Rail Crossing (m^3/sec)	1,589	439
January 2008 (Cyclone Helen)	**23 January**	**21 January**
Estimated ARI (Years)	100	10
Recorded Peak Flow at gauge (m^3/sec)	4,114	451
Estimated Flow at Rail Crossing (m^3/sec)	3,240	466
January 2011	**1 January**	**1 January**
Estimated ARI (Years)	10	5

	Belyando River	Mistake Creek
Recorded Peak Flow at gauge (m^3/sec)	1029	318
Estimated Flow at Rail Crossing (m^3/sec)	810	329

3.4 Estimation of Existing Flood Levels and Span Lengths at Waterway Crossings

The preliminary modelling undertaken by Golder Associates (2011) is of a provisional nature, based on concept design. The number and sizes of proposed bridges and culverts are likely to be revised as the detail design stage of the Project (Rail) design progresses. Model results for three "total bridge span scenarios" for each of the major waterway crossings are described. Note that in several cases one hydraulic model covers several neighbouring rivers and / or tributaries.

Initially bridge length estimates were based on a flow velocity through the openings of 2 m/s and are presented in Table 3-4.

Table 3-4 Summary of Watercourse Crossing Span Lengths (100 yr ARI Design Flood)

Waterway	Estimated Length of Span (m)
Grosvenor Creek	180
Diamond Creek	450
Logan Creek	400
Gowrie Creek	300
Mistake Creek	600
Combined branches of Belyando River and Ogenbeena Creek	2000
North Creek	300
Eight Mile Creek	300
5 minor crossings	100 to 250
45 minor crossings	10 to 100
15 minor crossings	<10

3.5 Afflux Modelling

Following completion of the Project (Rail) concept design (Aarvee Associates, 2011) additional bridge length scenarios were presented for consideration. Typically the additional scenarios involved bridge lengths that are longer and shorter than the provisional estimate. For Mistake Creek, however, all three bridge length scenarios are longer than the provisional estimate.

Hydraulic modelling of the 100 year ARI storm event using a 2-D model was conducted for pre- and post- development conditions at the Belyando River and Mistake Creek crossings to determine the afflux (the rise in flood level) of three bridge length scenarios.

The results for the pre-development conditions were transposed onto a LIDAR plot and calibrated against the satellite images of the historic floods. The modelled extent of the inundation in the Belyando River and Mistake Creek compared well with the 2008 Cyclone Helen inundation which was a 100 year ARI storm event. Table 3-5 and Table 3-6 show the modelled afflux results for the Belyando River and Mistake Creek, and Grosvenor Creek, Diamond Creek, Gowrie Creek and North Creek, respectively based on the 3 different span lengths modelled at each site. The locations of the Peak Afflux are described in Golder Associates (2011), but omitted from the table for clarity. Results are presented at three distances upstream of the railway, namely 0.5 km, 1 km and 2 km.

Table 3-5 Modelled Afflux for Crossings of the Belyando River and Mistake Creek.

		Modelled Afflux (m)			
	Span Length	Peak Afflux (m)	0.5 km upstream	1.0 km upstream	2 km upstream
Belyando River	6000 m	0.23 m	0.12	0.10	0.03
	2000 m	0.37 m	0.35	0.29	0.12
	800 m	1.95 m	0.71	0.61	0.33
Mistake Creek	4000 m	0.14 m	0.04	0.03	0.02
	1500 m	0.15 m	0.07	0.05	0.04
	800 m	0.28 m	0.20	0.13	0.09

Source: Golder Associates (2011).

Table 3-6 Modelled Afflux for Crossings of the Grosvenor Creek, Diamond Creek, Gowrie Creek and North Creek

		Modelled Afflux (m)			
	Span Length	Peak Afflux (m)	0.2 km upstream	0.5 km upstream	1 km upstream
Grosvenor Creek	240 m	1.08	0.04	<0.01	<0.01
	120 m	0.53	0.11	<0.01	<0.01
	60 m	1.00	0.54	<0.03	<0.01
Diamond Creek	680 m	0.23	0.23	0.26	0.19
	340 m	0.44	0.50	0.47	0.34
	200 m	0.60	0.79	0.70	0.52
Gowrie Creek	250 m	0.14	0.22	0.30	0.18
	125 m	0.34	0.31	0.34	0.20
	65 m	0.65	0.56	0.48	0.25
North Creek	520 m	0.23	0.08	0.01	<0.01
	260 m	0.51	0.10	0.10	<0.10
	130 m	0.47	0.42	0.23	<0.01
Eight Mile Creek	340 m	0.50	0.14	0.10	<0.01
	170 m	0.10	0.21	0.13	<0.01
	85 m	0.17	0.31	0.18	<0.01

Source: Golder Associates (2011).

Model limitations, such as artificial boundaries, preclude the presentation of data pertaining to the calculations on additional areas of inundation. Further afflux modelling of the other major waterway crossings is currently being undertaken as part of the engineering design process to determine the appropriate span lengths over those waterways and to determine the effect that any bridge configuration has on flood duration. The proposed modelling scope and methodology is outlined below.

In general, there is no defined acceptance criterion for afflux caused by railways that applies uniformly to all projects. Normally, the final result is a compromise between minimising the effects of afflux (and flooding) and cost. It is considered that this is an iterative process that continues through the design phase until potential and predicted impacts associated with flooding are considered reasonable and practical. The following observations may be useful to that decision making process:

- Longer bridges with less afflux cost more, but also provide some benefits to the proponent in the form of lower flood levels (which influence the elevation of the railway), and slower flow velocities through the bridges and hence a lower risk of scour at bridge abutments.
- In areas where land values are high (e.g., industrial, commercial and residential property, intensive horticulture), and / or where there are many flood vulnerable assets such as sealed roads, lower levels of afflux are sought.
- In areas where land values are lower, and where the flood affected assets are sparse and of lower value (e.g. broad acre dry land farming, limited unsealed roads that are lightly trafficked), and where the lateral gradients are generally steeper (implying modest additional flooding area for a given rise in flood level) higher values of afflux may be appropriate.
- For a given floodplain value, where the duration of flooding is moderately long (say 12 hours to 3 days), and where the lateral slope of the floodplain is generally flatter, acceptable afflux values will be generally smaller, and vice versa.

Further investigations, including detailed identification and consideration of all afflux affected property and asset owners, is currently being undertaken as part of the base engineering design and will progress as the detailed design progresses in order to refine afflux levels appropriately. The levels shown in Table 3-7 have been adopted as preliminary levels for the base engineering design. These levels are based on what is considered to be current industry practice for this type of infrastructure project in the region. However, discussions will need to be held with stakeholders as part of the design development process to ascertain final limits.

Table 3-7 Preliminary Afflux levels adopted for Base Engineering Design

	Afflux Limit (m)
Critical Infrastructure	0.2 maximum
Housing Areas	0.1 maximum
Other Areas	Limited to 0.3 where practicable
Non-critical infrastructure / housing or uninhabited areas	0.5 maximum

A hydrological/hydraulic report will be prepared to identify drainage structure dimension requirements based on the proposed design basis including afflux limitations, velocity limitation and stakeholder requirements in order that the construction of the railway and associated infrastructure has an acceptable effect on the hydrological behaviour of the associated region in its current state. The report will include the following as a minimum:

- Design criteria and methodology
- A qualitative and quantitative description of each major crossing
- The catchment area at each major crossing location
- Details of the watercourse for the mainstream and its tributaries
- Longitudinal slope of the main stream and average land slope of the catchment from the contours
- Extent of vegetation (forest, pasture, cultivated, barren, etc.)
- Probable changes that may occur in the catchment characteristics and flow velocity forecasts
- Information from the rainfall records of local or nearby rain gauges
- Other climatic conditions (like temperature, humidity, etc.)
- Changes in the course of the channel
- The nature of the material through which the channel flows (whether it consists of boulder, gravel, sand, clay or alluvium) to the extent possible using available geotechnical information
- Design flood levels at each major crossing (based on railway levels of optimised alignment)
- Flood inundation mapping, velocity profiles, peak water level and afflux levels
- Embankment protection options along the alignment
- Scour depth based on estimated flood in the vicinity of the proposed bridge to the extent possible using available geotechnical information
- Full description of bridges including relief and overflow structures
- Waterway area, span length and number of spans
- Pier orientation with consideration to alignment design
- Identification of debris classification
- Cross-sections near each structure and direction of the current during floods
- Longitudinal drainage requirements associated with cross drainage waterway areas
- Photographs of past floods, main channels and flood plains where available
- A detailed map showing flood patterns, location of proposed bridges, spill openings, if any, and alignment of piers

The methodology to produce the hydrological/hydraulic report will include:

- Field inspections of all major creek systems
- Mapping of the location of all waterway crossings for the proposed rail alignment
- Calculation of the catchment areas for each crossing

- Estimation of the design flood peak discharges for each crossing
- A detailed hydraulic investigation to provide the required waterway area to the immunity criteria for each crossing
- Determination of prospective water crossing structures (bridge or drainage structure) in consultation with the rail and structural designers
- Detailed assessment of afflux at each crossing and outline of resulting effects on properties, structures and infrastructure (both pre-developed and post-developed)
- Proposed modelling scenarios will be 20 year ARI, 50 year ARI and 100 year ARI of the 12 major river crossings. The 2000 year ARI will also be modelled for bridge serviceability design requirements.
- Protection design (including erosion control) subject to the availability of input data for each water crossing structure and any other relevant areas of the rail line as required.

4. Potential Impacts and Mitigation Measures – Construction Phase

4.1 Overview

This section assesses the potential impacts on the environment values identified in Section 2.2 during the construction phase of the Project (Rail) and presents mitigation strategies to address them

4.2 Stock Watering and Farm Use

4.2.1 Potential Impacts

A number of construction water supply options are available and have been investigated by Hyder Consulting (Hyder Consulting, 2012).These included groundwater and surface water (existing large storage dams, in line and offline storage and minor overland flow capture structures) options within 1-2 kms of the Project (Rail).

Overall water supply demands for construction activities including foundation preparation, material conditioning, haul road maintenance, earthworks, dust suppression, concrete batching, construction camp water and access track maintenance result in an estimated peak demand of 450 kL per day equating to a groundwater bore yield of about 8 L/s for 16 hours pumping over a period of 24 hours. The water supply investigation identified existing possible supply points along the proposed rail alignment to minimise construction of new supply points. Twenty-nine registered existing groundwater bores were investigated (18 within 10 km of the alignment and 11 between 10 and 20 km of the alignment). It is expected that any groundwater impacts will be localised and temporary and as such the construction phase of the Project (Rail) will not adversely impact on water quantity associated with stock watering and farm use.

With respect to water quality, there are potential impacts to stock watering and farm use associated with the potential for contamination and increased turbidity (through sedimentation and additional total dissolved solids (TSS)). Raised sediment levels, cement residues and hydrocarbon spillages diminish the value of the water as a farm supply. Potable use of these water supplies would require increased treatment. Irrigation lines can become clogged and downstream farm dams can silt up diminishing capacity of seasonal storage. Good water quality is essential for successful stock production. Poor quality water is less palatable to animals leading to poor health and impaired fertility.

If river and / or creek flows are temporarily impounded by the construction phase embankments, this can potentially reduce the supply of downstream stock water and / or irrigation supply. Sediment liberated by scouring can potentially have adverse water quality effects, which may adversely affect stock.

4.2.2 Mitigation Measures

Mitigation measures to address the potential deterioration in water quality comprise:

- A comprehensive suite of erosion and sediment control measures will be incorporated into the construction phase works (refer Volume 3 Section 13 Environmental Management Plan)
- Construction methodology allowing for construction within watercourses to be undertaken during the drier periods, as far as is practicable

4.2.3 Summary

Based on the proposed water supply option of utilising new groundwater bores and surface water options, it is expected that some temporal impacts to existing farm supplies may occur. Regulatory permits and approvals would need to be secured prior to the take up of these options and would require assessment and mitigation of potential impacts to surface flows. Water quality potential impacts will be mitigated by the measures described under Section 4.3, such as construction in dry periods and incorporating ESC measures in the construction phase works.

4.3 Aquatic Ecosystems

4.3.1 Potential Impacts

Corridor establishment activities, such as vegetation clearance, topsoil stripping and earthworks in the floodplain and bed and banks of the low flow channel, temporarily create areas of exposed earth, which potentially leads to a degradation of water quality, and hence potentially impacts upon the aquatic ecosystem in the downstream waterways after a rainfall event. Other construction activities that can also lead to erosion and hence a degradation of water quality, i.e. an increase in turbidity and TSS concentrations, include tracks made by construction vehicles, such as utilities, heavy trucks and mobile cranes.

Other potential sources of water pollution are:

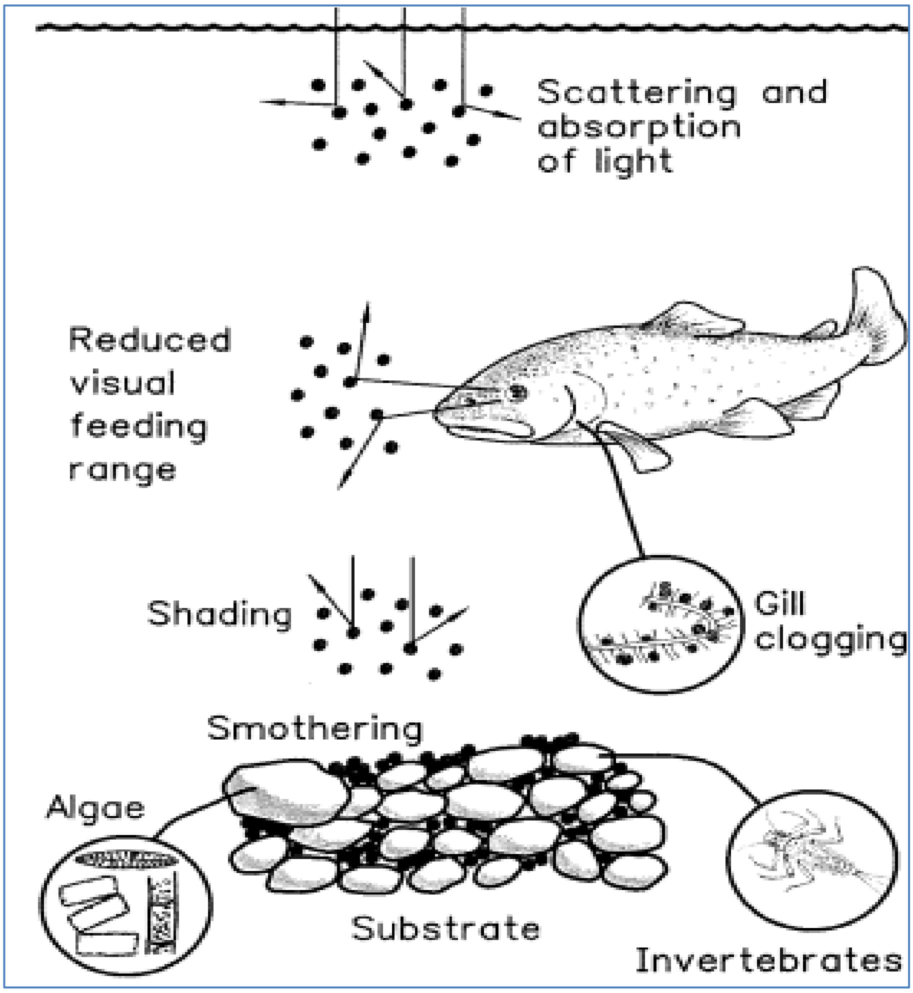
- Spillages of concrete and cement residue, which can originate from wash down of boxing and equipment used for in situ casting of waterway crossing components
- Fuel and lubricants from site machinery. Refuelling and lubrication maintenance activity on site carries the greatest risk

A degradation of water quality during the construction phase, as described above, would potentially have the following adverse effects, as illustrated in Figure 4-1. Elevated sediment loadings/turbidity lead to covered stable natural substrates and reduces habitat availability. Interstitial spaces are clogged, promoting oxygen depletion and food sources are contaminated (e.g. algal layers laden with silt are less palatable for browsing or grazing invertebrates). Suspended sediments can clog fish and invertebrate gills, decrease light availability for aquatic plants and reduce visibility for fish. Undersized culverts in a construction phase causeway increase velocities of flow through it. This can adversely affect the upstream migration of aquatic animals. If there is a blockage causing loss of flow, there is a risk of habitat damage. Scouring of the channel bed can cause loss of habitat and the displaced sediment can degrade water quality for animals and plants as described above.

Furthermore, localised high sediment contamination can become a barrier to migration of some species that then decline in abundance due to restriction in range or loss of seasonal habitat above the contaminated reach (ANZECC, 2000). Over time aquatic ecosystem values change from those accommodating a high biodiversity of species characteristic of clean water such as fish, to a low biodiversity environment of silt tolerant worms and invertebrates (Williamson, 1993). In addition to this, there can be a further loss of animals such as fish eating birds that were dependent on the cleaner water food sources.

Lime is a major component of cement and concrete. Spillages dissolve easily in water and readily overwhelm the buffering capacity of any stream. Receiving water becomes alkaline (pH in the range 11 to 13), which kills fish and other aquatic life.

Figure 4-1 Effects of High Sediment Loadings on Aquatic Ecosystems



Source: Christchurch City Council, 2003.

Although most minor oil and fuel spillages are believed to be relatively innocuous in the aquatic environment (Williamson ,1993), a constituent of oil and fuel spillages is polynuclear aromatic hydrocarbons (PAHs) which are known to adversely affect aquatic sediment-feeding animals (ANZECC, 2000 and Williamson, 1993). While the PAHs are only a small fraction of total oil discharge, it may have an effect far in excess of the volume of its contribution (Williamson 1993). PAHs typically become bound to fine particulate matter, which can be ingested by aquatic animals.

The development and operation of construction camps and concrete batching plants will potentially affect surface water resources through the potential discharges of:

- Runoff from the construction camps, concrete batching plants and stockpiling areas is likely to contain elevated levels of sediment plus concrete residues and hydrocarbons from vehicle movements fuelling and maintenance. Unimpeded run on water or floods would become contaminated if allowed to flow through the sites. This constitutes a potential impact to the aquatic ecosystems.
- Stormwater from the roofs and hardstand associated with the construction camps runoff will contain significant quantities of sediment from the coming and going of work parties and vehicles. The stormwater runoff from the concrete batching plants will contain high levels of sediment that may have significant lime content from cement dust, spilled concrete product and equipment wash down. Some hydrocarbon residues may also be present in this latter runoff.

4.3.2 Mitigation Measures

A comprehensive suite of erosion and sediment control measures will be incorporated into the construction phase works. Details of these include:

- Complete the crossing constructions in drier periods when most waterways are dry or have minimal flow, as far as possible
- Minimise any runoff and sedimentation from the construction to waterways. Before commencement of earthworks, install perimeter catch drains to prevent offsite upslope clean water from entering the site and bunding and basins downslope to confine dirty water within the site and out on the low flow channel. Design and manage the installation of such controls in accordance with IECA guidelines (IECA 2008).
- Minimise the area of vegetation disturbance and bare ground within the floodplain and conduct rehabilitation of disturbed ground progressively as soon as construction activities are complete in any area.
- Commence construction with the crossing (including any temporary structures) of the low flow channel. This will minimise time spent in the area of greatest potential environmental damage risk.
- Use bridges in preference to causeways as temporary building platforms/vehicle access as they involve less disturbance to the bed of the low flow channel
- Do not permit stockpiling of soil in the bed of the low flow channel or floodplain
- Do not permit spillages of concrete or wash down to enter water
- Do not permit refuelling or servicing of vehicles and plant within the low flow channel. Clean up spills immediately and dispose of contaminated soil and clean-up materials off site at an appropriate facility.
- Develop a surface water monitoring program for the Belyando River in accordance with the Australian Guidelines for Water Quality Monitoring and Reporting (NWQMS 2000). Include TSS, turbidity and pH in this program.

Mitigation measures that apply to the construction camps, concrete batching plants and hard stand area include:

- Locate construction camps and concrete batching plants away from creeks and waterways and at least 0.5 m above the 100 year ARI flood level
- Minimise any runoff and sedimentation from the camp to waterways. Before commencement of earthworks, install perimeter catch drains to prevent offsite upslope clean water from entering the site. Construct bunds and sediment basins downslope to confine dirty water within the site. Manage the installation of such controls in accordance with IECA guidelines (IECA 2008).
- Minimise the area of vegetation disturbance and bare ground within the floodplain and conduct rehabilitation of disturbed ground progressively as soon as construction activities are complete in any area.
- Discharge to ground all campsite stormwater runoff
- Contain all runoff from concrete batching plants within the plant footprint and incorporate it and wash down water into the process water supply recycling. Prevent spillages of concrete and wash down water from entering waterways.
- Do not permit refuelling or servicing of vehicles and plant outside designated areas. Clean up spills immediately and dispose of contaminated soil and clean-up materials off site at an appropriate waste disposal facility.

4.3.3 Summary

Potential impacts to the aquatic ecosystem arise from the possibility of deterioration in water quality. Mitigation measures will be incorporated to limit the water quality risks to acceptable levels.

4.4 Other Values (Floodplain)

4.4.1 Potential Impacts

The construction of temporary bridge/causeways over the channel as a construction platform, or for vehicular access, is a potential barrier to waterway flows. This could potentially cause additional flooding if there is insufficient hydraulic capacity to convey the flood flows, or the waterway becomes blocked by debris. It is likely that any construction phase causeways are built to a low flood immunity standard. Increases in flood level, and flood extent from these temporary works, may result.

4.4.2 Mitigation Measures

Construction phase activities within major watercourses are as far as is possible, likely to be limited to the drier periods and the risk of additional flooding of the floodplains is considered low. However, the following specific mitigation measures are proposed:

- Use bridges in preference to causeways as temporary building platforms/vehicle access as they involve less disturbance to the bed of the low flow channel
- If a causeway is preferred provide sufficient hydraulic capacity to allow the conveyance of natural flows with minimal increase in velocity or afflux

- Keep low flow channel and any culverts through site clear of debris
- Conduct a detailed scour assessment to determine the appropriate depth of cover or scour protection measures to be adopted at each crossing. The detail design of the creek crossings will incorporate works and measures to minimise the following:
  - The risk of damage to the creek banks during construction
  - Change in the sediment transport regime at the crossing
  - The risk of creek bank collapse or erosion during flood events

4.4.3 Summary

Temporary works in the waterways have the potential to raise flood levels in a flood. To mitigate this potential impact several control measures have been identified to avoid and/or reduce the potential adverse impacts.

5. Potential Impacts and Mitigation Measures - Operational Phase

5.1 Overview

This section assesses the potential impacts on the environmental values as identified in Section 2.2 that have the potential to be impacted on by the operational phase of the Project (Rail) and presents mitigation strategies to address them.

5.2 Stock Watering and Farm Use

The potential impacts to stock watering and farm use are expected to be limited because in the operational phase it is not intended that the railway will divert (or directly abstract or take) water from any of the rivers and creeks.

There are unlikely to be any adverse effects on stock water and irrigation due to afflux. Potential impacts in relation to farm road and stock routes are covered in Section 4.4 under Other Values (Floodplain).

A description of the flood modelling work undertaken by Golders Associates (2011), including the afflux (rise in flood level) results is presented in Section 3.

5.2.1 Mitigation Measures

No mitigation measures in relation to stock watering are proposed.

5.2.2 Summary

No adverse impacts on stock watering facilities or farm dams are expected during Project (Rail).

5.3 Aquatic Ecosystems

5.3.1 Potential Impacts

Faster flow velocities at the railway crossings leads to the following potential effects:

- Potential scouring of the river bed at crossings and immediately downstream due to faster flow velocities. Scour is exacerbated by turbulence at piles or the edges of rail embankments. Any scour leads to an increase in the silt load. Scour can cause holes to appear around the piles of bridges and immediately downstream of bridges and culverts.
- Increased difficulties for the upstream migration of fish and native animals through bridges and culverts

5.3.2 Mitigation Measures

Mitigation measures include:

- Select appropriate bridge and drainage structures, which will tend to limit the increase in flow velocity
- Incorporate into the detail design scour protection measures at all locations where analysis of the in-situ material and modelled flow velocities suggest the potential for scour. Erosion prevention measures include: rip-rap pads, wing walls on embankments, shotcrete, rip rap and / or gabion bed protection.
- Generally at bridges and culverts the placement of larger rocks of a size that enable fish to migrate through the flow in shorter more manageable steps, set the invert of culverts below the ground surface.

5.3.3 Summary

During the operational phase, potential impacts on the aquatic ecosystem associated with scour are possible. Mitigation measures, such as selecting longer bridges and incorporating scour protection measures will reduce this potential impact.

5.4 Other Values (Floodplain)

5.4.1 Potential Impacts

A description of the flood modelling work, including the afflux (rise in flood level) results is presented in Section 3. The overall context of the magnitude of afflux is also presented in Section 3.

It is noted that the Project (Rail) concept design considers a range of crossing openings (i.e. bridge lengths and/or culvert widths). As such, the magnitude of the afflux was not defined at that stage. It is considered however that while afflux will be unavoidable, predicted flood levels upstream of bridges and drainage structures will be assessed throughout the detailed design phase such that no existing buildings, structures or other infrastructure will be adversely affected by increased flood levels as a result of the Project (Rail). Further to this preliminary afflux, limits have been adopted for the base engineering design which is currently being completed (refer Table 3-7). These limits are presented in Section 3.

Potential impacts arising as a result of afflux are described below:

- Graziers currently lose the use of grazing land for the duration of flooding. An increased afflux has the potential to lead to greater areas of lost grazing land being inundated during floods. Inundation may also be present for longer. According to DEEDI (2010), five days full of inundation is sufficient to kill the exotic buffel grass. Buffel grass is a common species of grazing land pasture in the Dry Tropics. The estimated average flood duration only exceeds five days for the Belyando River so incremental loss of buffel grass is unlikely to be of concern.
- Widespread grass death caused by weeks of flooding in the Belyando River associated with Cyclone Helen in 2008 (an estimated 100 ARI event) resulted in a proliferation of the toxic pest herb *Pathenium hysterophorus* (parthenium). An increase in flood extent and duration will potentially increase the area at risk of invasion by parthenium.

- Infrastructure assets in the floodplain, such as roads and farm tracks, will most likely be affected by the increased depth and duration of flooding.
- In areas where land values are lower, and where the flood affected assets are sparse and of lower value (e.g. broad acre dry land farming, limited unsealed roads that are lightly trafficked), and where the lateral gradients are generally steeper (implying modest additional flooding for a given rise in flood level), higher values of afflux may be appropriate.
- For a given floodplain "value", where the duration of flooding is moderately long (say 12 hours to 3 days), and where the lateral slope of the floodplain is generally flatter, acceptable afflux values will be generally smaller, and vice versa.

5.4.2 Mitigation Measures

Mitigation measures associated with potential impacts to the floodplain as a result of the operation of the Project (Rail) will consider the following:

- Continued and iterative flood modelling through detailed design will determine afflux values in association with refinement in bridge and culvert crossing design.
- Further work will be undertaken to catalogue the impacts of afflux on the floodplain, properties, assets and infrastructure
- Selectively raising farm roads, by placing fill material, will reduce the impact on farm roads subject to negotiations and agreements with landholders and asset owners
- Consideration of compensation to flood affected land and asset owners in relation to excessive afflux

5.4.3 Summary

Conceptual flood modelling presents results for three waterway opening scenarios as a preliminary step based on concept level design. Individual crossing structures will require further modelling as detailed design for the Project (Rail) progresses to determine exact afflux impacts and limits can be determined.

The principal effect of the operating railway crossings is likely to be changes to the flows of waterways and overland flow paths, and particularly the rise in flood levels (afflux). Current hydrology and hydraulic modelling is being undertaken with base afflux limits being used as a basis for determining an acceptable afflux and to refine the assessment of potential impacts on infrastructure, landholdings and ecosystems.

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6. Conclusion

At the current time (concept design complete) the Project (Rail) has not adopted specified bridge lengths. As such the magnitude of the afflux, and its impacts on farm roads and other floodplain assets, is defined across a range rather than as set limits. The base engineering design currently being completed has adopted specific preliminary afflux limits which will result in base bridge lengths being developed along with the identification of impacts on farm roads and other floodplain assets.

This report provides:

- Sufficient information for an informed decision on the impacts of the Project (Rail) on existing surface water environmental values within the Study Area, albeit that the impact on Other Values (Floodplain) is limited and modelling is ongoing.
- A management hierarchy to be applied to address the potential impacts

This report specifically addresses the criteria of the terms of reference for the Project EIS outlined in Section 3.4 Water resources, relating to the Project (Rail).

The Project (Rail) traverses the western most extremity of the Fitzroy River catchment across the broad flat Suttor and Belyando River sub-catchments of the Burdekin River to a looped terminus on the eastern side of the proposed Project (Mine).

The hydrological regime is characterised by a prolonged dry autumn, winter and spring with little or no flow and summers where large tropical rain systems and cyclones flood local creeks and rivers for weeks at a time across wide floodplains. Highly dispersive cracking clay soils in a recently deforested gilgai landscape absorb large amounts of rain before discharging highly turbid sediment charged runoff to the rivers and creeks.

Local land use is predominantly cattle grazing. Ecologically the waterways are described as slight to moderately disturbed due to the loss of much riparian vegetation and as a result of the land use.

Twelve major waterways and 76 minor waterways and overland flow paths are crossed by the railway. The major waterway crossings will comprise locally cast concrete or prefabricated concrete spans for the main channel supplemented by large box and circular concrete culverts in the floodplains. Crossings of the smaller waterways and overland flow paths will comprise smaller box and circular culverts.

Identified environmental values for the affected waterways include:

- Aquatic ecosystems
- Farm supply and stockwater
- Other values (floodplain)

The main surface water environmental effects on these values of the construction phase relate to the disturbance of watercourses for the crossings, which manifest as:

- Change and / or interruption to flows, particularly a rise in flood levels upstream of the railway (afflux)
- Degradation of water quality

- Barriers to movement of aquatic fauna

The main surface water environmental effects of the railway during the operating (permanent) phase on the environmental values derive from long term changes to surface water flows and include:

- Increased depth and extent of flooding
- Possibly longer inundation periods
- Possibly altered drainage patterns
- Scouring and geomorphological changes

Appropriate mitigation measures presented are predominantly aimed at minimisation of additional erosion and sediment discharge and selecting a bridge length scenario with limited afflux.

Further hydrology and hydraulic modelling is being undertaken with preliminary base afflux limits defined. These limits will be utilised as a basis for determining acceptable afflux and to refine the assessment of potential impacts on infrastructure, landholdings and ecosystems.

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Appendix A

Terms of Reference Cross-reference

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Terms of Reference Requirement/Section Number	Cross-reference
Climate, Natural Hazards and Climate Change	
3.1.1 Flood Plain Management Due to the site location, a comprehensive flood study should be included in the EIS, including: ◗ quantification of flood impacts on properties surrounding and external to the project site from redirection or concentration of flows ◗ identification of likely increased flood levels, increased flow velocities or increased time of flood inundation as a result of the development	Section 1.5.3 and Section 5.4
The flood study should address any requirements of local or regional planning schemes for flood affected areas.	Volume 4 Appendix D Project Approvals and Planning Assessment
The study report should include details of all calculations along with descriptions of base data, any potential for loss of flood plain storage, and triangulated surface meshes produced in terrain modelling software.	Section 1.5
Refer to any studies undertaken by the local council in relation to flooding.	N/A (none)
Provide details on: ◗ potential impacts of floods at a range of flood intervals, including the probable maximum flood event ◗ potential impacts of flooding on environmental values due to the identified likely increased flood levels, increased flow velocities or increased time of flood inundation as a result of the project ◗ impacts and mitigation measures for flooding. Describe the construction of any flood protection levees with regards to construction material, design and methods	Section 1.5.3 and Section 4 and 5
Water Resources	
3.4.1 Description of Environmental Values Describe the existing water resources that may be affected	Section 2.1
Describe present and potential users and uses of water in areas potentially affected by the project	Section 2.2
Provide a detailed description quality and quantity of the surface and groundwater resources, describe: ◗ Existing surface and groundwater in terms of physical, chemical and biological characteristics ◗ Existing surface drainage patterns, flows, history of flooding including extent, levels and frequency and present water uses	Section 2
Describe the surface water and ground water quality considering seasonal variations in depth and flow. Parameters should include: Electrical conductivity; Major cations and anions; Dissolved metals; Minor ions; Hydrocarbons; Any other potential toxic or harmful substances; Turbidity; Suspended sediments; and pH.	Section 2

Terms of Reference Requirement/Section Number	Cross-reference
Investigate the relationship between groundwater and surface water to assess the nature of any interaction between the two, and any implications of the proposed mine that would affect the interaction	Volume 2 Section 6
Describe the environmental values of the **surface waterways** and groundwater of the affected area in terms of: values identified in the EPP; Physical integrity, fluvial processes and morphology; Any impoundments; Hydrology of waterways and groundwater; Sustainability (quality and quantity); Dependent ecosystems; Existing and other potential surface and groundwater users; Details of any proposed buffer widths between project activities and waterways; Any water resource plans relevant to the affected catchments	Section 2
If the project is likely to use or affect local sources, describe: A comprehensive hydrogeological description covering: the coal seams and surrounding aquifers, both artesian and sub-artesian; inter-aquifer connectivity; flow of water; recharge and discharge mechanisms; and hydrogeological processes at work:	Volume 2 Section 6
Define and describe the objectives and practical measures for protecting or enhancing water resource	Section 4 and Section 5
Address and describe (including provision of maps): ◗ Potential impacts on the flow and quality of surface and groundwater from all phases of the project	Section 4 and Section 5
◗ All likely impacts on groundwater depletion or recharge regimes	Volume 4 Appendix AC
◗ Likely volume of groundwater to be dewatered during the operations	Volume 4 Appendix AC
◗ The impacts on groundwater resources in each aquifer	Volume 4 Appendix R
◗ How extracted groundwater will be managed in the surface water management system	Volume 4 Appendix P and Appendix R
◗ Measures to prevent, mitigate and remediate any impacts on existing users or groundwater dependent ecosystems	Volume 4 Appendix AC Volume 4 Appendix R
◗ Potential environmental impact caused by the project to local ground water resources	Volume 4 Appendix AC
◗ Response of the groundwater resource to the progression and cessation of the proposal	Volume 4 Appendix R
◗ Impact on the local groundwater regime caused by the altered porosity and permeability of any land disturbance	Volume 4 Appendix R
◗ Any potential for the project to impact on groundwater-dependent vegetation	Volume 4 Appendix R
◗ Potential impacts of surface water flow on existing infrastructure	Section 4.3
◗ Chemical and physical properties of any wastewater	Volume 2 Section 10

Terms of Reference Requirement/Section Number	Cross-reference
◗ How contaminants and waste are avoided, minimised, treated and managed	Volume 2 Section 10
◗ Environmental monitoring to check the effectiveness of mitigation measures	Section 4.3
◗ Potential impacts on other downstream receiving environments	Section 4.3
◗ Mitigation measures for water treatment if proposed to discharge water into riverine system	Volume 4 Appendix P and Appendix R
◗ Results of a risk assessment for uncontrolled releases	Volume 4 Appendix P and Appendix R
◗ Potential to contaminate surface and groundwater resources and measures to prevent, mitigate and remediate such contamination	Section 4.3
Outline impacts on all surface water resources by describing: ◗ Local overland flow catchment characteristics and estimated change to mean and median (50th percentile) annual run off from local overland flow catchments ◗ Change to flows including mean and median (50th percentile) annual flow, in watercourses immediately downstream of the site	Section 2
Describe the option for supplying water to the project, and assess the consequential impacts.	Section 2
Reference the properties of the land disturbed and processing liquid wastes, the technology for settling suspended clays from contaminated water, and the techniques to be employed to ensure contaminated water is contained and successfully treated on site.	Volume 2 Sections 6 and 10
Describe management strategies in adequate detail to demonstrate best practice management and environmental values of receiving waters will be maintained to nominated water quality objectives.	Sections 4.2.2, 4.3.2, 4.4.2, 5.2.1, 5.3.2 and 5.4.2

Appendix B

Preliminary Railway Hydrological Investigations and Flood Modelling

Carmichael Coal Mine Project: Preliminary Railway Hydrological Investigation Report Number 117632041-009-R-Rev0. Report prepared by Golder Associates for Adani Mining Pty Ltd, October 2011.

Carmichael Coal Rail Line – Hydraulic Modelling for Major Watercourses, Report Number 117632041-017-R-Rev0. Report prepared by Golder Associates for Adani Mining Pty Ltd, December 2011

October 2011

ADANI MINING PTY LTD

Carmichael Coal Mine Project: Preliminary Railway Hydrological Investigation

Submitted to:
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REPORT

Report Number. 117632041-009-R-Rev1

Golder Associates

Record of Issue

Company	Client Contact	Version	Date Issued	Method of Delivery
Adani Mining Pty Ltd	Ben Harrison	RevA	10 October, 2011	email
Adani Mining Pty Ltd	Ben Harrison	Rev0	11 October, 2011	email
Adani Mining Pty Ltd	Ben Harrison	Rev1	19 October, 2011	email

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APPENDICES

1.0 INTRODUCTION

1.1 Background and Scope

Adani Mining Pty Ltd (Adani) proposes to construct 190 km of new rail track from its proposed Carmichael Mine to the existing rail track at Moranbah. Golder Associates (Golder) has performed an initial hydrological study for the length of the new rail track to provide preliminary assessments for input to the environmental impact statement (EIS) and conceptual railway design. The study also provides a basis for scoping the necessary hydrological investigations required as input to the detail design stage. The tasks for this hydrological investigation have included:

- Identification and mapping of the locations of all watercourses and associated catchments crossing the railway alignment
- Estimation of peak flows for the 50 and 100 year ARI storm events at the waterway crossings (additional events were analysed with the regression method)
- Preliminary estimation of existing flood levels at the waterway crossings
- Preliminary estimation of watercourse crossing structure size
- Hydraulic modelling at Belyando River and Mistake Creek crossings to provide initial indications of the potential afflux at major crossings for a range of bridge openings

The railway alignment used in this study is Option 7, Revision 5, dated 14 April 2011. This alignment was supplied to Golder by Adani in GIS format. Crossings are identified by their chainage along the length of the track, with the chainage point ‘0 km’ set at the western-most point of the track.

1.2 Previous Draft Results

Draft peak flows and crossing sizes were provided to Adani on 16 September 2011 with updates on the 18 and 20 of September. Indicative peak water levels for existing conditions in the vicinity of the crossings were also provided to Adani on 23 September. These estimates were issued to Adani for the immediate needs of the preliminary conceptual rail design. However, with the need to better define the peak discharges for the afflux modelling at the major crossings, updates have been incorporated into this report. The updates can be summarised as follows:

- The Rational Method calculations were updated to use varying C values from Table 4.05.3(b) found in the *Queensland Urban Drainage Manual* (Queensland Government 2007) rather than a constant C value as previously used. The new results show much better transition between regression method and Rational Method.
- Small differences in the regression method due to added gauge data and more consistent method for estimating station skews.
- Mistake Creek peak flows are now estimated from historic gauge data rather than using the regression method.
- The more detailed hydraulic modelling of Belyando River and Mistake Creek indicate that the average depth of the natural crossing appears to be more representative of the depth of flow due to the extensive floodplain. Consequently, the draft analysis of the span lengths was updated using average depth rather than maximum depth and a minimum depth 0.5 m rather than 1.0 m.

There is no significant change to the calculated peak water levels, despite resulting changes to peak flows. The water levels generally are reduced by approximately 0 to 0.4 m. The only exception is Mistake Creek where the water level has been reduced by approximately 0.9 m.

Watercourse crossing spans generally increased in length using the new assumptions. However, it is likely that higher velocities and deeper flow depths in more detailed analyses will reduce the span lengths. This is demonstrated by the hydraulic modelling for Belyando River (Section 7.0), which indicates that acceptable afflux could be achieved with a width of approximately 1 km which is in between the two preliminary estimates for this crossing.

A comparison of the peak flow data, water levels (presented as depth), and span lengths for the draft and updated assessments is provided in Appendix G.

2.0 MAPPING OF WATERCOURSES AND CATCHMENTS

Golder has undertaken the task of mapping the locations of all of the watercourses that will cross the proposed railway. Watercourses include ephemeral, intermittent, and perennial streams. The associated catchments have also been mapped.

2.1 Major Watercourses

Ten major watercourse crossings have been identified. These are all named watercourses with the exception of an unnamed tributary of the Belyando River, which is approximately 5 km east of the Belyando River at the railway. This tributary is referred to the East Tributary of Belyando River in this report. All of these watercourses have catchment areas over approximately 100 km². The major watercourses that cross the railway are presented in Table 1.

Table 1: Major watercourse crossings

Name	Catchment Area, km²	Railway Crossing Chainage West to East)*, km
Eight Mile Creek	180	4.7
North Creek	300	10.4
Ogenbeena Creek	870	27.9, 30.8
Belyando River	22 000	31.4, 31.9, 34.9
East Tributary of Belyando R.	210	41.6
Mistake Creek	7900	58.8, 59.4, 60.2, 62.1
Gowrie Creek	210	67.3
Logan Creek	2900	102.5, 103.5
Diamond Creek	1000	119.4
Grosvenor Creek	130	163.7

**Belyando River, Mistake Creek and Logan Creek all have multiple channels and therefore have multiple crossing locations. Ogenbeena Creek has a single channel, but crosses the railway twice.*

The catchment boundaries of the ten major watercourses were delineated using GIS based on aerial photography, SRTM data (Jarvis 2008), and drainage mapping from Geofabric (BOM 2010). Figure A1, APPENDIX A shows the location for each of these watercourses.

2.2 Minor Watercourses

In addition to the ten major watercourse crossings, approximately 80 minor watercourse crossings have been identified. These are located at low areas in the natural topography that the railway crosses. Stream channels do not always exist at these locations. Without a drainage crossing structure, the new railway would cause water to backup and may result in overtopping the railway.

In some cases, where the railway traverses a continuous slope, intermediate drainage crossings have been included approximately one every km to allow for surface water to cross the railway. It has been assumed that a parallel drain to the railway will be constructed to direct surface water to the drainage crossings.

Note that these minor drainage crossings have been located at a conceptual level for the purposes of the EIS. The position of these may vary during a more detail design stage.

Delineation of the minor watercourses and associated catchments was completed using AutoCAD and was based on:

- LIDAR survey data that was supplied to Golder by Adani (Vekta 2011)
- SRTM data (Jarvis 2008)
- Drainage mapping from Geofabric (BOM 2010)
- Available aerial photography

Figures A2 through A5 in Appendix A shows the locations and catchment areas for these proposed crossings.

3.0 ESTIMATED PEAK FLOWS

3.1 Major Watercourses (Regression Method)

A flood frequency regression analysis using regional historic stream flow data has been performed to calculate the peak flows in the major watercourse for the 2, 10, 50, 100 and 500 year ARI flood events. The regression analysis included identifying similar gauged catchments in the region of the project and establishing a relationship between their annual series peak flow and the catchment area, catchment slope and annual rainfall.

Stream gauge stations used for the flood frequency regression analysis were selected based on the following criteria:

- Record length greater than approximately 10 years
- Located within a distance of approximately 300 km from the railway
- Catchments without large manmade water storage reservoirs

A total of 25 stations were selected. Figure A6 in Appendix A shows the locations for each of the stream gauge stations.

Note that Belyando River and Mistake Creek are the only gauged watercourses that cross the railway. The gauge on Mistake Creek gauge (120309A) is approximately 10 km upstream of the railway, where Belyando River (120301B) is approximately 50 km downstream of the railway. Both stations have period of records from 1977 to present – 35 years of data.

Catchment area, average slope, and average annual rainfall for each catchment were assessed using GIS. The average annual rainfall data was spatially estimated using GIS formatted data provided from the Bureau of Meteorology (BOM 2009). Average annual rainfall for the catchments is also presented in Figure A6 in Appendix A. Average slope and catchment area were derived in GIS using the SRTM dataset (Jarvis 2008). The resulting catchment areas of these stations ranged from 66 km^2 to 50 300 km^2.

Following the selection process, standard ARI peak flows for each of the selected stations were estimated using a Log Pearson Type 3 (LP3) analysis from the historical gauged datasets.

For the higher ARI events, the LP3 analysis is highly sensitive to the adopted skew. Adopted skew values were calculated using a weighted average of the station skew and a generalised skew. The generalised skew was estimated by the weighted average of all of the station skews. Weighting, in both cases, were based on the number years on record, where stations with longer period of record had more influence. In some cases where the LP3 did not appear to match well, the adopted skew values were manually adjusted for a better fit.

Regression curves were then fit to the results of the LP3 annual peak analysis as a function of catchment area, catchment slope and annual rainfall. A weighted least-square linear regression technique was performed. Again, weighting was based on the number years on record. The form of the regression equation for the major watercourses is as follows:

$$Q = aA^bP^cS^d$$

Where, Q (m^3/s) is peak flow, A (m^2) is catchment area, P (m) is annual average rainfall, and S (%) is average catchment slope.

The resulting regression equation parameters: a, b, c, and d are presented in Table 2.

Table 2: Resulting regression parameters

Parameters	2 yr	10 yr	50 yr	100 yr	500 yr
a	123	231	212	191	142
b	0.536	0.523	0.509	0.503	0.489
c	8.14	6.39	4.58	3.83	2.20
d	0	0	0	0	0

It was found that there was no correlation between catchment slope and the annual peak flow; therefore, the d parameter resulted in zero.

The standard error for the regression analyses ranged from 54% to 101%, with the greater uncertainty corresponding to the greater ARI.

The gauge with the lowest correlation happened to be Mistake Creek. The regression equations overestimate the peak flows for Mistake Creek. Since the Mistake Creek gauge is so close to the railway crossing, the regression method was not used for estimating the peak flows at Mistake Creek. Rather, an area prorated method of the Mistake Creek gauging station was used for estimating the peak flow at the crossing.

Table 3 presents a summary of the estimated peak flows for the major watercourse crossings for the 50, 100 and 500 year ARI flood events.

Table 3: Estimated peak flows using the regression analysis

River Name	50 year ARI Peak Flow, m^3/s	100 year ARI Peak Flow, m^3/s	500 year ARI Peak Flow, m^3/s
Eight Mile Creek	230	310	530
North Creek	370	470	740
Ogenbeena Creek	550	710	1200
Ogenbeena Creek (lower crossing)	550	720	1200
Belyando River	2600	3300	5400
East Tributary of Belyando River	310	400	630
Mistake Creek*	640	700	800
Gowrie Creek	350	440	660
Logan Creek	1000	1300	2100
Diamond Creek	460	620	1100
Grosvenor Creek	240	310	490
Combined Belyando River, Ogenbeena Creek and East Tributary of Belyando	2600	3400	5500

** The estimated peak flow for Mistake Creek is a result of area proration from Station 120309A.*

Supporting calculations for the analysis are included in Appendix B.

3.2 Minor Watercourses (Rational Method)

The Rational Method has been used to estimate the peak flows for the minor watercourse crossings for the 50 and 100 year ARI flood events.

Time of concentration calculations were estimated with the Bransby-Williams equation.

Runoff coefficients were estimated using methods developed from the Queensland Government Department of Natural Resources and Mines (2005). Land conditions for all catchments were assumed to have medium dense bushland with low permeability soils.

Supporting calculations for the analysis and the resulting peak flows are included in Appendix C.

3.3 Comparison of Hydrologic Methods

The regression method has been applied to the major watercourses and the Rational Method to the minor watercourses. A lower catchment area limit of approximately 100 km² has been set to the regression method because the lack of gauged data for smaller catchments.

Figure 1 presents the resulting 100 year ARI peak flows for both the regression and Rational methods. The plotted data shows that the two methods match relatively well at their transition point.

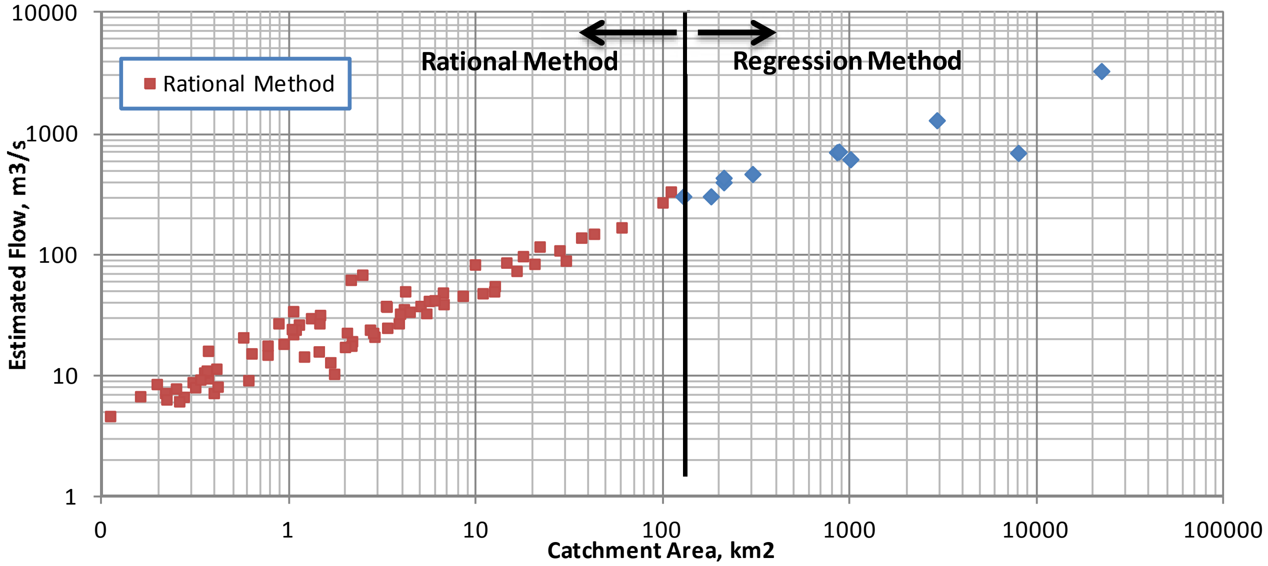

Figure 1: Comparison of peak flows from Rational and Regression methods

4.0 HISTORIC FLOODS

As previously mentioned, both Belyando River and Mistake Creek have streamflow gauging stations located near the proposed railway. These gauging stations provide information of past floods of the major watercourses at the railway site. Figure 2 presents the annual peak flows from these gauging stations.

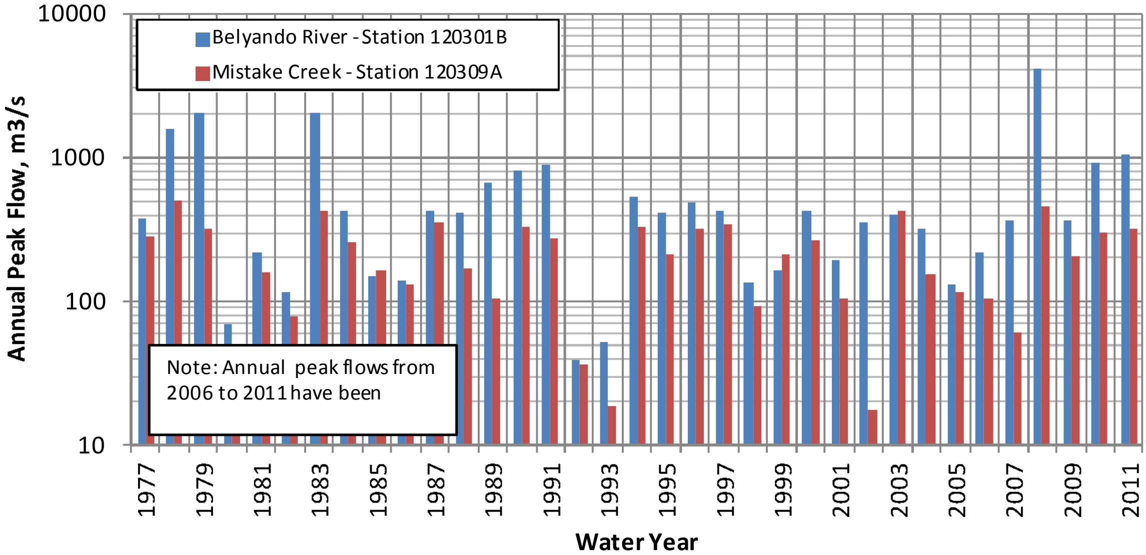

Figure 2: Annual peak flows for Belyando River and Mistake Creek

Satellite images from the NASA Landsat program are taken routinely of much of the earth's surface (approximately once per month) since the 1970s. Landsat imagery has been obtained of the railway site during three of the major historic flood events. These images include the floods of May 1983, January 2008, and January 2011 (NASA 1983, 2008, 2011). The images are presented in Figures A7, A8, and A9 of Appendix A.

Extensive flooding is noted in all three of these images on the major watercourses including the Belyando River, Mistake Creek, and Diamond Creek. The floodplain width at Belyando River along the railway alignment is approximately 15 km wide during the 2008 flood.

None of these images were taken on the exact day of the peak flow, but were within a few days of the peak. Table 4 presents a summary of recorded flow at gauge, estimated flow at railway, and the estimated ARI for each of the floods on Belyando River and Mistake Creek.

Table 4: Historic flood summary

Flood	Description	Belyando River	Mistake Creek
May 1983	**Estimated ARI (years)**	**20**	**10**
	Peak flow date	3 May, 1983	3 May, 1983
	Recorded flow at gauge (m^3/s)	2018	425
	Estimated flow at railway (m^3/s)	*1589*	*439*
	Image date	6 May, 1983	6 May, 1983
	Recorded flow at gauge (m^3/s)	1353	394
	Estimated flow at railway (m^3/s)	*1066*	*407*
Jan 2008	**Estimated ARI (years)**	**100**	**10**
	Peak flow date	23 Jan, 2008	21 Jan, 2008
	Recorded flow at gauge (m^3/s)	4114	451
	Estimated flow at railway (m^3/s)	*3240*	*466*
	Image date	28 Jan, 2008	28 Jan, 2008
	Recorded flow at gauge (m^3/s)	1250	272
	Estimated flow at railway (m^3/s)	*985*	*280*
Jan 2011	**Estimated ARI (years)**	**10**	**5**
	Peak flow date	1 Jan, 2011	1 Jan, 2011
	Recorded flow at gauge (m^3/s)	1029	318
	Estimated flow at railway (m^3/s)	*810*	*329*
	Image date	4 Jan, 2011	4 Jan, 2011
	Recorded flow at gauge (m^3/s)	735	212
	Estimated flow at railway (m^3/s)	*579*	*219*

These historic flood images have been used for purposes of calibration of the hydraulic models of the Belyando River and Mistake Creek described later in this report.

It should be noted that particularly on the 2008 image, brown coloured vegetation surrounding the flood water is visible, which is most likely evidence of the peak flow inundation limits.

5.0 ESTIMATION OF EXISTING CONDITIONS FLOOD LEVELS

A preliminary estimation of flood levels for all of the major and minor crossings (approximately 90 crossings) was performed using the peak flows calculated using the regression and rational methods. Both the 50 year and 100 year ARI peak flows were analysed.

The flood levels were calculated using Manning's equation assuming steady, uniform flow. Additionally, average velocity, top width, average depth, and maximum depth were calculated.

The sections for each crossing were defined using LIDAR survey data (Vekta 2011). The sections were cut as close to the rail alignment as possible while ensuring that they were cut perpendicular to the apparent flow direction at the crossing. Where possible the cross sections were extended to include the inundation area of the 100 year ARI flood; however, in some of the less defined channels the 100 year ARI peak flow would overflow into adjacent crossings. This effect was most obvious in areas where the flow was closer to 'sheet flow' than 'stream flow'.

An average Manning's n value for both the channel and overbank areas was set to 0.05 in all cases.

The crossing slope was measured from the LIDAR survey data as an average slope from 0.5 km upstream of the crossing to 0.5 km downstream of the crossing.

The calculations and results from the estimation of existing flood levels are presented in Appendix E.

6.0 INDICATIVE ESTIMATES OF WATERCOURSE CROSSING SIZES

Preliminary estimates of the watercourse crossing sizes are based on simplified methods. The estimated sizes are intended to help lead to a definition of scope and costs for the necessary hydrological investigations required as input to the detailed design stage.

The opening sizes are based on the design criteria as proposed in the *Mine Railway Route Definition Study Design Basis Report* (GHD 2010). This design report suggests that the openings be sized by a maximum available headwater and an outlet velocity not exceeding 2 m/s.

It has therefore been assumed that the cross sectional area of the crossing structures is equal to the design flow (Q) divided by the velocity (V), as follows:

$$A = Q / V$$

The velocity is set to the maximum design velocity, 2 m/s. As shown in Section 5.0, nearly all of the existing watercourses have average velocities much less than 2 m/s. This results in a much smaller cross sectional area required at each of the crossings compared to the natural watercourse. However, in cases where the average velocity of the existing watercourse is above 2 m/s, the velocity through the crossing is set to the same as the velocity in the natural channel.

The estimated crossing span length (L) is then the cross sectional area (A) divided by the average water depth (D), as follows:

$$L = A / D$$

The depth is taken as the average depth of the existing watercourse. However, in the smaller watercourses where the average watercourse depth is very shallow, it has been assumed that there is at least a nominal 0.5 m of depth through the crossing, which results in a small amount of backwater during the peak flow.

Watercourse crossings have been sized for both the 50 and 100 year ARI events. The calculations and results presented in Appendix F.

The cumulative total span length for the entire railway alignment is estimated at approximately 7 km and 8 km for 50 and 100 year ARI design events, respectively. There are approximately 15 watercourse crossings with spans less than 10 m. These may be designed as culverts, depending upon detailed design. All other crossings will most likely be bridges.

Table 5 summarises the estimated span lengthsfor the watercourse crossings. It also includes the previous draft results based on maximum rather than average flow depth at the crossings.

Table 5: Summary of watercourse crossing spans (100 year ARI design)

Description	Estimated Span Length, m	
	Based on average depth (with min depth of 0.5 m)	Based on maximum depth (with min depth of 1.0 m) [as per previous draft results]
Eight Mile Creek	280	170
North Creek	310	130
Combined Belyando,Ogenbeena, and E. Trib. Of Belyando	2100*	670
Mistake Creek	610*	500
Gowrie Creek	300	120
Logan Creek	430	100
Diamond Creek	460	340
Grosvenor Creek	180	60
Minor watercourse crossings	18 crossings between 50 and 300 m	13 crossings between 50 and 300 m
	44 crossings between 10 and 50 m	40 crossings between 10 and 50 m
	15 crossings less than 10 m	24 crossings less than 10 m

**See Section 0 for detailed hydraulic models of Belyando River and Mistake Creek crossings, which provide estimated afflux and flood inundation mapping.*

As shown by Table 5, the indicated crossing spans generally increased in length using the average rather than the maximum flow depth criteria. However, it is likely that higher velocities and deeper flow depths in more detailed analyses will reduce the span lengths. This is demonstrated by the hydraulic modelling for Belyando River (Section 7.0), which indicates that acceptable afflux could be achieved with a width of approximately 1 km which is in between the two preliminary estimates for this crossing.

7.0 HYDRAULIC MODELLING TO INDICATE RANGE OF POTENTIAL AFFLUX AT MAJOR CROSSINGS

Hydraulic modelling has been undertaken at the Belyando River and Mistake Creek crossings over a range of crossing spans to provide an indication of the potential afflux effects of bridges upstream of these crossings. A 2-D XPSWMM/TUFLOW model was used due to the complexity of multiple channels and broad floodplains of each of the crossings at 100 year ARI peak flows.

7.1 Belyando River

The Belyando River model was run for existing conditions plus three developed conditions scenarios. The three developed conditions included differing total bridge span values. These scenarios are defined in Table 6.

Table 6: Configuration of Belyando River Model Scenarios

Scenario	Total Bridge Span (m)
Existing Conditions	n/a
Scenario 1	6000
Scenario 2	2000
Scenario 3	800

The following considerations were taken into account in the development of the hydraulic model:

- Topography data was provided from the LIDAR survey (Vekta 2011).
- Manning's Roughness The Manning's value can be expected to change throughout the study reach; however, a fixed value of 0.05 was used for simplicity. A sensitivity analysis was conducted for a range of reasonable Manning's values of 0.03 to 0.07. The sensitivity analysis resulted in a depth variation of approximately +/- 0.25 m from the depth using an n value of 0.05.
- Downstream boundary – The downstream boundary of the model was positioned as far downstream as possible within the limit of the available LIDAR data, which approximately 10 km downstream of the crossing. The downstream boundary was set as a constant water level less than critical depth, which forces the model to pass through critical depth. It has been assumed that normal depth is established within the lower extent of the model, well downstream of the railway. The downstream boundary condition is the same for all scenarios.
- Flow – The model upstream boundaries were flow boundaries based on the estimated 100 year ARI peak flow, which is 3400 m³/s. During the 100 year ARI flood, the flow the Belyando River spills into Ogenbeena Creek and the East Tributary of the Belyando River. The regression method was used to estimate the combined flow of these watercourses. The total flow was then proportioned to the multiple streams based on comparisons to historic satellite images. The proportioned flows include: 1000, 1400, and 1000 m³/s for Ogenbeena Creek, Belyando River, and the East Tributary of Belyando River, respectively.
- Time step and grid size – A 10 second time step and grid size of 50 m x 50 m for the Belyando River model was found to provide an acceptable resolution for results while allowing the model to run without becoming unstable.

7.2 Mistake Creek

The Mistake Creek model was run for 4 Scenarios with different total bridge span values. These scenarios are defined in Table 7 below.

Table 7: Configuration of Mistake Creek Model Scenarios

Scenario	Total Bridge Span (m)
Existing Conditions	n/a
Scenario 1	4000
Scenario 2	1500
Scenario 3	800

The following considerations were taken into account in the development of the hydraulic model:

- Topography data was provided from a LIDAR survey of the crossing locality taken at a 10m grid resolution.
- Manning's Roughness The Manning's value was set to constant value of 0.05. See discussion of Manning's value for Belyando River model.
- Downstream boundary – The downstream boundary of the model was positioned as far downstream as possible within the limit of the available LIDAR data, which approximately 5 km downstream of the crossing. The downstream boundary was set as a constant water level less than critical depth, which forces the model to pass through critical depth. It has been assumed that normal depth is established within the lower extent of the model, well downstream of the railway. The downstream boundary condition is the same for all scenarios.

- Flow – The model upstream boundaries were flow boundaries based on the estimated 100 year ARI peak flow, which is 700 m^3/s. During the 100 year ARI flood, flow Mistake Creek has several inflow points including Gowrie Creek. The total flow was proportioned to the multiple inflow points based on comparisons to historic satellite images.

- Time step and grid size – A 10 second time step and grid size of 35 m x 35 m for the Mistake Creek model was found to provide an acceptable resolution for results while allowing the model to run without becoming unstable.

7.3 Results

The water depths and flood inundation mapping for Belyando River and Mistake Creek are presented in Figures A10 through A17 in Appendix A.

The peak flows modelled in the Belyando River are nearly the same as the flows in the 2008 flood, with both close to the 100 year ARI flood. These results compare very well to the extent of the mud stained vegetation indicated in the historic 2008 flood imagery.

Similarly, the Mistake Creek 2008 flood imagery corresponded to approximately the 10 year ARI flood. The extent of flooding indicated in the imagery also compared well to the equivalent flood in the model.

The water elevation was measured for each scenario at 0.5 km, 1 km and 2 km upstream of the rail alignment. This data was used calculate the average afflux predicted by the model for Scenarios 1, 2 and 3. The average afflux for each Scenario at 0.5 km, 1 km and 2 km upstream of the rail alignment is shown in Table 8.

Table 8: Average Afflux Results from XPSWMM

Scenario	Average Afflux (mm)		
Belyando River			
	0.5 km Upstream	1 km Upstream	2 km Upstream
Scenario 1 – 6000 m span	80	60	15
Scenario 2 – 2000 m span	270	240	70
Scenario 3 – 800 m span	710	610	330
Mistake Creek			
	0.5km Upstream	1km Upstream	2km Upstream
Scenario 1 – 4000 m span	20	15	<10
Scenario 2 – 1500 m span	110	90	15
Scenario 3 – 800 m span	240	200	40

8.0 LIMITATIONS

Your attention is drawn to the document - “Limitations”, which is included in Appendix H of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

9.0 REFERENCES

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Vekta. August 2011. LIDAR survey provided in a 1 m x 1 m horizontal grid with a vertical accuracy of +/- 10 cm [RMSE 1 sigma].

Report Signature Page

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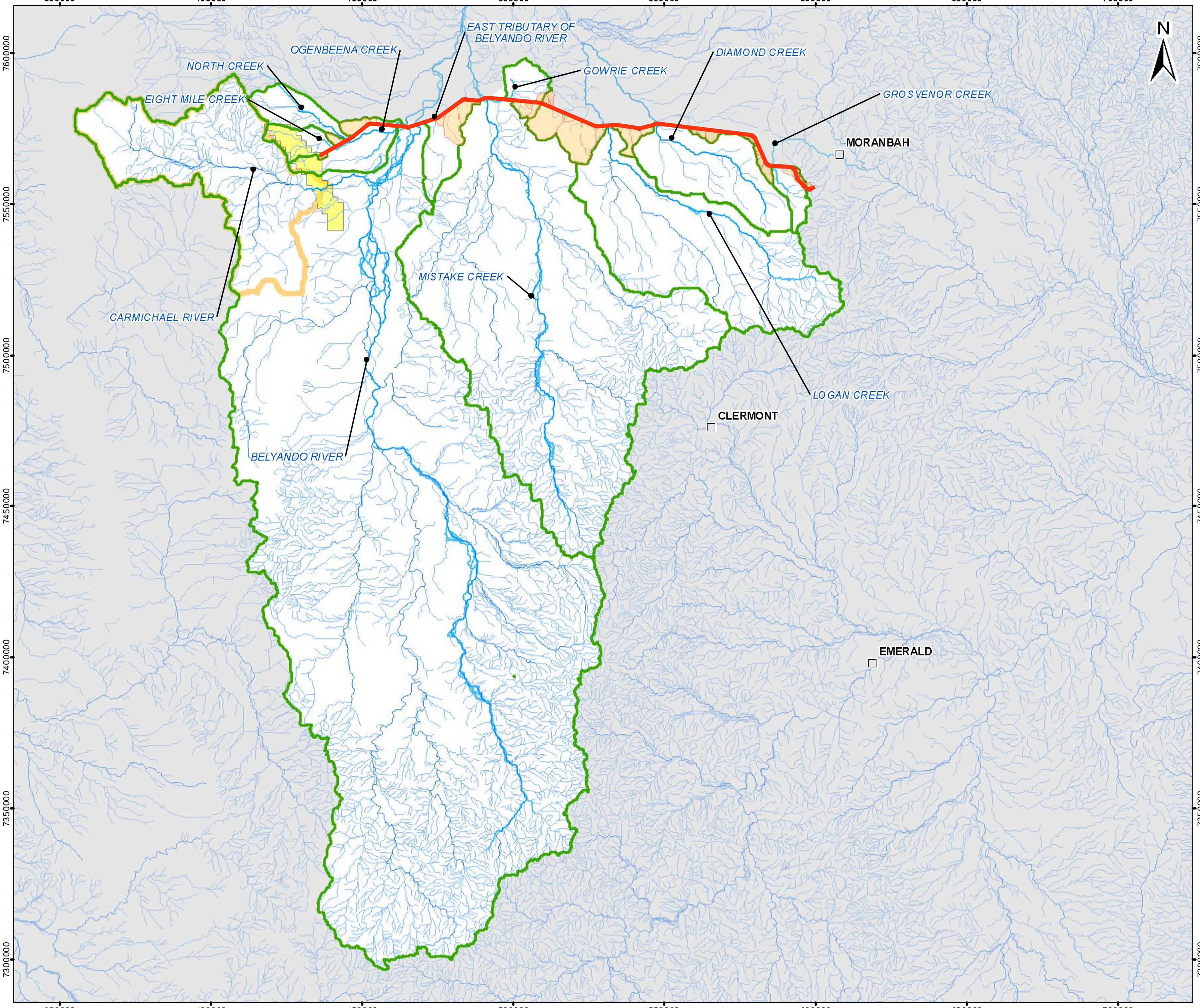
APPENDIX A

Figures

FIGURES

Checked by:..

Date: 11/10/2011



CARMICHAEL COAL PROJECT

ADANI GROUP

MAJOR WATERCOURSE CROSSINGS AND CATCHMENTS

LEGEND

- Town
- Rail Alignment Option-7 Rev-5
- Creek/River
- Minor Catchment
- Major Catchment
- Mine Catchment
- Carmichael Coal Mine Tenement

COPYRIGHT

1- Streams and catchments from Australian Hydrological Geospatial Fabric (Geofabric) PRODUCT SUITE V1.0, Bureau of Meteorology

0 5 10 20 30 40 50 km

SCALE (at A3) 1:1,250,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: BQ / DK
CHECKED: SJS

FIGURE A1

Golder Associates

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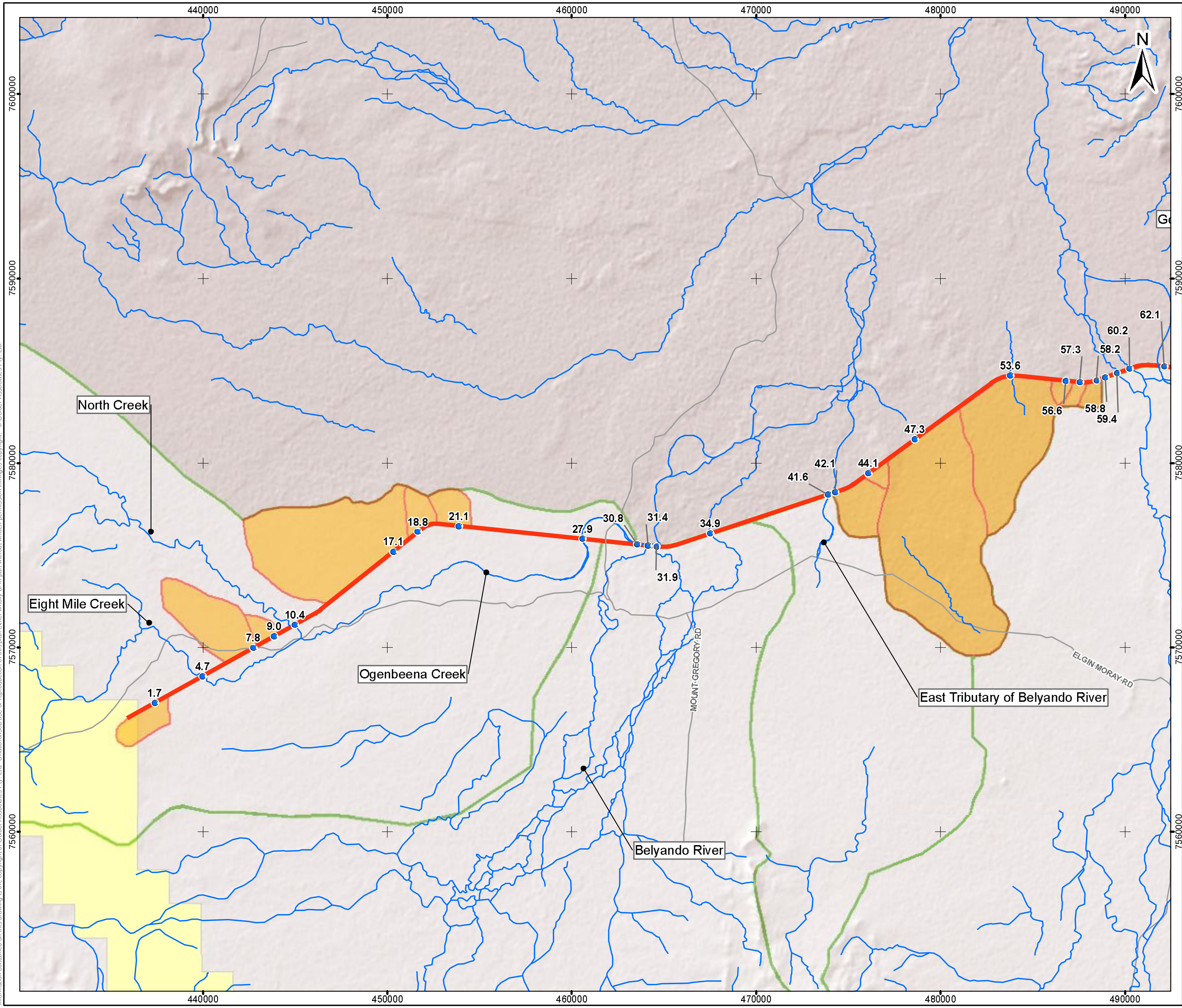

CARMICHAEL COAL PROJECT

ADANI GROUP

MINOR WATERCOURSE CROSSINGS AND CATCHMENTS

LEGEND

- Creek / River
- Road
- Rail Alignment Option-7 Rev-5
- Minor Catchment
- Major Catchment
- Carmichael Coal Mine Tenement

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1- Streams and catchments from Australian Hydrological Geospatial Fabric (Geofabric) PRODUCT SUITE V1.0, Bureau of Meteorology

0 0.75 1.5 3 4.5 6 7.5 km

SCALE (at A3) 1:200,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT:	117632041
DATE:	11 OCT 2011
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CHECKED:	SJS

FIGURE A2

Golder Associates

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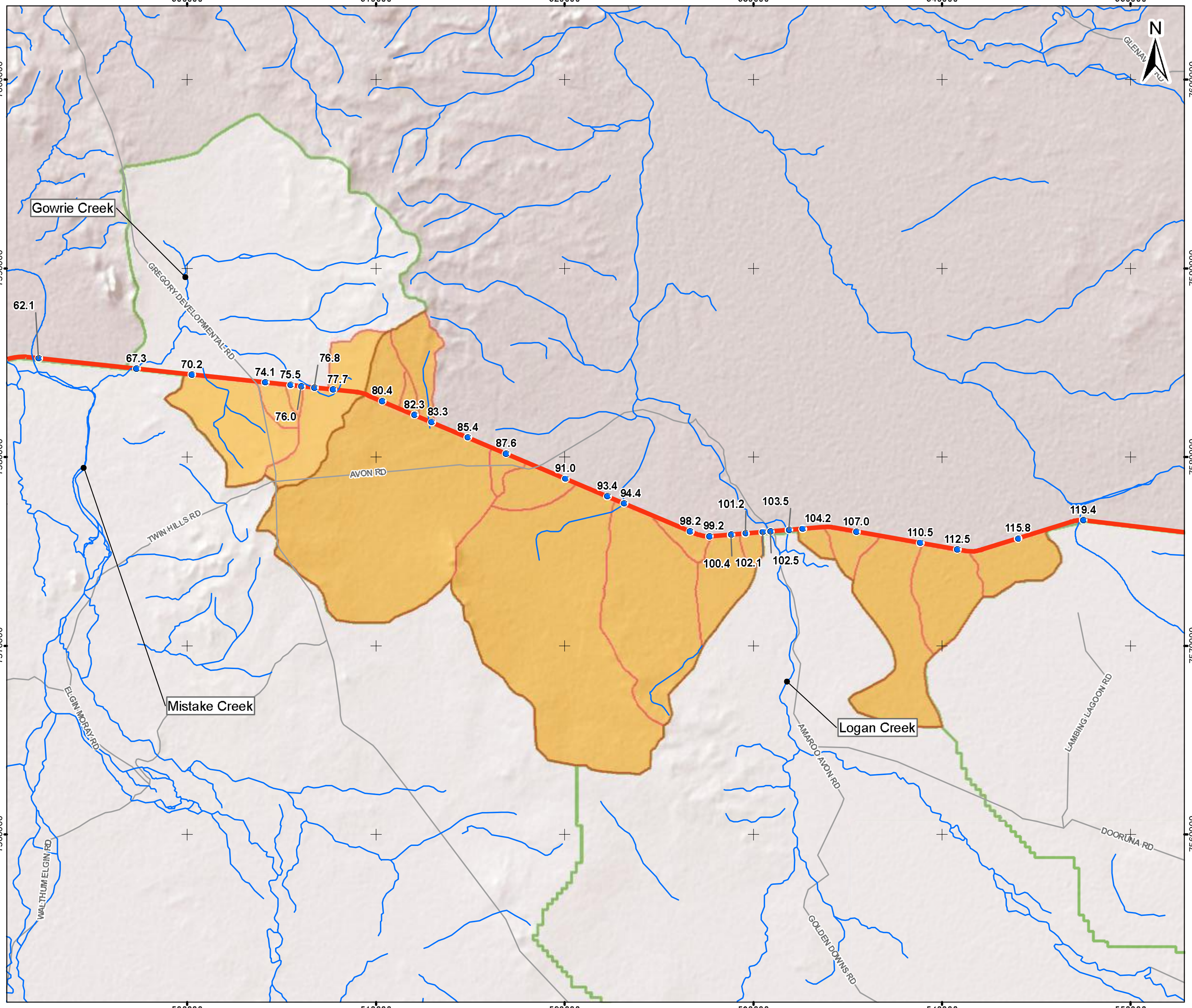

CARMICHAEL COAL PROJECT

ADANI GROUP

MINOR WATERCOURSE CROSSINGS AND CATCHMENTS

LEGEND

- Creek / River
- Road
- Rail Alignment Option-7 Rev-5
- Minor Catchment
- Major Catchment
- Carmichael Coal Mine Tenement

0 0.75 1.5 3 4.5 6 7.5 km

SCALE (at A3) 1:200,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: DK
CHECKED: SJS

FIGURE A3

Golder Associates

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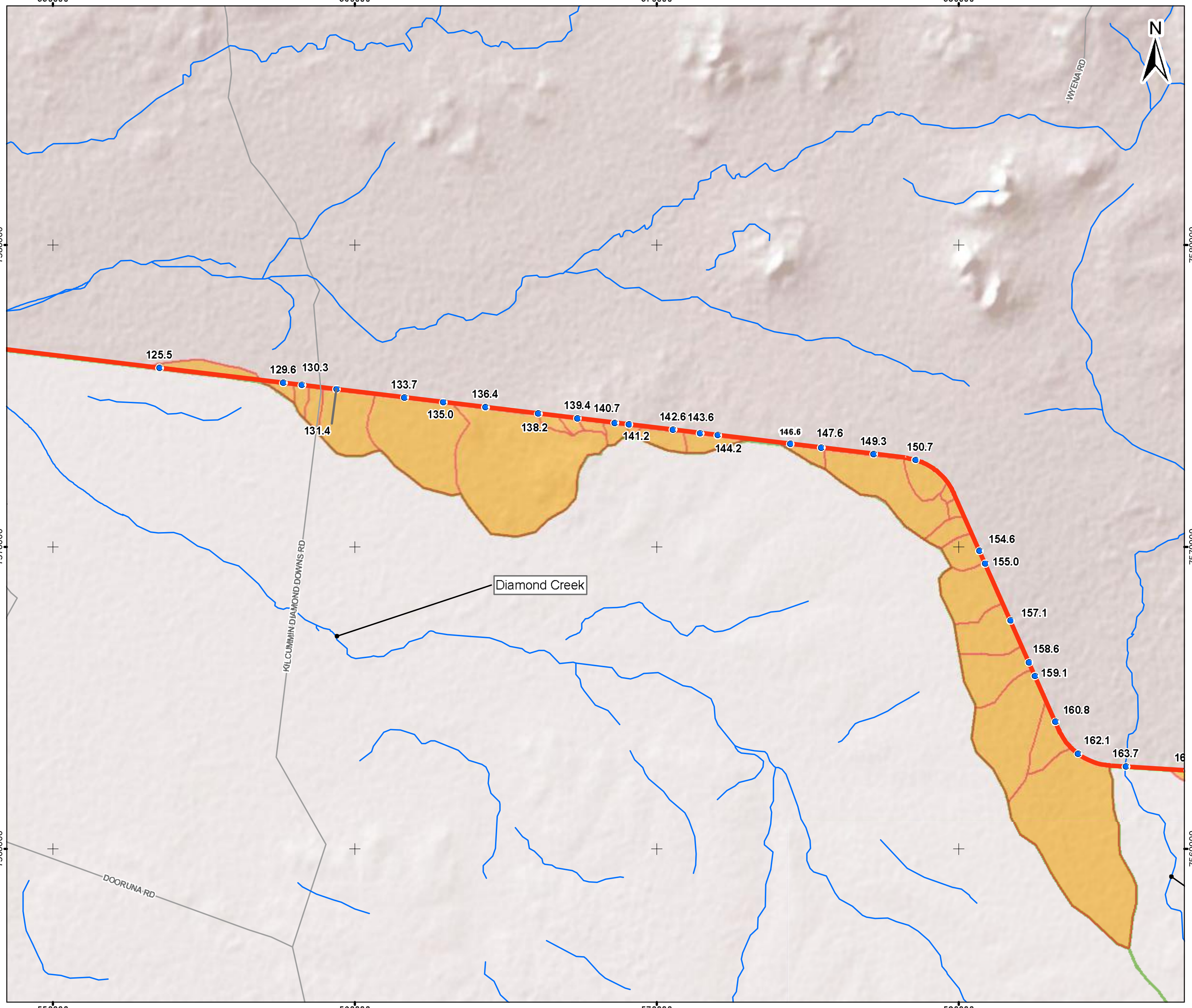

CARMICHAEL COAL PROJECT

ADANI GROUP

MINOR WATERCOURSE CROSSINGS AND CATCHMENTS

LEGEND

- Creek / River
- Road
- Rail Alignment Option-7 Rev-5
- Minor Catchment
- Major Catchment
- Carmichael Coal Mine Tenement

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1- Streams and catchments from Australian Hydrological Geospatial Fabric (Geofabric) PRODUCT SUITE V1.0, Bureau of Meteorology

0 0.75 1.5 3 4.5 6 7.5 km

SCALE (at A3) 1:125,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT:	117632041
DATE:	11 OCT 2011
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FIGURE A4

Golder Associates

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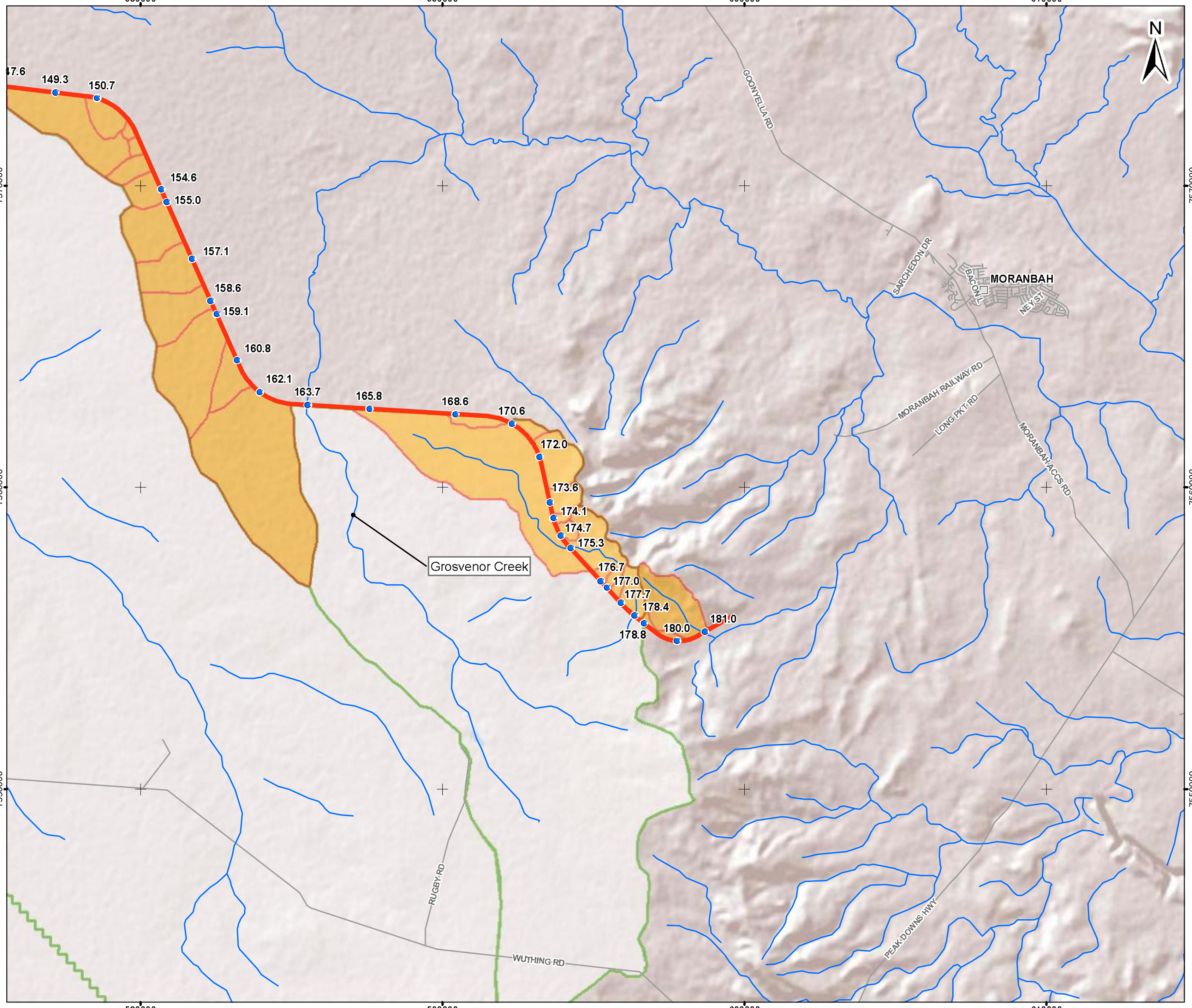

CARMICHAEL COAL PROJECT

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MINOR WATERCOURSE CROSSINGS AND CATCHMENTS

LEGEND

- Creek / River
- Road
- Rail Alignment Option-7 Rev-5
- Minor Catchment
- Major Catchment
- Carmichael Coal Mine Tenement

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1- Streams and catchments from Australian Hydrological Geospatial Fabric (Geofabric) PRODUCT SUITE V1.0, Bureau of Meteorology

0 0.75 1.5 3 4.5 6 7.5 km

SCALE (at A3) 1:125,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: DK
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FIGURE A5

Golder Associates

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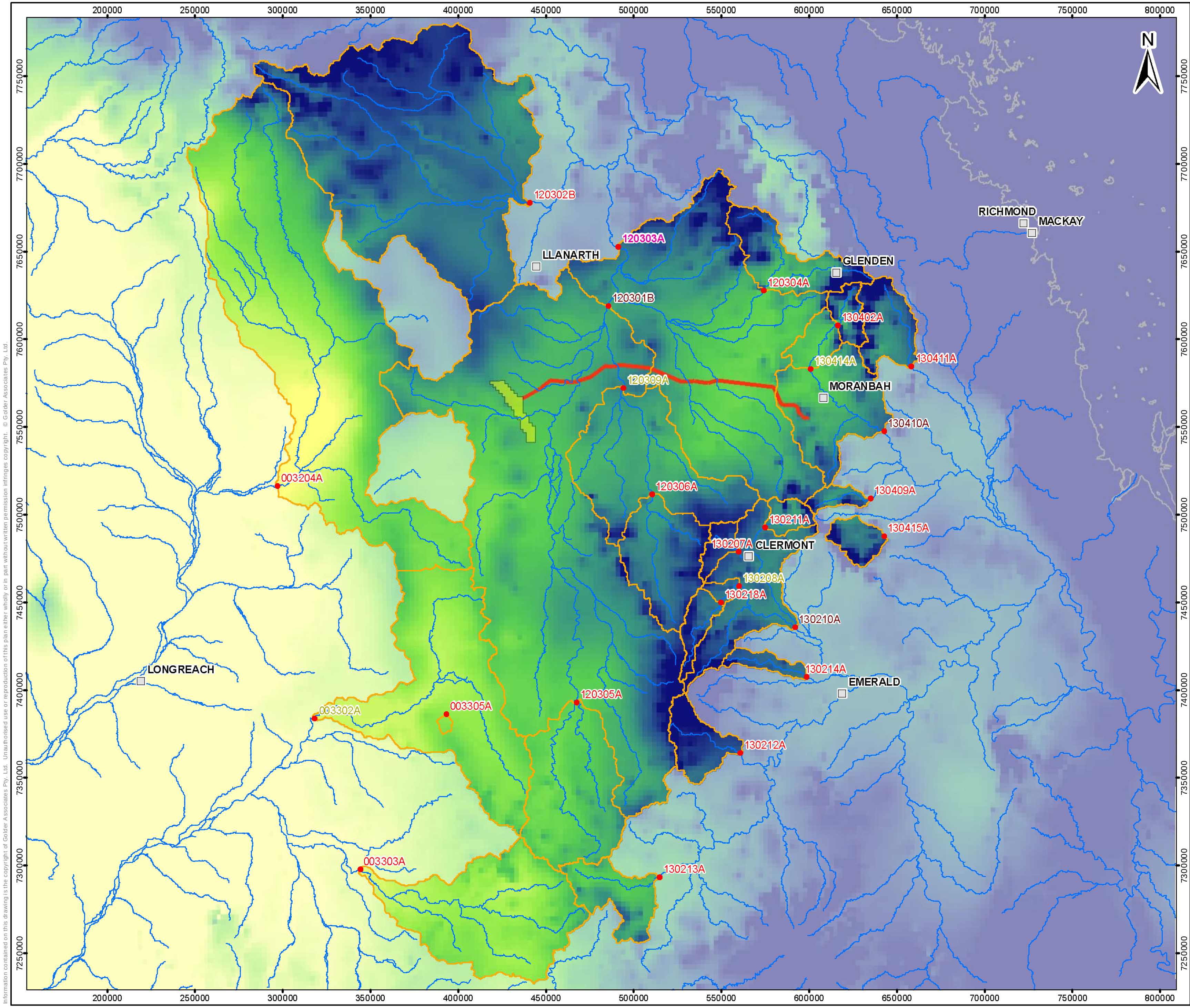
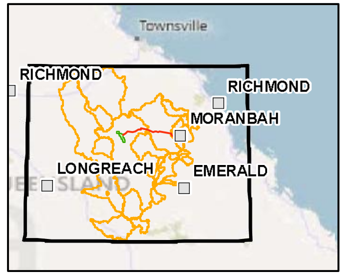


CARMICHAEL COAL PROJECT

ADANI GROUP

AVERAGE RAINFALL IN PROJECT CATCHMENTS



LEGEND

- Town
- Selected QLD Gauge Stations
- Creek/River
- Rail Alignment Option-7 Rev-5
- Gauge Station Catchments (AHGF-Overlapping)
- Carmichael Coal Mine Tenement

Average Rainfall - Annual

High : 700

Low : 450

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0 10 20 40 60 80 km

SCALE (at A3) 1:2,100,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: DK
CHECKED: SS

FIGURE A6

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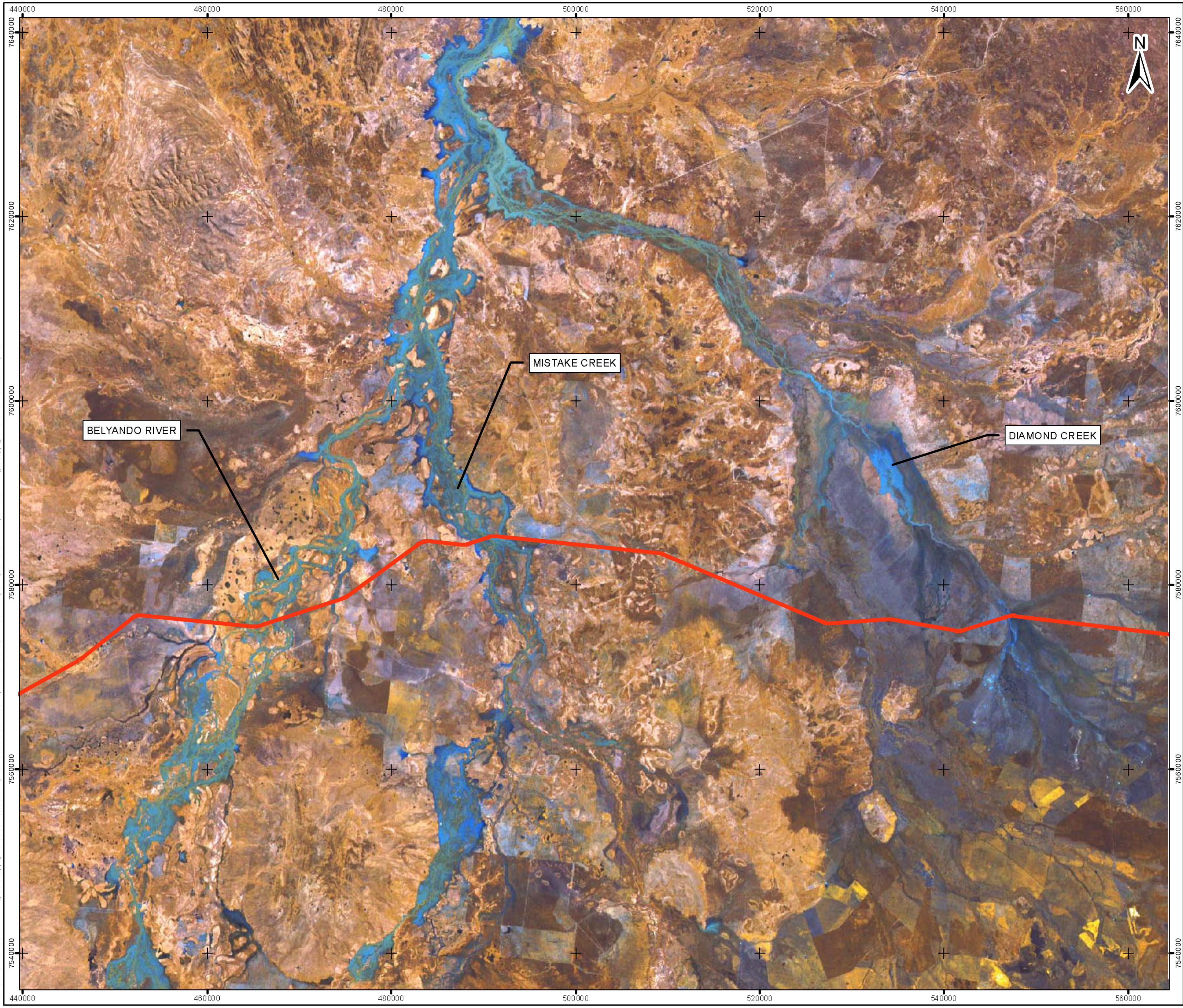

CARMICHAEL COAL PROJECT

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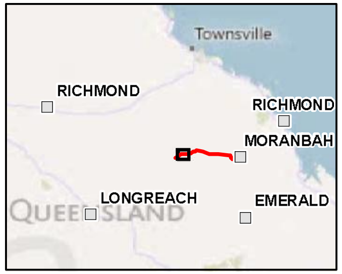
HISTORICAL FLOOD IMAGE - MAY 1983



LEGEND

Rail Alignment Option-7 Rev-5

NOTES

1. Landsat4 Image taken on 6 May 1983
2. Peak flow occurred on 3 May 1983.

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0 1.25 2.5 5 7.5 10 12.5 15 Kilometres

SCALE (at A3) 1:400,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: DK
CHECKED: SJS

FIGURE A7

Golder Associates

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CARMICHAEL COAL PROJECT

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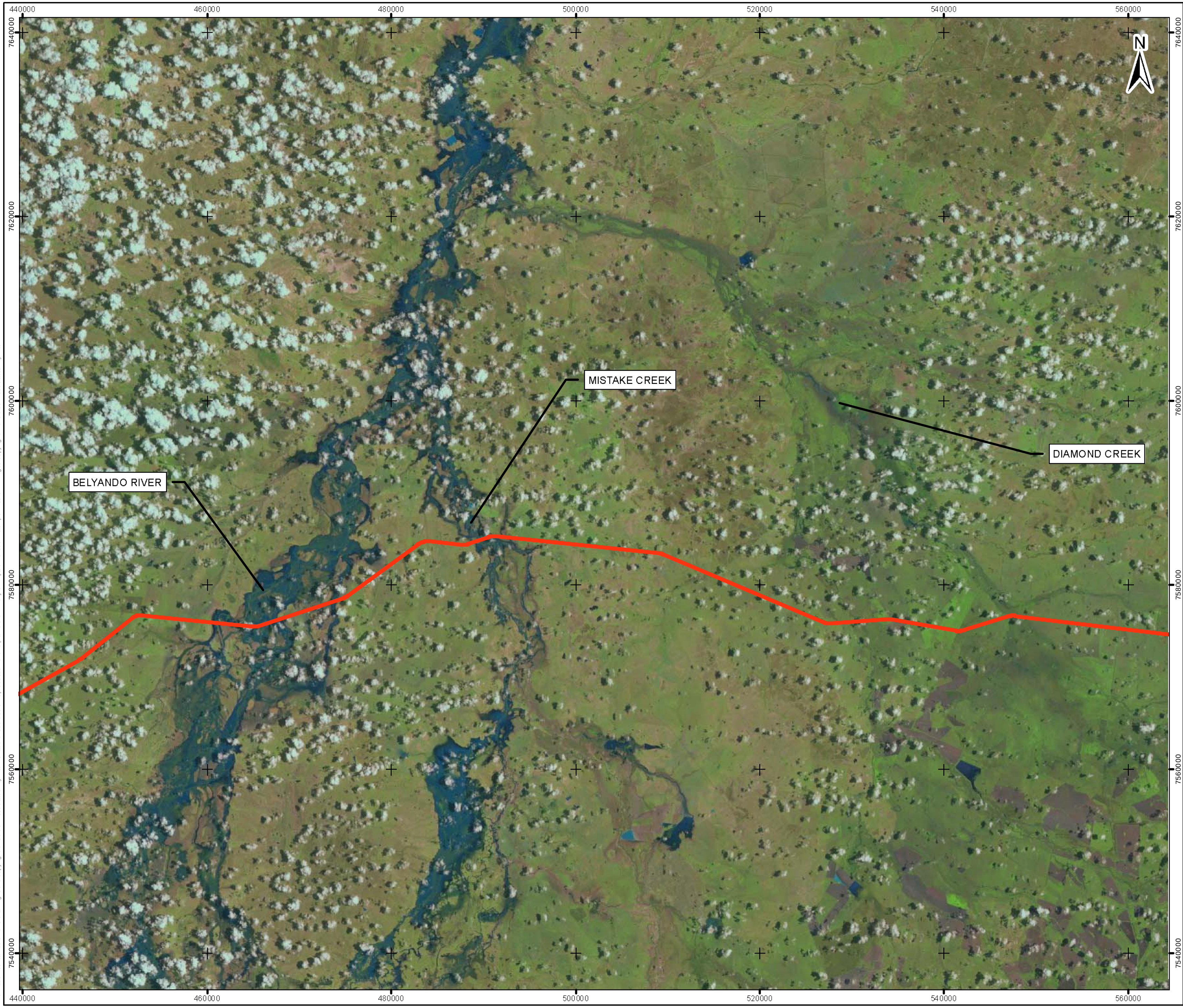
HISTORICAL FLOOD IMAGE - JANUARY 2008



LEGEND

Rail Alignment Option-7 Rev-5

NOTES

1. Landsat5 Image taken on 28 January 2008.
2. Peak flow occurred on 23 January 2008 for Belyando River and 21 January for Mistake Creek.

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0 1.25 2.5 5 7.5 10 12.5 15 Kilometres

SCALE (at A3) 1:400,000

DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: DK
CHECKED: SJS

FIGURE A8

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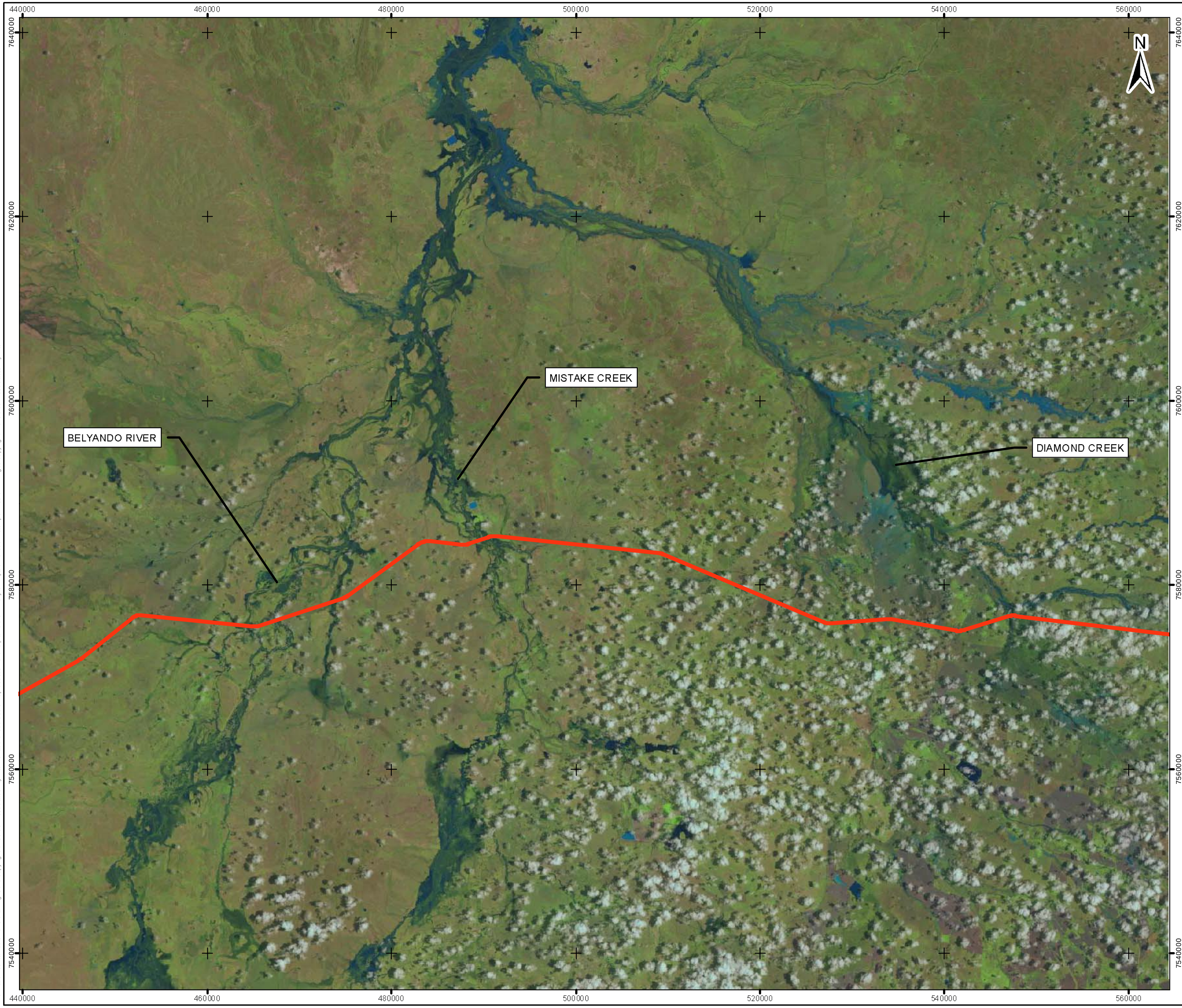
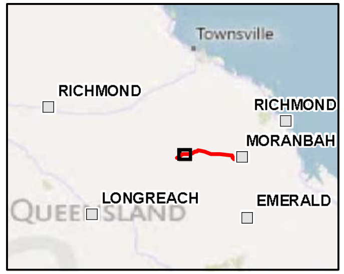


CARMICHAEL COAL PROJECT

ADANI GROUP

HISTORICAL FLOOD IMAGE - JANUARY 2011



LEGEND

Rail Alignment Option-7 Rev-5

NOTES

1. Landsat5 Image taken on 4 January 2011.
2. Peak flow occurred on 1 January 2010.

COPYRIGHT

0 1.25 2.5 5 7.5 10 12.5 15 Kilometres

SCALE (at A3) 1:400,000

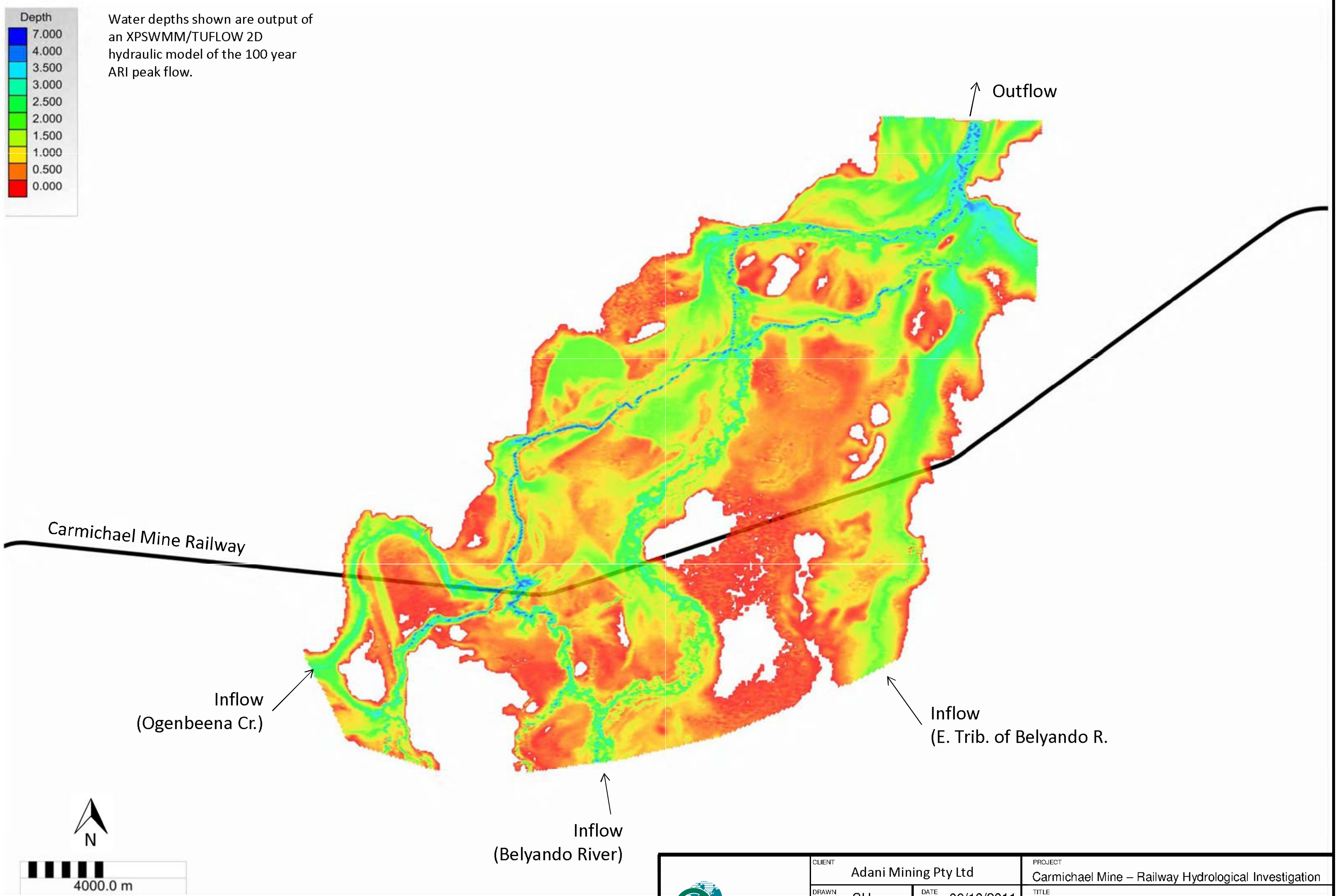
DATUM GDA 94, PROJECTION MGA Zone 55

PROJECT: 117632041
DATE: 11 OCT 2011
DRAWN: DK
CHECKED: SJS

FIGURE A9

Golder Associates

File Location: R:\01 Client\Adani Group\117632041\Programs\ArcGIS\117632041_003_Rev0_A3_2011.mxd



CLIENT Adani Mining Pty Ltd			PROJECT Carmichael Mine – Railway Hydrological Investigation
DRAWN SH	DATE 06/10/2011		TITLE XPSWMM Output - Existing Conditions Belyando River Crossing
CHECKED SS	DATE 06/10/2011		
SCALE see scale bar			PROJECT No 117632041 / FIGURE No A10 / REV No

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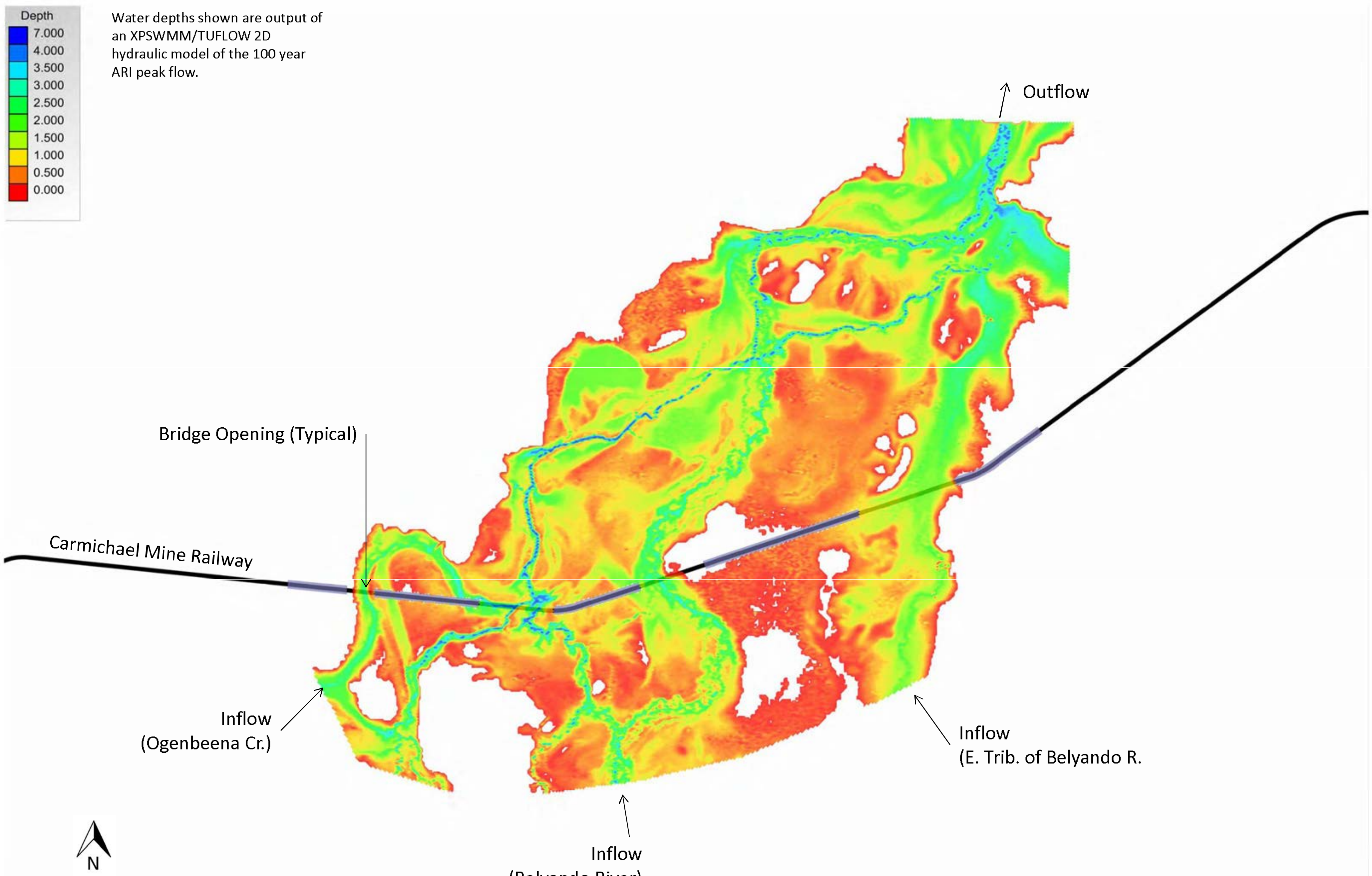
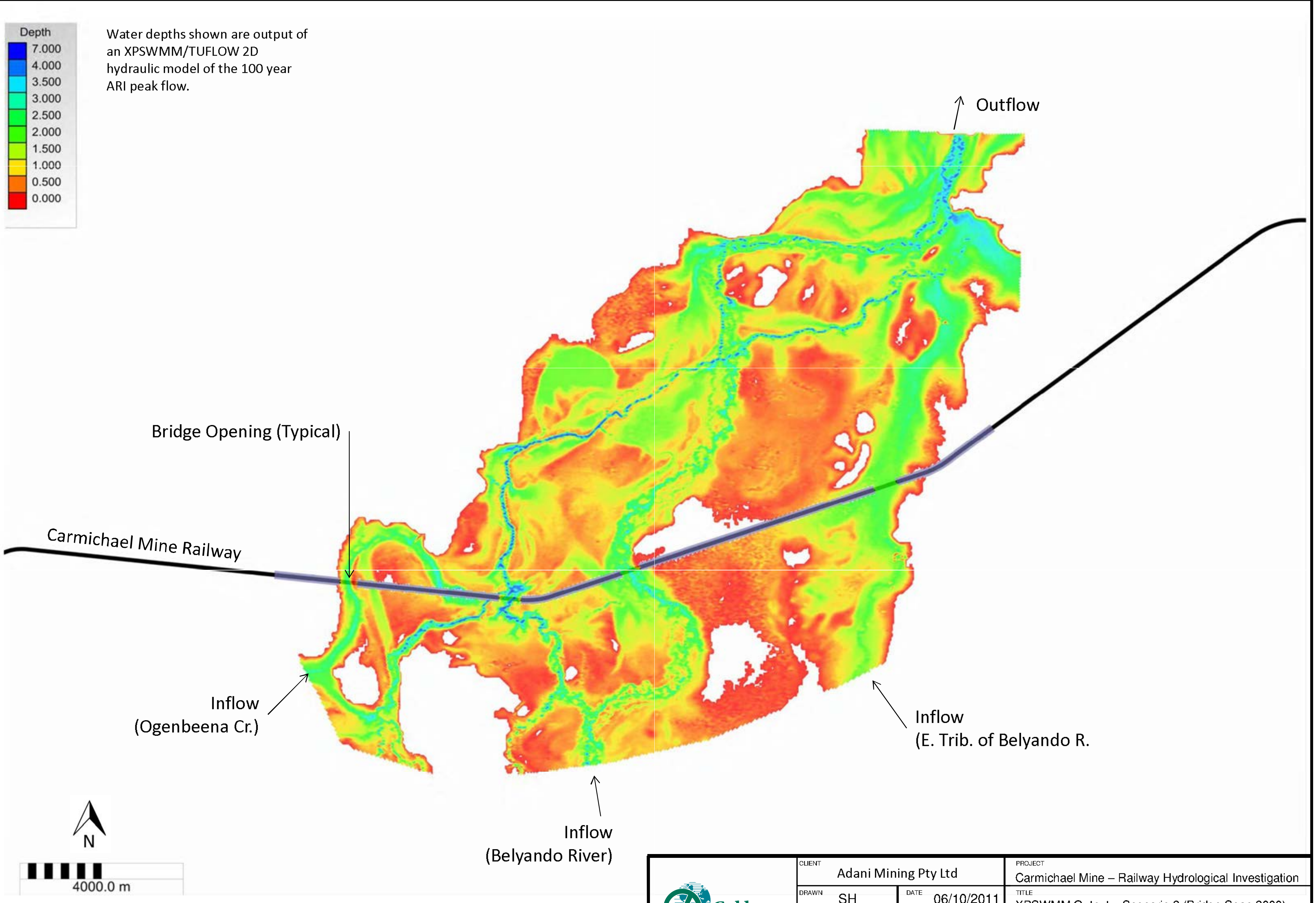


CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Railway Hydrological Investigation	
DRAWN SH	DATE 06/10/2011	TITLE XPSWMM Output – Scenario 1 (Bridge Span 6000) Belyando River Crossing	
CHECKED SS	DATE 06/10/2011		
SCALE see scale bar		PROJECT No 117632041	FIGURE No A11 REV No

Golder Associates



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	DRAWN SH	DATE 06/10/2011	TITLE XPSWMM Output – Scenario 2 (Bridge Span 2000) Belyando River Crossing	
	CHECKED SS	DATE 06/10/2011		
	SCALE see scale bar		PROJECT No 117632041	FIGURE No A12 REV No

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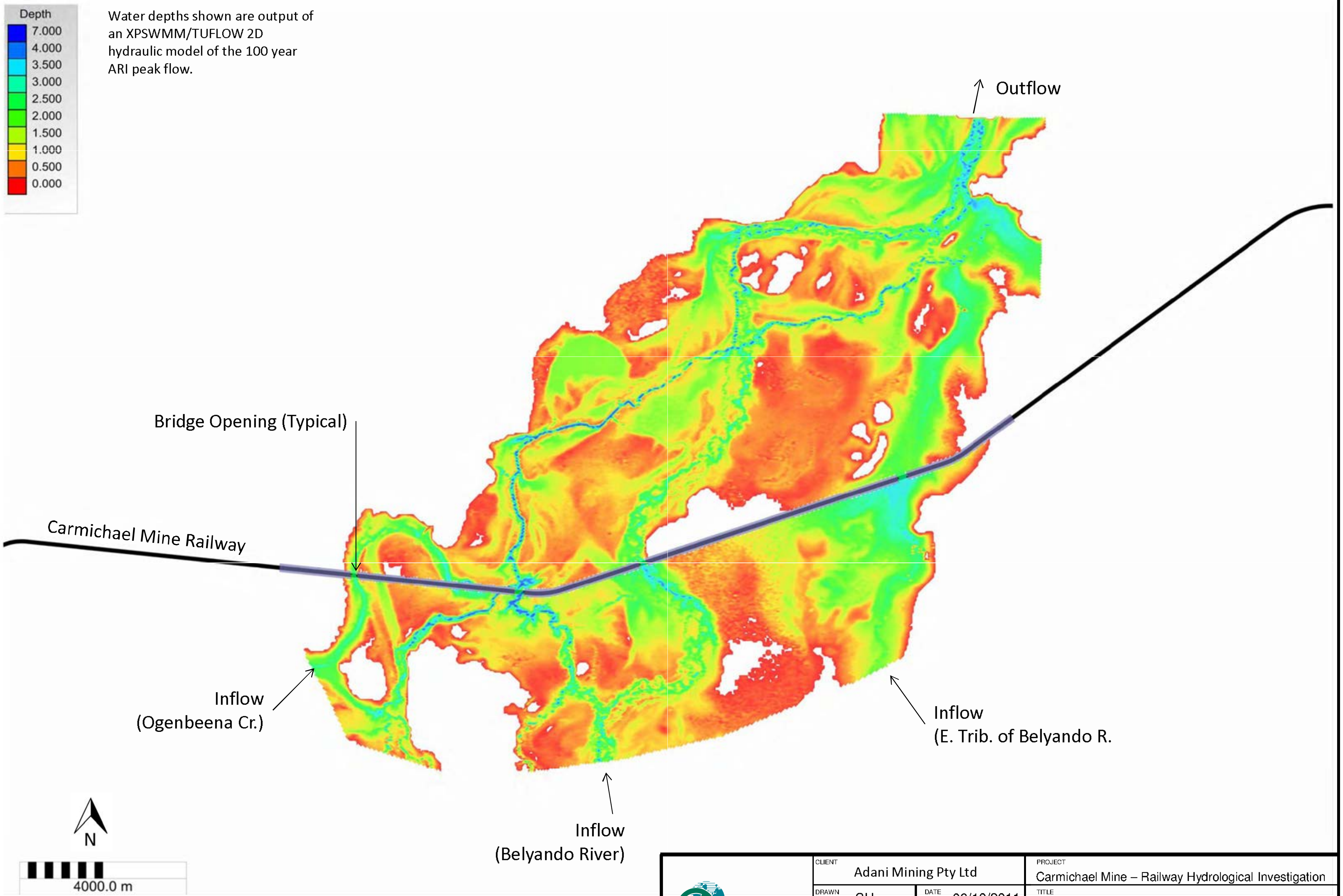

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DRAWN: SH	DATE: 06/10/2011	TITLE: XPSWMM Output – Scenario 3 (Bridge Span 800) Belyando River Crossing
CHECKED: SS	DATE: 06/10/2011	
SCALE: see scale bar		PROJECT No: 117632041 / FIGURE No: A13 / REV No:

Golder Associates

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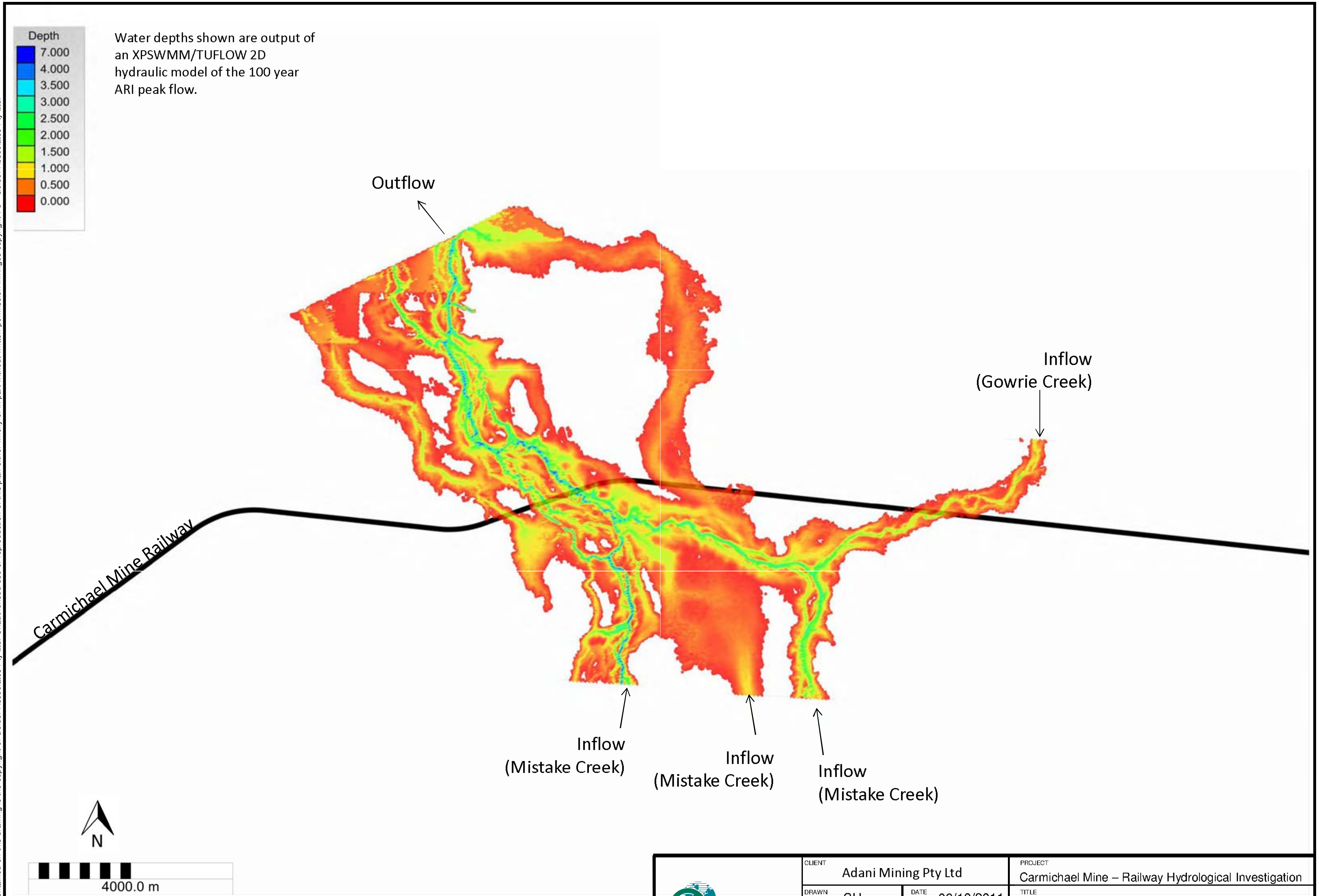

CLIENT	Adani Mining Pty Ltd		PROJECT	Carmichael Mine – Railway Hydrological Investigation
DRAWN	SH	DATE 06/10/2011	TITLE	XPSWMM Output – Existing Condition Mistake Creek Crossing
CHECKED	SS	DATE 06/10/2011		
SCALE	see scale bar		PROJECT No 117632041	FIGURE No A14 REV No

Golder Associates

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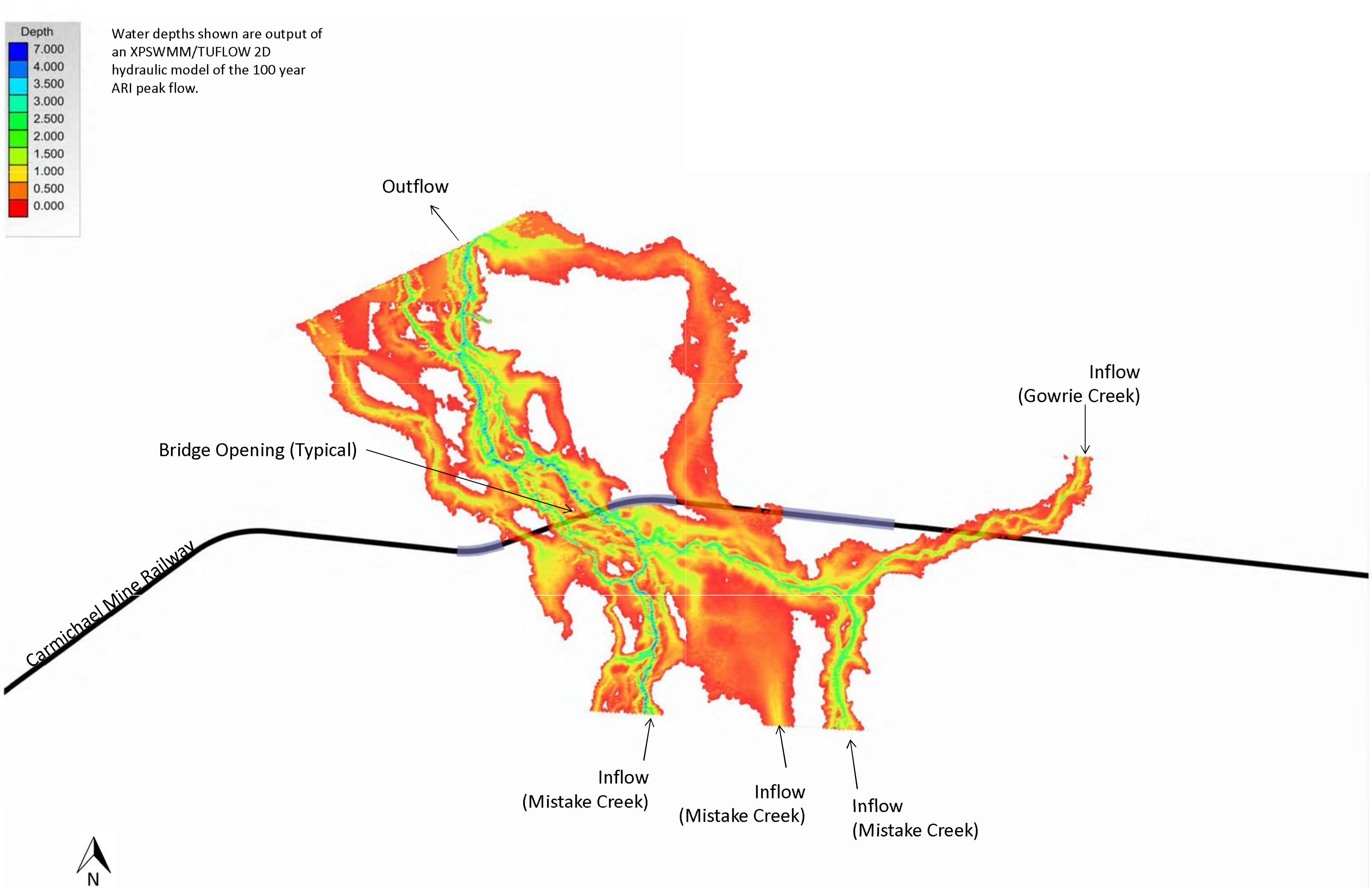
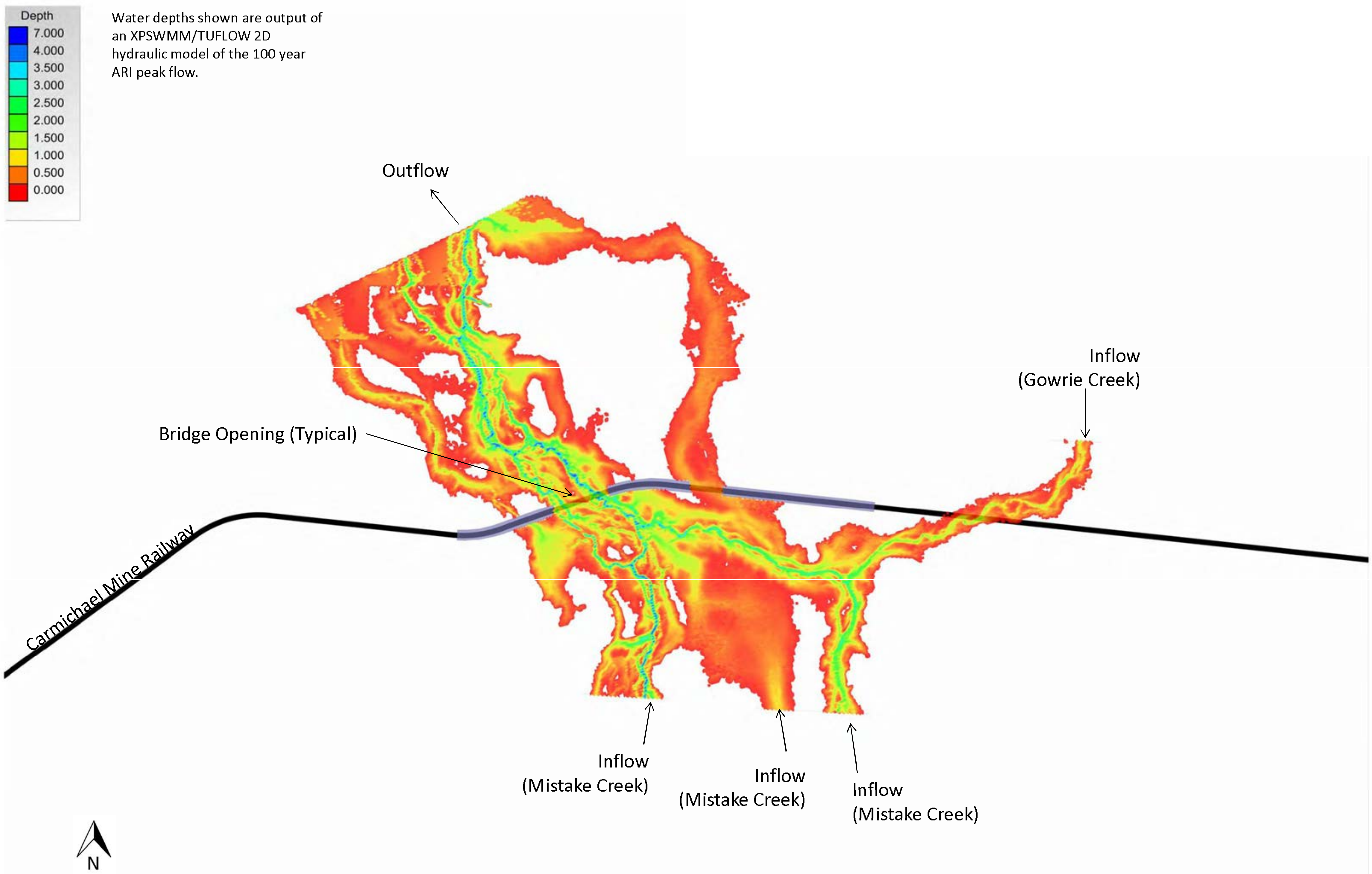


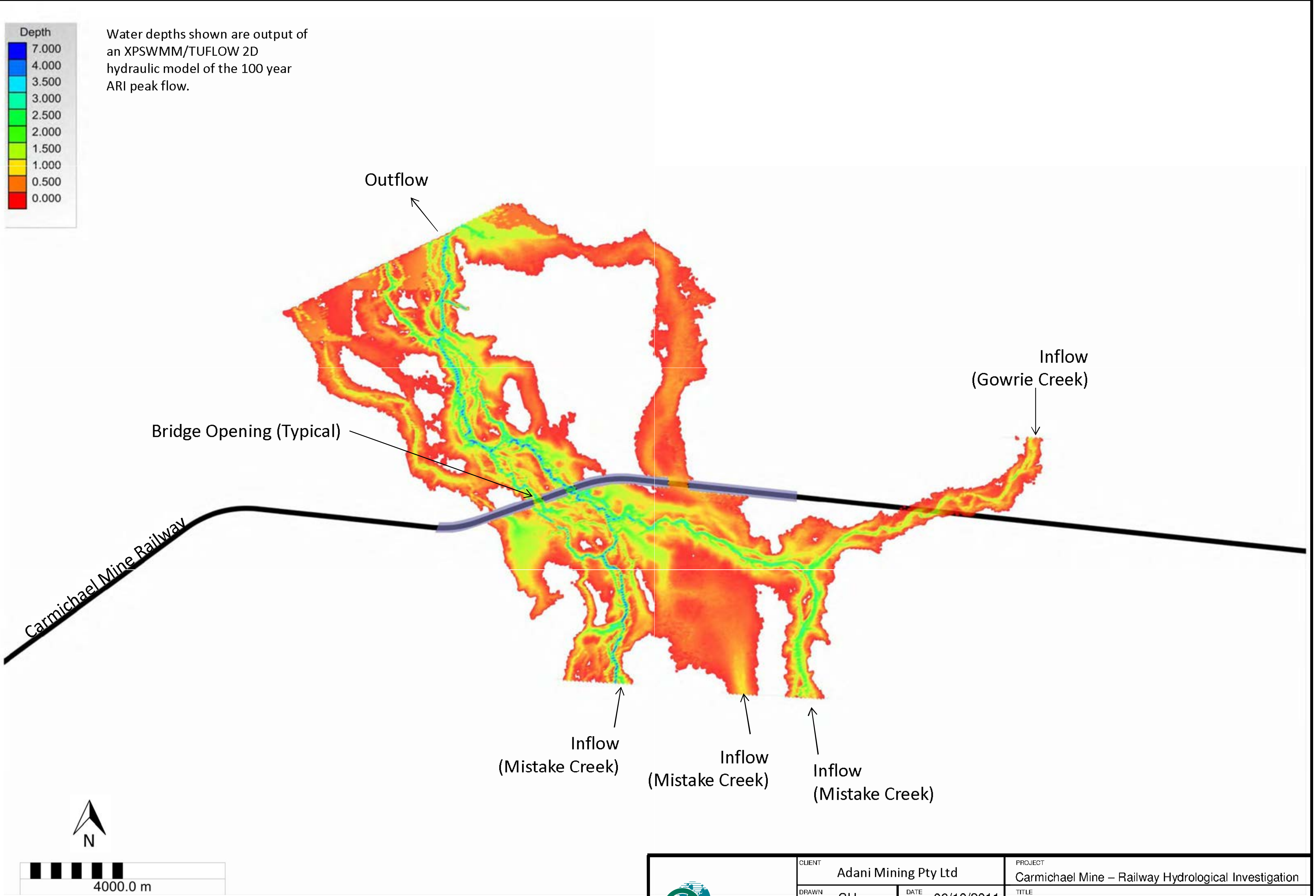
CLIENT: Adani Mining Pty Ltd		PROJECT: Carmichael Mine – Railway Hydrological Investigation	
DRAWN: SH	DATE: 06/10/2011	TITLE: XPSWMM Output – Scenario 1 (Bridge Span 4000) Mistake Creek Crossing	
CHECKED: SS	DATE: 06/10/2011		
SCALE: see scale bar		PROJECT No: 117632041	FIGURE No: A15 REV No:

Golder Associates



CLIENT: Adani Mining Pty Ltd		PROJECT: Carmichael Mine – Railway Hydrological Investigation	
DRAWN: SH	DATE: 06/10/2011	TITLE: XPSWMM Output – Scenario 2 (Bridge Span 1500) Mistake Creek Crossing	
CHECKED: SS	DATE: 06/10/2011		
SCALE: see scale bar		PROJECT No: 117632041	FIGURE No: A16

Golder Associates



Golder Associates	CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Railway Hydrological Investigation	
	DRAWN SH	DATE 06/10/2011	TITLE XPSWMM Output – Scenario 3 (Bridge Span 800) Mistake Creek Crossing	
	CHECKED SS	DATE 06/10/2011		
	SCALE see scale bar		PROJECT No 117632041	FIGURE No A17 / REV No

APPENDIX B

Regression Analysis Calculations

Peak flow estimates for major watercourse crossings

Carmichael Mine - Railway

Regression Equation based on Regression Analysis

$Q=aA^bP^c$

a	123.0	230.6	211.7	191.0	141.5
b	0.5364	0.5232	0.5087	0.5026	0.4891
c	8.143	6.387	4.575	3.826	2.200

Estimated Peak Flows

River Name - Chainage, km	Catchment Area measured from GIS, km²	Catchment Area measured from CAD, km²	A, Catchment Area (rounded), km²	P, Catchment Avg Annual Rain, m	2 year ARI Flow (Regression Estimated), m³/s	10 year ARI Flow (Regression Estimated), m³/s	50 year ARI Flow (Regression Estimated), m³/s	100 year ARI Flow (Regression Estimated), m³/s	500 year ARI Flow (Regression Estimated), m³/s
Carmichael River (at mine site) - n/a	2529		2500	0.573	87	393	884	1154	1906
Eight Mile Creek - 4.7	207	183	180	0.572	21	98	231	306	525
North Creek - 10.4	408	296	300	0.597	39	170	365	468	742
Ogenbeena Creek - 27.9	1032	853	850	0.581	55	246	547	711	1162
Ogenbeena Creek (lower crossing) - 30.8		868	870	0.581	56	248	552	718	1174
Belyando River - 31.4, 31.9, 34.9	22496		22000	0.568	262	1162	2572	3336	5421
East Tributary of Belyando River - 41.6		207	210	0.600	34	145	311	398	629
Mistake Creek - 58.8, 59.4, 60.2, 62.1	7932		7900	0.613	282	1108	2168	2672	3887
Gowrie Creek - 67.3	226	207	210	0.614	41	168	346	435	662
Logan Creek - 102.5, 103.5	2859		2900	0.579	104	458	1006	1302	2103
Diamond Creek - 119.4	1000		1000	0.549	38	186	458	620	1110
Grosvenor Creek - 163.7	154	128	130	0.597	25	109	238	307	492
Combined Belyando, Ogenbeena and E.Trib			23080	0.568	268	1191	2636	3417	5549

Revise the above Mistake Creek flow based on prorated flow analysis from gauge station 120309A

Mistake Creek is the only watercourse crossing that is gauged near the railway and the regression analysis overestimated the flow.

Area prorated flow from gauge station catchment to rail crossing catchment Qc = Qg * (Ac/Ag)^n, m³/s

Gauge station reported area is 8048 km2. However, gauge is upstream of railway so catchment was re-assessed for prorated flow analysis.

A, Area at gauged catchment, km²	7414					
Ac, Area at rail crossing, km²	7900					
Ac/A, area ratio	1.07					
n, area ration factor from regression analysis		0.5364	0.5232	0.5087	0.5026	0.4891
Qg, flow at Mistake Creek gauged catchment, m3/s		191	446	620	675	771
Qc, flow at Mistake Creek crossing, m3/s		198	461	640	697	795

Golder Associates

RegressionApplied7.xlsx

Regression Equation - 2 year

Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	123
A	Catchment Area, km^2	b	0.536
P	Annual Rainfall, m	c	8.14
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.89
standard error	54%
minimize sum	24.2

Station No.	No. of years	A, Area km2	Average Annual Rainfall, m	S, Average Slope	LP3 Estimated Flow, m3/s	Regression Estimated Flow, m3/s	percent error	log of LP3 flow	log of regression flow	weighted squared residuals
003204A	25	22825	0.521	0.01	180	133	-26%	2.26	2.12	0.433
003302A	36	7918	0.508	0.02	35	61	75%	1.54	1.79	2.111
003303A	36	8782	0.508	0.03	76	64	-16%	1.88	1.81	0.203
003305A	9	66	0.514	0.03	8	5	-36%	0.90	0.71	0.330
120301B	35	35411	0.585	0.02	367	432	18%	2.56	2.64	0.177
120302B	37	16074	0.645	0.02	580	624	8%	2.76	2.80	0.037
120303A	38	50291	0.588	0.02	685	544	-21%	2.84	2.74	0.383
120304A	38	1915	0.636	0.03	302	177	-41%	2.48	2.25	2.031
120305A	37	4065	0.551	0.03	44	83	90%	1.64	1.92	2.865
120306A	24	2583	0.637	0.03	181	212	17%	2.26	2.33	0.110
120309A	35	8048	0.612	0.05	191	280	46%	2.28	2.45	0.957
130207A	40	409	0.675	0.05	104	125	21%	2.01	2.10	0.277
130208A	37	758	0.660	0.05	164	147	-10%	2.21	2.17	0.085
130210A	32	4421	0.644	0.04	272	309	13%	2.44	2.49	0.095
130211A	13	438	0.625	0.03	51	70	36%	1.71	1.84	0.235
130212A	15	1108	0.683	0.09	187	238	27%	2.27	2.38	0.160
130213A	14	1498	0.575	0.06	173	69	-60%	2.24	1.84	2.239
130214A	14	401	0.646	0.03	129	87	-33%	2.11	1.94	0.413
130218A	7	563	0.675	0.06	159	149	-7%	2.20	2.17	0.006
130402A	22	551	0.667	0.07	56	135	142%	1.75	2.13	3.244
130409A	19	344	0.634	0.07	103	69	-33%	2.01	1.84	0.564
130410A	36	4092	0.600	0.04	369	167	-55%	2.57	2.22	4.240
130411A	16	1306	0.661	0.04	354	198	-44%	2.55	2.30	1.016
130414A	20	1214	0.620	0.05	139	113	-19%	2.14	2.05	0.165
130415A	13	388	0.656	0.08	41	98	137%	1.62	1.99	1.818

Regression Equation - 2 year

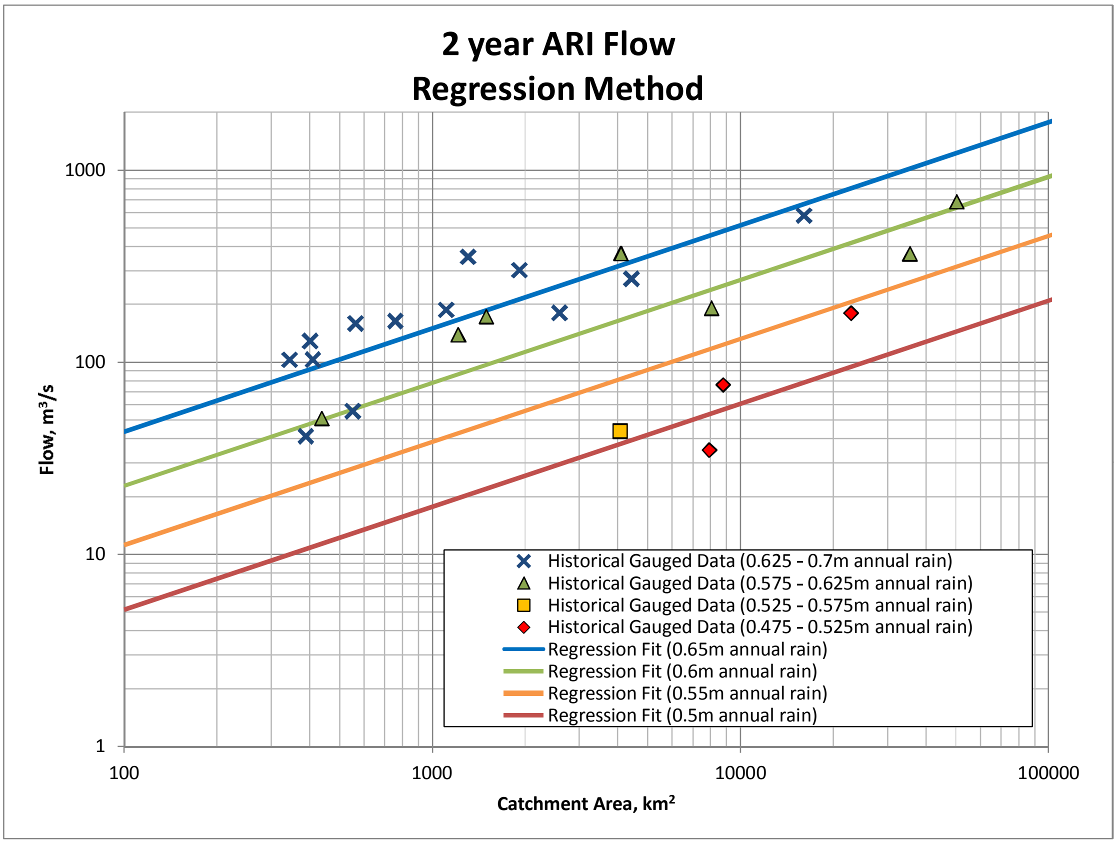
Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	123
A	Catchment Area, km^2	b	0.536
P	Annual Rainfall, m	c	8.14
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.89
standard error	54%
minimize sum	24.2



Regression Equation - 10 year

Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	231
A	Catchment Area, km^2	b	0.523
P	Annual Rainfall, m	c	6.39
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.84
standard error	58%
minimize sum	28.2

Station No.	No. of years	A, Area km2	Average Annual Rainfall, m	S, Average Slope	LP3 Estimated Flow, m3/s	Regression Estimated Flow, m3/s	percent error	log of LP3 flow	log of regression flow	weighted squared residuals
003204A	25	22825	0.521	0.01	1061	686	-35%	3.03	2.84	0.893
003302A	36	7918	0.508	0.02	204	334	64%	2.31	2.52	1.662
003303A	36	8782	0.508	0.03	421	351	-17%	2.62	2.55	0.225
003305A	9	66	0.514	0.03	28	29	5%	1.44	1.47	0.004
120301B	35	35411	0.585	0.02	1345	1808	34%	3.13	3.26	0.577
120302B	37	16074	0.645	0.02	2401	2225	-7%	3.38	3.35	0.040
120303A	38	50291	0.588	0.02	3027	2244	-26%	3.48	3.35	0.642
120304A	38	1915	0.636	0.03	1424	667	-53%	3.15	2.82	4.129
120305A	37	4065	0.551	0.03	286	397	39%	2.46	2.60	0.749
120306A	24	2583	0.637	0.03	476	790	66%	2.68	2.90	1.155
120309A	35	8048	0.612	0.05	446	1104	147%	2.65	3.04	5.413
130207A	40	409	0.675	0.05	433	434	0%	2.64	2.64	0.000
130208A	37	758	0.660	0.05	650	522	-20%	2.81	2.72	0.335
130210A	32	4421	0.644	0.04	794	1123	41%	2.90	3.05	0.725
130211A	13	438	0.625	0.03	186	275	48%	2.27	2.44	0.381
130212A	15	1108	0.683	0.09	480	793	65%	2.68	2.90	0.717
130213A	14	1498	0.575	0.06	411	310	-25%	2.61	2.49	0.210
130214A	14	401	0.646	0.03	325	324	0%	2.51	2.51	0.000
130218A	7	563	0.675	0.06	414	513	24%	2.62	2.71	0.061
130402A	22	551	0.667	0.07	427	473	11%	2.63	2.68	0.043
130409A	19	344	0.634	0.07	293	268	-9%	2.47	2.43	0.028
130410A	36	4092	0.600	0.04	1669	689	-59%	3.22	2.84	5.322
130411A	16	1306	0.661	0.04	845	699	-17%	2.93	2.84	0.109
130414A	20	1214	0.620	0.05	988	447	-55%	2.99	2.65	2.376
130415A	13	388	0.656	0.08	131	354	170%	2.12	2.55	2.413

Regression Equation - 10 year

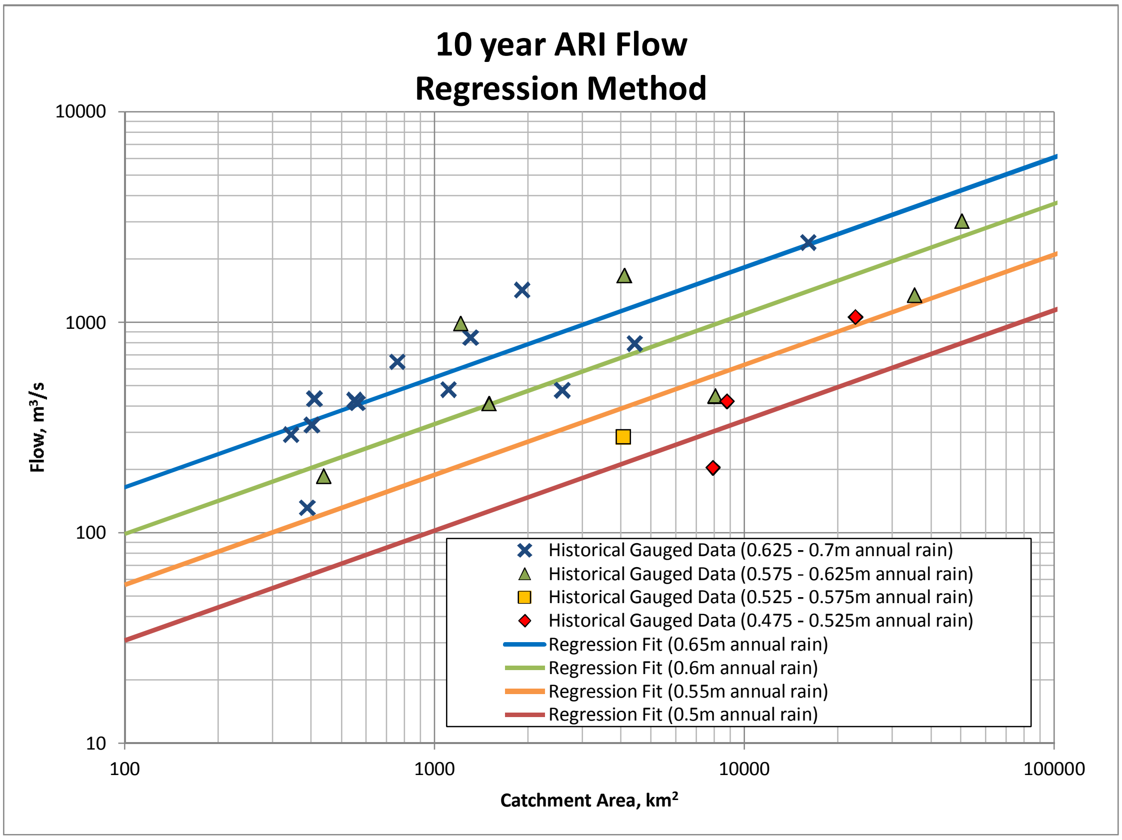
Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	231
A	Catchment Area, km^2	b	0.523
P	Annual Rainfall, m	c	6.39
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.84
standard error	58%
minimize sum	28.2



Regression Equation - 50 year

Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	212
A	Catchment Area, km^2	b	0.509
P	Annual Rainfall, m	c	4.58
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.82
standard error	70%
minimize sum	35.2

Station No.	No. of years	A, Area km2	Average Annual Rainfall, m	S, Average Slope	LP3 Estimated Flow, m3/s	Regression Estimated Flow, m3/s	percent error	log of LP3 flow	log of regression flow	weighted squared residuals
003204A	25	22825	0.521	0.01	2400	1773	-26%	3.38	3.25	0.433
003302A	36	7918	0.508	0.02	637	918	44%	2.80	2.96	0.910
003303A	36	8782	0.508	0.03	1274	965	-24%	3.11	2.98	0.523
003305A	9	66	0.514	0.03	51	85	65%	1.71	1.93	0.431
120301B	35	35411	0.585	0.02	2915	3764	29%	3.46	3.58	0.431
120302B	37	16074	0.645	0.02	4210	3928	-7%	3.62	3.59	0.034
120303A	38	50291	0.588	0.02	6590	4605	-30%	3.82	3.66	0.920
120304A	38	1915	0.636	0.03	2981	1246	-58%	3.47	3.10	5.455
120305A	37	4065	0.551	0.03	824	951	15%	2.92	2.98	0.144
120306A	24	2583	0.637	0.03	763	1464	92%	2.88	3.17	1.925
120309A	35	8048	0.612	0.05	620	2168	250%	2.79	3.34	10.356
130207A	40	409	0.675	0.05	868	745	-14%	2.94	2.87	0.176
130208A	37	758	0.660	0.05	1030	924	-10%	3.01	2.97	0.082
130210A	32	4421	0.644	0.04	1330	2024	52%	3.12	3.31	1.067
130211A	13	438	0.625	0.03	399	543	36%	2.60	2.73	0.234
130212A	15	1108	0.683	0.09	816	1312	61%	2.91	3.12	0.636
130213A	14	1498	0.575	0.06	630	696	10%	2.80	2.84	0.026
130214A	14	401	0.646	0.03	535	603	13%	2.73	2.78	0.038
130218A	7	563	0.675	0.06	711	877	23%	2.85	2.94	0.058
130402A	22	551	0.667	0.07	1149	825	-28%	3.06	2.92	0.455
130409A	19	344	0.634	0.07	439	515	17%	2.64	2.71	0.091
130410A	36	4092	0.600	0.04	3208	1412	-56%	3.51	3.15	4.572
130411A	16	1306	0.661	0.04	1210	1225	1%	3.08	3.09	0.000
130414A	20	1214	0.620	0.05	2559	880	-66%	3.41	2.94	4.298
130415A	13	388	0.656	0.08	267	640	140%	2.43	2.81	1.877

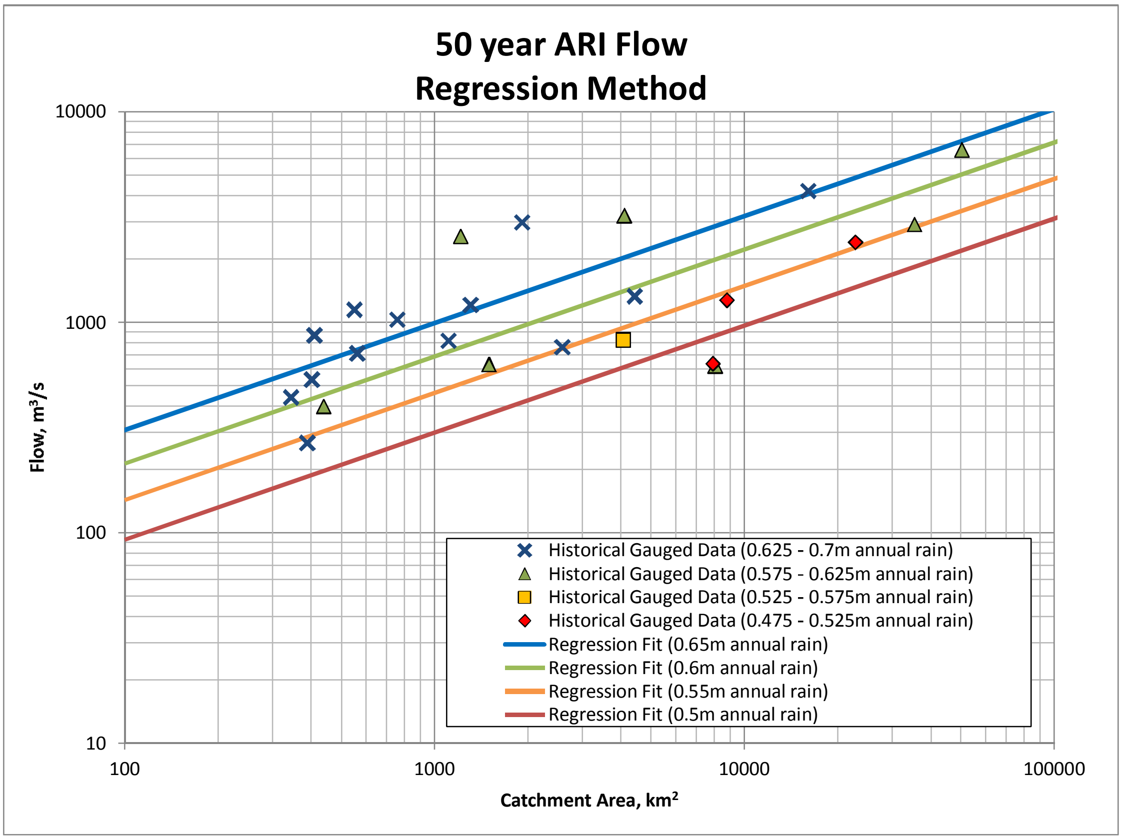
Regression Equation - 50 year
Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables			Resulting Regression Coefficients	
Q	flow, m^3/s		a	212
A	Catchment Area, km^2		b	0.509
P	Annual Rainfall, m		c	4.58
S	Avg Catchment Slope, m/m		d	0.000

correl. coef.	0.82
standard error	70%
minimize sum	35.2



Regression Equation - 100 year

Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	191
A	Catchment Area, km^2	b	0.503
P	Annual Rainfall, m	c	3.83
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.82
standard error	77%
minimize sum	38.7

Station No.	No. of years	A, Area km2	Average Annual Rainfall, m	S, Average Slope	LP3 Estimated Flow, m3/s	Regression Estimated Flow, m3/s	percent error	log of LP3 flow	log of regression flow	weighted squared residuals
003204A	25	22825	0.521	0.01	3060	2451	-20%	3.49	3.39	0.233
003302A	36	7918	0.508	0.02	960	1303	36%	2.98	3.11	0.633
003303A	36	8782	0.508	0.03	1898	1370	-28%	3.28	3.14	0.724
003305A	9	66	0.514	0.03	62	122	99%	1.79	2.09	0.802
120301B	35	35411	0.585	0.02	3807	4758	25%	3.58	3.68	0.329
120302B	37	16074	0.645	0.02	4895	4640	-5%	3.69	3.67	0.020
120303A	38	50291	0.588	0.02	8463	5787	-32%	3.93	3.76	1.035
120304A	38	1915	0.636	0.03	3732	1507	-60%	3.57	3.18	5.892
120305A	37	4065	0.551	0.03	1174	1274	9%	3.07	3.11	0.047
120306A	24	2583	0.637	0.03	882	1765	100%	2.95	3.25	2.182
120309A	35	8048	0.612	0.05	675	2676	296%	2.83	3.43	12.511
130207A	40	409	0.675	0.05	1074	870	-19%	3.03	2.94	0.337
130208A	37	758	0.660	0.05	1147	1093	-5%	3.06	3.04	0.016
130210A	32	4421	0.644	0.04	1557	2413	55%	3.19	3.38	1.157
130211A	13	438	0.625	0.03	518	671	29%	2.71	2.83	0.163
130212A	15	1108	0.683	0.09	976	1508	55%	2.99	3.18	0.536
130213A	14	1498	0.575	0.06	720	909	26%	2.86	2.96	0.143
130214A	14	401	0.646	0.03	629	728	16%	2.80	2.86	0.056
130218A	7	563	0.675	0.06	853	1022	20%	2.93	3.01	0.043
130402A	22	551	0.667	0.07	1558	970	-38%	3.19	2.99	0.932
130409A	19	344	0.634	0.07	489	631	29%	2.69	2.80	0.232
130410A	36	4092	0.600	0.04	3865	1774	-54%	3.59	3.25	4.117
130411A	16	1306	0.661	0.04	1337	1442	8%	3.13	3.16	0.017
130414A	20	1214	0.620	0.05	3430	1088	-68%	3.54	3.04	4.972
130415A	13	388	0.656	0.08	342	763	123%	2.53	2.88	1.582

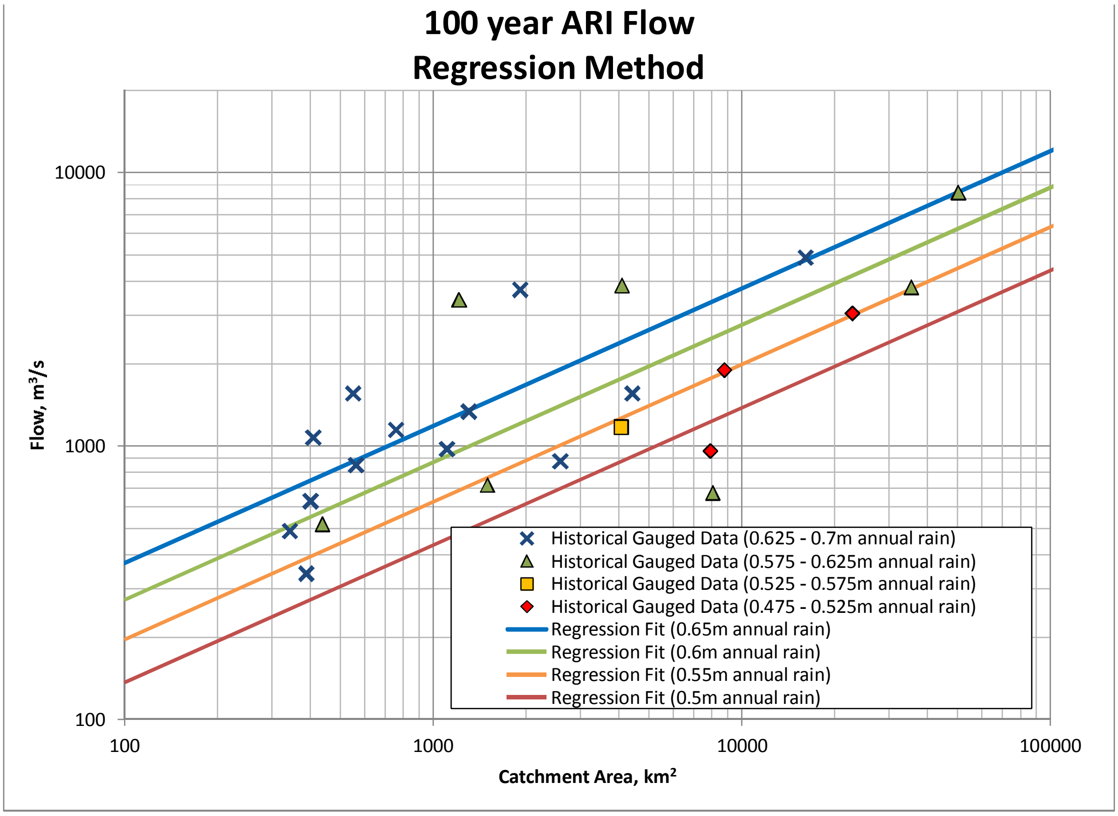
Regression Equation - 100 year
Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	191
A	Catchment Area, km^2	b	0.503
P	Annual Rainfall, m	c	3.83
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.82
standard error	77%
minimize sum	38.7



Regression Equation - 500 year

Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables		Resulting Regression Coefficients	
Q	flow, m^3/s	a	142
A	Catchment Area, km^2	b	0.489
P	Annual Rainfall, m	c	2.20
S	Avg Catchment Slope, m/m	d	0.000

correl. coef.	0.81
standard error	101%
minimize sum	48.2

Station No.	No. of years	A, Area km2	Average Annual Rainfall, m	S, Average Slope	LP3 Estimated Flow, m3/s	Regression Estimated Flow, m3/s	percent error	log of LP3 flow	log of regression flow	weighted squared residuals
003204A	25	22825	0.521	0.01	4648	4573	-2%	3.67	3.66	0.001
003302A	36	7918	0.508	0.02	2186	2573	18%	3.34	3.41	0.180
003303A	36	8782	0.508	0.03	4222	2703	-36%	3.63	3.43	1.350
003305A	9	66	0.514	0.03	86	253	195%	1.93	2.40	1.991
120301B	35	35411	0.585	0.02	6389	7313	14%	3.81	3.86	0.121
120302B	37	16074	0.645	0.02	6194	6154	-1%	3.79	3.79	0.000
120303A	38	50291	0.588	0.02	13394	8780	-34%	4.13	3.94	1.279
120304A	38	1915	0.636	0.03	5528	2106	-62%	3.74	3.32	6.676
120305A	37	4065	0.551	0.03	2297	2223	-3%	3.36	3.35	0.007
120306A	24	2583	0.637	0.03	1139	2449	115%	3.06	3.39	2.652
120309A	35	8048	0.612	0.05	771	3904	406%	2.89	3.59	17.371
130207A	40	409	0.675	0.05	1568	1127	-28%	3.20	3.05	0.821
130208A	37	758	0.660	0.05	1328	1454	10%	3.12	3.16	0.058
130210A	32	4421	0.644	0.04	2057	3263	59%	3.31	3.51	1.286
130211A	13	438	0.625	0.03	863	985	14%	2.94	2.99	0.043
130212A	15	1108	0.683	0.09	1371	1888	38%	3.14	3.28	0.290
130213A	14	1498	0.575	0.06	913	1499	64%	2.96	3.18	0.649
130214A	14	401	0.646	0.03	851	1014	19%	2.93	3.01	0.081
130218A	7	563	0.675	0.06	1205	1319	9%	3.08	3.12	0.011
130402A	22	551	0.667	0.07	2667	1274	-52%	3.43	3.11	2.267
130409A	19	344	0.634	0.07	577	905	57%	2.76	2.96	0.725
130410A	36	4092	0.600	0.04	5265	2693	-49%	3.72	3.43	3.052
130411A	16	1306	0.661	0.04	1567	1902	21%	3.20	3.28	0.113
130414A	20	1214	0.620	0.05	5754	1594	-72%	3.76	3.20	6.216
130415A	13	388	0.656	0.08	556	1035	86%	2.74	3.01	0.948

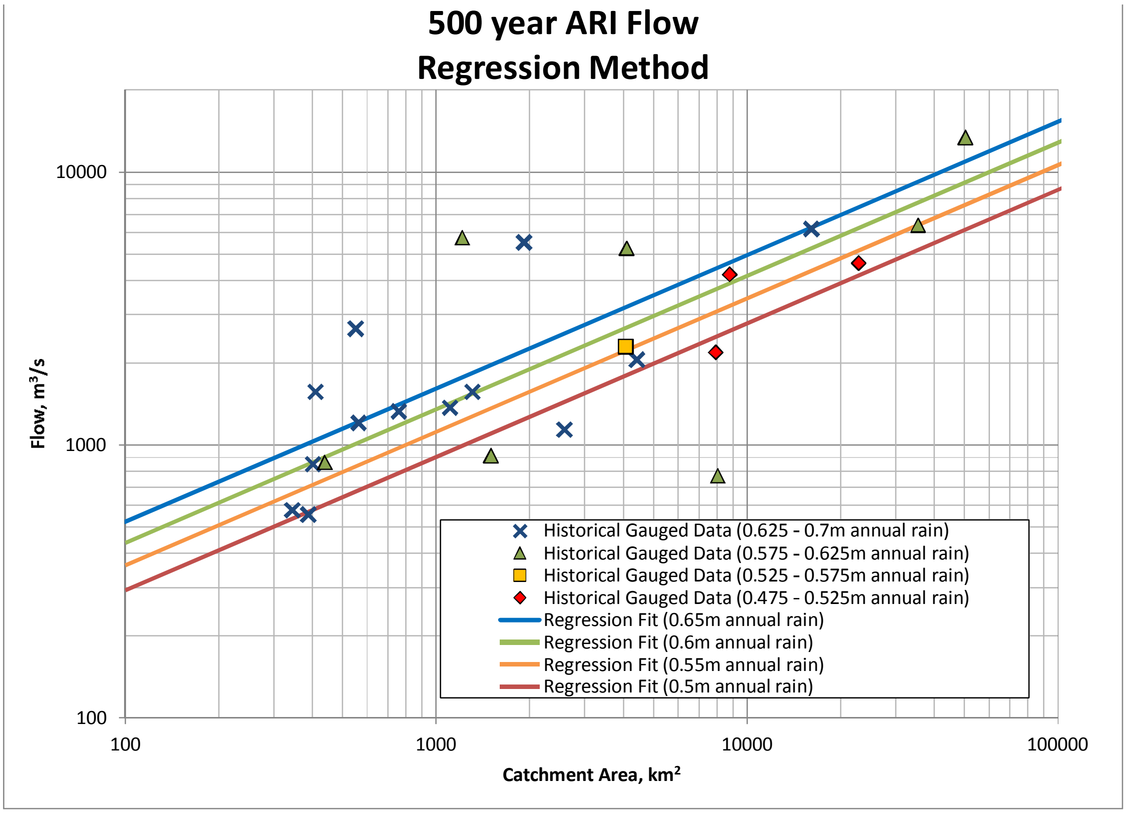
Regression Equation - 500 year
Carmichael Mine - Railway

Method: Solve for regression coefficients using least-square linear regression

$$Q=aA^bP^cS^d$$

Variables			Resulting Regression Coefficients	
Q	flow, m^3/s		a	142
A	Catchment Area, km^2		b	0.489
P	Annual Rainfall, m		c	2.20
S	Avg Catchment Slope, m/m		d	0.000

correl. coef.	0.81
standard error	101%
minimize sum	48.2



LP3 Analysis - Generalised Skew Calculation

Carmichael Mine - Railway

Method: Generalised skew is calculated using a simplification of the method found in USGS Bulletin 17B.

Station No.	No of Years	Gs, Station skew
003204A	25	-0.74
003302A	36	0.38
003303A	36	0.39
003305A	9	-1.74
120301B	35	0.07
120302B	37	-1.09
120303A	38	-0.36
120304A	38	-0.64
120305A	37	-0.13
120306A	24	-0.83
120309A	35	-1.15
130207A	40	-1.99
130208A	37	-1.43
130210A	32	-0.60
130211A	13	0.29
130212A	15	-0.21
130213A	14	-0.51
130214A	14	-0.17
130218A	7	0.33
130402A	22	0.11
130409A	19	-1.23
130410A	36	-0.89
130411A	16	-1.11
130414A	20	-0.38
130415A	13	0.45

Gg, Generalized skew (average, weighted by no. of years)	**-0.58**
Ng, Weighting factor for calculating weighted skew for each station	10

The weighted skew for each station is calculated as follows:

Gw = (Gg*Ng + Gs*Ns) / (Wg + Ns)

where Gw=weighted skew, Gg=generalised skew, Gs=station skew

Ng=generalised skew weighting factor, Ns=no. of year for each station

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

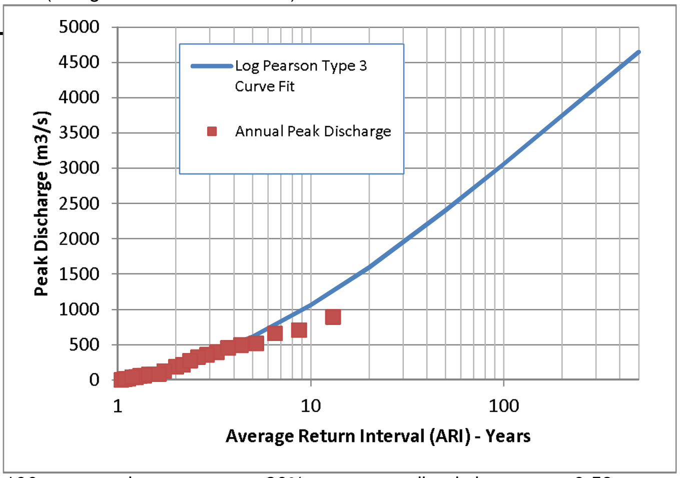
Golder

Catchment Area (km2)	22825	Latitude	-22.4492
Qld NRW WaterShed		Longitude	145.0242
Peak Series Table Report		Distance (k	147

*** 003204A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	180
5	613
10	1061
20	1594
50	2400
100	3060
500	4648



calc'd 100yr regression error	-20%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.74	weighted skew	-0.69
selected skew	-0.69	count	25

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
23/01/1969	400	1.3	1.38	0.14	25	1.04
28/12/1969	600	4.02	80.26	1.90	17	1.53
22/04/1971	400	5.26	518.04	2.71	5	5.20
8/03/1972	1200	5.15	395.04	2.60	8	3.25
30/03/1973	2359	5.39	707.08	2.85	3	8.67
28/01/1974	1620	6.26	4621.24	3.66	1	26.00
27/02/1975	1000	5.11	357.55	2.55	9	2.89
26/12/1975	1800	5.49	893.21	2.95	2	13.00
25/02/1977	0	4.68	188.19	2.27	13	2.00
9/09/1978	100	2.51	17.21	1.24	23	1.13
15/03/1979	959	5.36	658.93	2.82	4	6.50
10/02/1980	2100	4.68	188.19	2.27	13	2.00
25/01/1981	507	5.07	323.11	2.51	10	2.60
4/03/1982	654	3.33	39.29	1.59	21	1.24
6/05/1983	1251	4.79	213.78	2.33	12	2.17
31/01/1984	547	5.24	493.38	2.69	6	4.33
8/06/1985	0	3.75	59.97	1.78	19	1.37
16/11/1985	1154	4.36	127.08	2.10	15	1.73
4/01/1987	946	3.72	57.99	1.76	20	1.30
25/08/1988	2300	4	78	1.89	18	1.44
30/04/2001	1200	2.23	12.52	1.10	24	1.08
24/02/2002	600	3.32	38.99	1.59	22	1.18
3/03/2003	930	4.03	81.87	1.91	16	1.63
18/01/2004	1500	5.21	453.97	2.66	7	3.71
8/01/2005	745	5	272.7	2.44	11	2.36

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

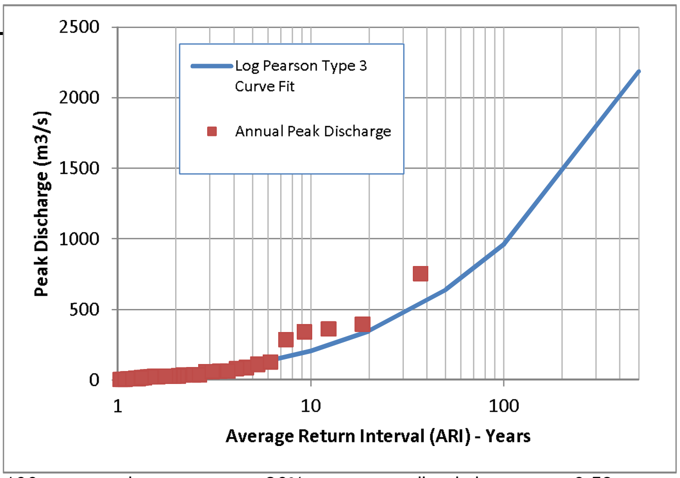
Catchment Area (km2)	7918	Latitude	-23.6493
Qld NRW WaterShed		Longitude	145.216
Peak Series Table Report		Distance (k	230

*** 003302A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	35
5	109
10	204
20	346
50	637
100	960
500	2186



calc'd 100yr regression error	36%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.38	weighted skew	0.17
selected skew	0.17	count	36

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
18/03/1969	1400	0.34	8.5	0.93	32	1.16
16/03/1970	1708	5.31	34.87	1.54	17	2.18
13/12/1970	0	5.82	87.88	1.94	8	4.63
27/12/1971	2100	5.23	28.75	1.46	18	2.06
31/03/1973	1500	5.34	37.3	1.57	15	2.47
1/02/1974	1300	7.25	341.51	2.53	4	9.25
4/01/1975	1700	5.18	25.21	1.40	22	1.68
27/12/1975	2200	5.22	28.03	1.45	19	1.95
14/05/1977	1504	5.76	80.35	1.90	9	4.11
18/01/1978	0	5.14	22.53	1.35	26	1.42
27/12/1978	2100	4.88	7.81	0.89	33	1.12
7/01/1980	442	5.17	24.53	1.39	23	1.61
2/06/1981	900	5.58	59.73	1.78	13	2.85
11/03/1982	1800	4.94	10.56	1.02	30	1.23
21/05/1983	811	7.34	362.11	2.56	3	12.33
5/02/1984	1010	5.34	37.3	1.57	15	2.47
24/01/1985	2100	4.75	3.79	0.58	35	1.06
26/11/1985	400	4.95	11.06	1.04	29	1.28
9/03/1987	800	4.71	2.74	0.44	36	1.03
22/11/1987	1030	5.06	17.36	1.24	27	1.37
4/02/1989	2300	5.99	110.94	2.05	7	5.29
22/04/1990	2214	8.77	753.76	2.88	1	37.00
11/02/1991	1315	5.21	27.52	1.44	20	1.85
9/02/1992	1330	5.6	61.7	1.79	11	3.36
9/03/1994	0	5.34	37.54	1.57	14	2.64
14/02/1995	0	5.17	24.33	1.39	24	1.54
10/01/1996	45	7	286.32	2.46	5	7.40
5/02/1997	0	7.48	395.57	2.60	2	18.50
11/09/1998	445	4.83	5.96	0.78	34	1.09
11/03/1999	1200	4.9	8.68	0.94	31	1.19
22/02/2000	130	5.62	63.5	1.80	10	3.70
30/12/2000	0	5.2	26.26	1.42	21	1.76
17/12/2001	1200	6.08	128.44	2.11	6	6.17
16/02/2003	1200	5.15	23.25	1.37	25	1.48
17/01/2004	545	5.6	60.08	1.78	12	3.08
22/06/2005	408	5.04	15.72	1.20	28	1.32

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

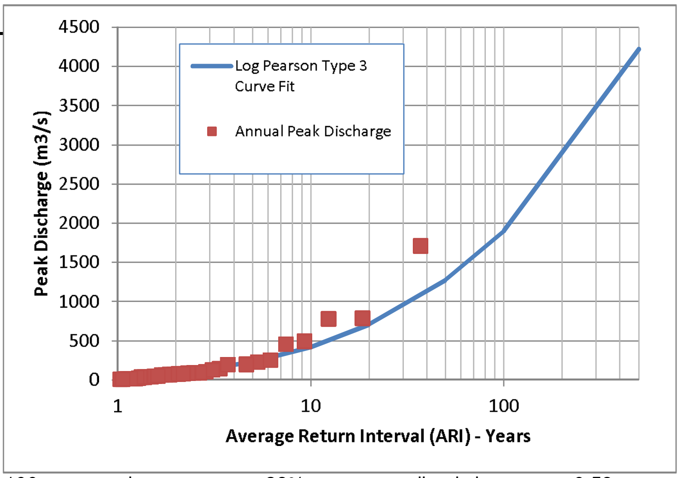
Catchment Area (km2)	8782	Latitude	-24.42675
Qld NRW WaterShed		Longitude	145.4583
Peak Series Table Report		Distance (k	287

*** 003303A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	76
5	230
10	421
20	705
50	1274
100	1898
500	4222



calc'd 100yr regression error	-28%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.39	weighted skew	0.18
selected skew	0.18	count	36

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
16/03/1970	2100	4.82	200.01	2.30	8	4.63
11/12/1970	100	4.31	91.69	1.96	15	2.47
7/01/1972	1200	3.51	22.16	1.35	29	1.28
18/02/1973	1400	4.6	144.64	2.16	11	3.36
11/01/1974	600	4.14	68.99	1.84	20	1.85
5/01/1975	2200	3.26	15.48	1.19	34	1.09
15/01/1976	1600	3.81	38.96	1.59	26	1.42
12/03/1977	1400	4.1	64.46	1.81	22	1.68
12/07/1978	2224	4.81	197.17	2.29	10	3.70
8/03/1979	129	3.76	35.6	1.55	28	1.32
9/02/1980	1403	3.37	17.52	1.24	30	1.23
3/06/1981	1124	6.29	494.29	2.69	4	9.25
5/03/1982	2359	5.01	228.63	2.36	7	5.29
24/05/1983	707	7.01	779.34	2.89	3	12.33
1/02/1984	740	4.39	104.42	2.02	13	2.85
5/06/1985	1952	2.72	9.04	0.96	36	1.03
8/02/1986	1440	3.36	17.33	1.24	31	1.19
30/01/1987	1937	4.16	71.44	1.85	19	1.95
19/11/1987	2115	3.29	16.03	1.20	33	1.12
18/03/1989	18	4.82	200.01	2.30	8	4.63
21/04/1990	200	8.24	1710.75	3.23	1	37.00
8/01/1991	912	3.77	36.09	1.56	27	1.37
30/04/1992	1313	3.27	16.12	1.21	32	1.16
18/12/1992	1845	3.82	39.55	1.60	25	1.48
3/02/1994	415	4.52	127.62	2.11	12	3.08
9/02/1995	2130	4.31	91.87	1.96	14	2.64
10/01/1996	1100	6.14	457.31	2.66	5	7.40
2/02/1997	300	7.02	787.75	2.90	2	18.50
13/12/1997	2145	3.92	47.28	1.67	24	1.54
3/03/1999	0	4.29	88.76	1.95	16	2.31
23/11/1999	915	2.8	9.86	0.99	35	1.06
18/12/2000	0	4.1	64.9	1.81	21	1.76
9/01/2002	0	4.21	77.77	1.89	18	2.06
11/02/2003	245	3.97	51.64	1.71	23	1.61
14/01/2004	115	5.17	253.95	2.40	6	6.17
11/12/2004	1520	4.22	79.22	1.90	17	2.18

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

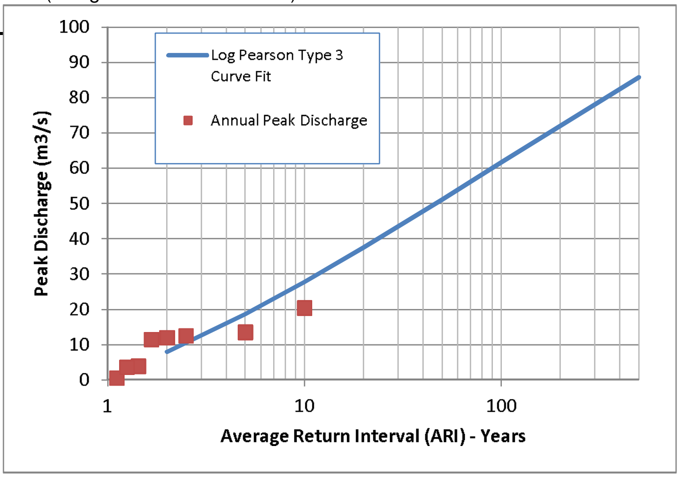
Catchment Area (km2)	66	Latitude	-23.6323
Qld NRW WaterShed		Longitude	145.9523
Peak Series Table Report		Distance (k	185

*** 003305A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	8
5	19
10	28
20	38
50	51
100	62
500	86



calc'd 100yr regression error	99%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.74	weighted skew	-1.13
selected skew	-0.58	count	9

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
16/11/1974	1700	0.63	3.88	0.59	7	1.43
17/01/1978	630	0.45	0.54	-0.27	9	1.11
1/04/1981	155	0.83	12.47	1.10	4	2.50
9/03/1982	2305	0.81	11.48	1.06	6	1.67
1/05/1983	2345	0.97	20.4	1.31	1	10.00
27/01/1984	100	0.85	13.51	1.13	2	5.00
17/12/1984	2030	0.62	3.57	0.55	8	1.25
4/12/1985	1816	0.85	13.51	1.13	2	5.00
16/08/1987	2210	0.82	11.97	1.08	5	2.00

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

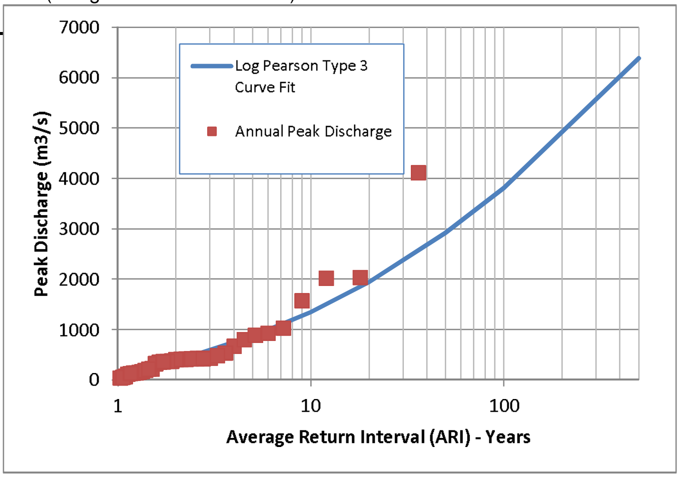
Golder

Catchment Area (km2)	35411	Latitude	-21.5332
Qld NRW WaterShed		Longitude	146.8596
Peak Series Table Report		Distance (k	52

*** 120301B 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	367
5	863
10	1345
20	1939
50	2915
100	3807
500	6389



calc'd 100yr regression error	25%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.07	weighted skew	-0.07
selected skew	-0.07	count	35

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)	
22/05/1977	455	5.91	374	2.57	19	1.89	
6/02/1978	824	7.35	1572.21	3.20	4	9.00	
14/03/1979	1500	7.63	2036.96	3.31	2	18.00	
18/02/1980	2221	3.65	69.48	1.84	33	1.09	
8/02/1981	645	5.39	220.29	2.34	24	1.50	
11/03/1982	1600	4.35	114.26	2.06	32	1.13	
3/05/1983	1800	7.62	2018.95	3.31	3	12.00	
3/02/1984	500	6.06	432	2.64	12	3.00	
9/06/1985	2100	4.8	151.03	2.18	28	1.29	
7/12/1985	1600	4.67	139.71	2.15	29	1.24	
2/02/1987	1400	6.04	424.49	2.63	14	2.57	
31/12/1987	600	6.01	409.26	2.61	17	2.12	
7/04/1989	416	6.53	670.66	2.83	9	4.00	
30/04/1990	1148	6.7	800.79	2.90	8	4.50	
13/02/1991	1026	6.79	887.22	2.95	7	5.14	
13/12/1991	1245	2.78	39.27	1.59	35	1.03	
11/09/1993	515	3.35	52.54	1.72	34	1.06	
14/03/1994	1800	6.31	536.34	2.73	10	3.60	
23/02/1995	2115	6.02	413.07	2.62	16	2.25	
14/01/1996	1200	6.19	482.98	2.68	11	3.27	
4/03/1997	0	6.66	421.17	2.62	15	2.40	
31/08/1998	1500	4.78	136.23	2.13	30	1.20	
11/01/1999	0	5.13	165.61	2.22	27	1.33	
22/02/2000	500	6.68	425.23	2.63	13	2.77	
6/02/2001	420	5.4	190.45	2.28	26	1.38	
16/11/2001	1730	6.31	353.36	2.55	22	1.64	
16/02/2003	0	6.58	405.01	2.61	18	2.00	
21/01/2004	600	6.14	324.32	2.51	23	1.57	
16/02/2005	1200	4.7	129.96	2.11	31	1.16	
2006			215.96	2.33	25	1.44	unverified daily data
2007			367.542	2.57	20	1.80	unverified daily data
2008			4114.066	3.61	1	36.00	unverified daily data
2009			360.4704	2.56	21	1.71	unverified daily data
2010			927.23	2.97	6	6.00	unverified daily data
2011			1028.762	3.01	5	7.20	unverified daily data

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

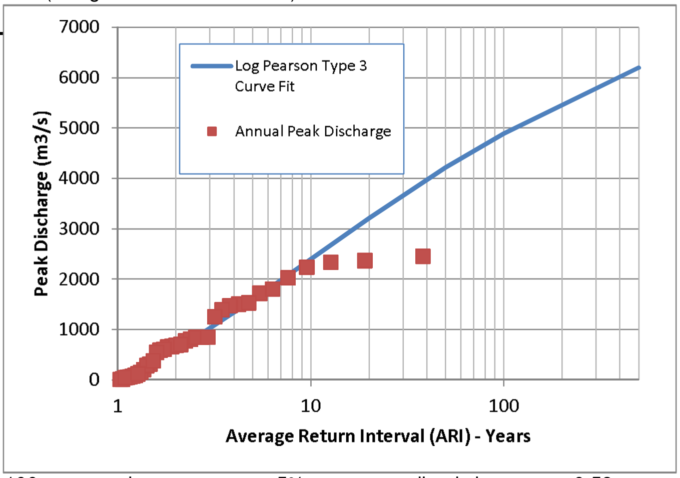
Golder

Catchment Area (km2)	16074	Latitude	-20.9996
Qld NRW WaterShed		Longitude	146.4271
Peak Series Table Report		Distance (k	109

*** 120302B 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	580
5	1586
10	2401
20	3208
50	4210
100	4895
500	6194



calc'd 100yr regression error	-5%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.09	weighted skew	-0.98
selected skew	-0.98	count	37

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
17/03/1969	2200	4.48	313.33	2.50	26	1.46
26/12/1969	900	3.79	204.26	2.31	28	1.36
9/03/1971	1600	5.72	591.99	2.77	23	1.65
8/03/1972	1700	8.69	1722.49	3.24	7	5.43
19/02/1973	2216	5.99	667.6	2.82	20	1.90
25/01/1974	1048	9.59	2369	3.37	2	19.00
17/01/1975	1101	9.56	2333.39	3.37	3	12.67
22/12/1975	1847	5.95	655.8	2.82	21	1.81
17/05/1977	739	6.35	776.69	2.89	17	2.24
31/01/1978	326	1.62	19.03	1.28	36	1.06
12/03/1979	1053	9.48	2239.9	3.35	4	9.50
6/03/1980	818	6.45	809.09	2.91	16	2.38
25/07/1981	600	2.36	59.62	1.78	33	1.15
5/12/1981	1441	2.27	53.92	1.73	34	1.12
2/05/1983	130	8.24	1506.34	3.18	9	4.22
31/01/1984	1300	6.06	688.07	2.84	19	2.00
15/12/1984	1700	1.07	7	0.85	37	1.03
6/05/1986	1730	2.76	89.06	1.95	31	1.23
31/01/1987	1508	3.38	152.18	2.18	29	1.31
31/12/1987	1000	6.12	705.92	2.85	18	2.11
5/04/1989	1612	6.57	849.3	2.93	14	2.71
3/04/1990	1231	8.17	1474.67	3.17	10	3.80
19/02/1991	900	9.66	2454.46	3.39	1	38.00
27/02/1992	1730	2.63	76.12	1.88	32	1.19
1/03/1993	45	2.32	47.67	1.68	35	1.09
9/03/1994	1630	5.78	609	2.78	22	1.73
12/02/1995	0	4.36	286.02	2.46	27	1.41
7/01/1996	945	5.54	546.66	2.74	24	1.58
5/02/1997	2014	6.57	847.21	2.93	15	2.53
13/01/1998	2115	8.86	1808.1	3.26	6	6.33
17/02/1999	150	4.74	378.26	2.58	25	1.52
21/02/2000	1800	7.99	1396.1	3.14	11	3.45
31/12/2000	0	7.66	1254.17	3.10	12	3.17
18/02/2002	0	9.28	2028.94	3.31	5	7.60
2/03/2003	1200	6.58	850.57	2.93	13	2.92
11/01/2004	2240	3.08	119.59	2.08	30	1.27
26/01/2005	410	8.29	1530.86	3.18	8	4.75

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

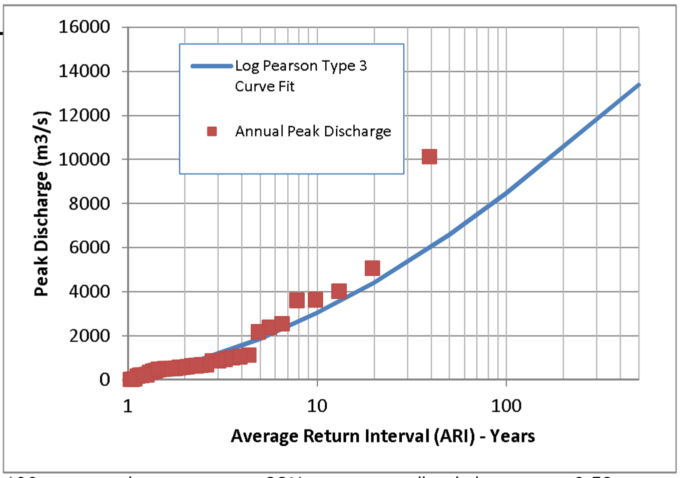
Golder

Catchment Area (km2)	50291	Latitude	-21.229
Qld NRW WaterShed		Longitude	146.9134
Peak Series Table Report		Distance (k	87

*** 120303A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	685
5	1868
10	3027
20	4417
50	6590
100	8463
500	13394



calc'd 100yr regression error	-32%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.36	weighted skew	-0.41
selected skew	-0.41	count	38

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
12/02/1968	500	8.17	3641.02	3.56	4	9.75
17/03/1969	1200	1.25	22.48	1.35	38	1.03
27/12/1969	300	3.47	427.5	2.63	28	1.39
11/12/1970	2359	2.49	209.86	2.32	34	1.15
9/03/1972	5	3.9	505.11	2.70	25	1.56
23/02/1973	2300	5.03	859.54	2.93	14	2.79
2/02/1974	937	10.2	10142.94	4.01	1	39.00
8/03/1975	1200	3.35	398.19	2.60	29	1.34
3/02/1976	2321	3.13	346.29	2.54	30	1.30
20/05/1977	218	4.01	567.71	2.75	20	1.95
4/02/1978	2145	7.16	2387.32	3.38	7	5.57
13/03/1979	2236	8.35	4025.35	3.60	3	13.00
9/02/1980	2037	2.81	244.93	2.39	31	1.26
9/02/1981	446	5.05	866.57	2.94	13	3.00
12/03/1982	1700	2.42	172.51	2.24	35	1.11
5/05/1983	500	8.78	5076.12	3.71	2	19.50
4/02/1984	600	4.52	689.24	2.84	15	2.60
11/06/1985	900	2.65	213.85	2.33	33	1.18
7/02/1986	1300	3.83	485.91	2.69	26	1.50
4/02/1987	700	3.92	525.34	2.72	22	1.77
5/03/1988	1800	6.94	2185.3	3.34	8	4.88
7/04/1989	1056	5.58	1139.3	3.06	9	4.33
2/04/1990	1523	5.24	939.71	2.97	12	3.25
7/02/1991	652	8.16	3618.07	3.56	5	7.80
14/05/1992	2359	1.47	37.49	1.57	37	1.05
12/09/1993	600	1.6	50.99	1.71	36	1.08
12/03/1994	0	5.36	1009.32	3.00	11	3.55
25/02/1995	1137	4.46	679.67	2.83	16	2.44
12/01/1996	1200	4.21	605.06	2.78	19	2.05
4/03/1997	1700	6.89	2551.19	3.41	6	6.50
5/09/1998	1200	3.77	477.87	2.68	27	1.44
11/01/1999	0	4.35	643.35	2.81	18	2.17
24/02/2000	1800	5.4	1059.49	3.03	10	3.90
28/11/2000	600	3.91	514.86	2.71	24	1.63
18/11/2001	2145	4.08	562.4	2.75	21	1.86
18/02/2003	600	4.39	653.93	2.82	17	2.29
23/01/2004	600	3.94	522.55	2.72	23	1.70
14/01/2005	0	2.67	224.67	2.35	32	1.22

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

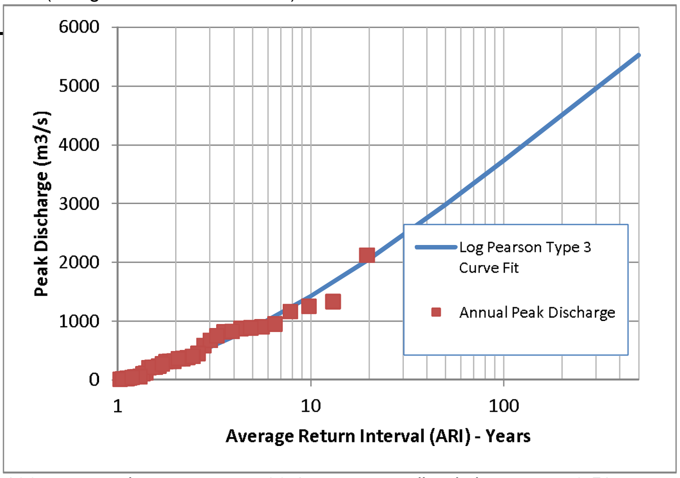
Golder

Catchment Area (km2)	1915	Latitude	-21.4503
Qld NRW WaterShed		Longitude	147.7142
Peak Series Table Report		Distance (k	57

*** 120304A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	302
5	876
10	1424
20	2053
50	2981
100	3732
500	5528



calc'd 100yr regression error	-60%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.64	weighted skew	-0.62
selected skew	-0.62	count	38

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
17/02/1968	700	6.25	317.79	2.50	21	1.86
16/01/1969	2100	2.04	11.38	1.06	38	1.03
20/01/1970	1100	9.02	877.25	2.94	9	4.33
7/02/1971	2359	4.27	118.62	2.07	28	1.39
8/03/1972	1745	3.2	51.7	1.71	32	1.22
13/02/1973	1930	5.38	218.08	2.34	25	1.56
1/02/1974	1630	8.8	819.79	2.91	11	3.55
14/01/1975	1201	6.17	311.18	2.49	22	1.77
5/03/1976	1600	9.1	904.44	2.96	7	5.57
16/05/1977	600	5.2	208.42	2.32	27	1.44
1/02/1978	735	10.28	1254.47	3.10	4	9.75
10/03/1979	1505	7.78	586.83	2.77	14	2.79
7/01/1980	1928	4.59	106.76	2.03	29	1.34
6/02/1981	2331	8.18	675.05	2.83	13	3.00
19/01/1982	658	3.88	56.06	1.75	31	1.26
21/05/1983	1351	10.52	1333.64	3.13	3	13.00
20/01/1984	653	3.48	25.7	1.41	35	1.11
11/12/1984	1505	6.7	382.54	2.58	17	2.29
10/12/1985	1128	5.85	237.47	2.38	24	1.63
25/01/1987	1045	6.34	319.7	2.50	20	1.95
2/03/1988	718	12.87	2242.34	3.35	1	39.00
6/04/1989	929	9.27	952.3	2.98	6	6.50
29/03/1990	553	5.7	215.89	2.33	26	1.50
3/02/1991	2215	12.6	2124.22	3.33	2	19.50
12/12/1991	1715	3.34	19.09	1.28	36	1.08
7/12/1992	445	3.61	31.69	1.50	34	1.15
11/03/1994	300	8.49	752.33	2.88	12	3.25
21/01/1995	845	4.11	58.48	1.77	30	1.30
6/01/1996	700	7.09	451.52	2.65	15	2.60
25/02/1997	1745	9.98	1164.43	3.07	5	7.80
30/08/1998	1040	6.59	365.03	2.56	18	2.17
4/01/1999	1120	8.78	825.53	2.92	10	3.90
19/12/1999	1100	6.57	362.21	2.56	19	2.05
29/12/2000	1550	9.02	886.55	2.95	8	4.88
2/02/2002	1250	3.12	17.78	1.25	37	1.05
26/02/2003	250	6.05	273.99	2.44	23	1.70
4/02/2004	710	6.81	401.68	2.60	16	2.44
9/01/2005	46	3.77	42.58	1.63	33	1.18

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

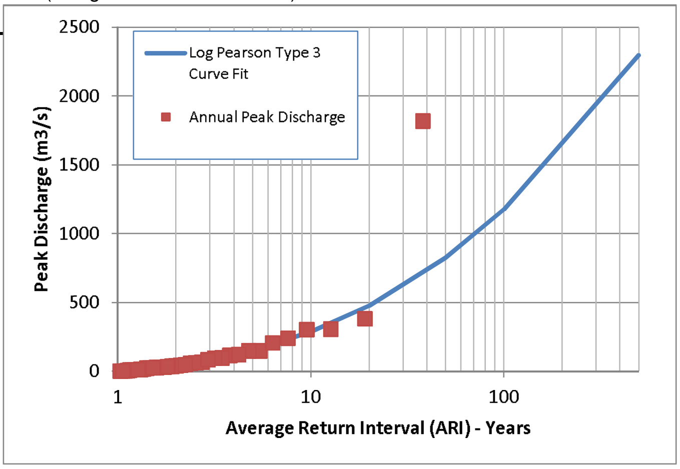
Golder

Catchment Area (km2)	4065	Latitude	-23.57570667
Qld NRW WaterShed		Longitude	146.6779
Peak Series Table Report		Distance (k	173

*** 120305A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	44
5	153
10	286
20	475
50	824
100	1174
500	2297



calc'd 100yr regression error	9%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.13	weighted skew	-0.23
selected skew	-0.23	count	37

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
19/03/1969	1200	2.27	11.99	1.08	31	1.23
17/03/1970	1200	3.7	36.5	1.56	20	1.90
9/12/1970	205	4.63	65.91	1.82	14	2.71
15/01/1972	900	1.37	1.64	0.21	37	1.03
18/02/1973	200	7.45	306.95	2.49	3	12.67
11/01/1974	300	6.02	149.03	2.17	7	5.43
5/01/1975	1300	4.45	58.81	1.77	16	2.38
23/01/1976	1900	4.54	62.31	1.79	15	2.53
15/05/1977	650	6.61	205.28	2.31	6	6.33
3/02/1978	13	3.06	23.19	1.37	27	1.41
27/12/1978	2300	4.08	45.61	1.66	18	2.11
11/02/1980	1751	3.3	28.45	1.45	23	1.65
3/06/1981	506	6.01	148.18	2.17	8	4.75
11/03/1982	1109	3.13	24.73	1.39	26	1.46
22/05/1983	719	6.92	239.86	2.38	5	7.60
30/01/1984	2156	5.6	115.95	2.06	10	3.80
17/12/1984	115	2.02	8.8	0.94	33	1.15
7/02/1986	1024	3.26	27.69	1.44	24	1.58
6/05/1987	100	2.61	16.55	1.22	28	1.36
2/05/1988	35	3.33	29.43	1.47	22	1.73
6/02/1989	1259	3.79	39.99	1.60	19	2.00
21/04/1990	200	11.46	1819.29	3.26	1	38.00
11/02/1991	1923	3.65	35.43	1.55	21	1.81
13/12/1991	2359	1.57	1.97	0.29	35	1.09
16/09/1993	715	2.56	13.64	1.13	29	1.31
9/03/1994	2000	5.32	97.4	1.99	11	3.45
9/02/1995	830	4.17	48.48	1.69	17	2.24
3/01/1996	1945	2	5.11	0.71	34	1.12
3/02/1997	215	7.92	381.8	2.58	2	19.00
20/12/1997	2215	2.36	10.31	1.01	32	1.19
5/03/1999	700	5.3	96.3	1.98	12	3.17
12/01/2000	0	1.53	1.74	0.24	36	1.06
4/02/2001	810	5.05	84.29	1.93	13	2.92
18/12/2001	1200	2.53	12.01	1.08	30	1.27
10/02/2003	1340	7.42	303.11	2.48	4	9.50
17/01/2004	0	5.69	122.2	2.09	9	4.22
13/12/2004	1120	3.15	24.95	1.40	25	1.52

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

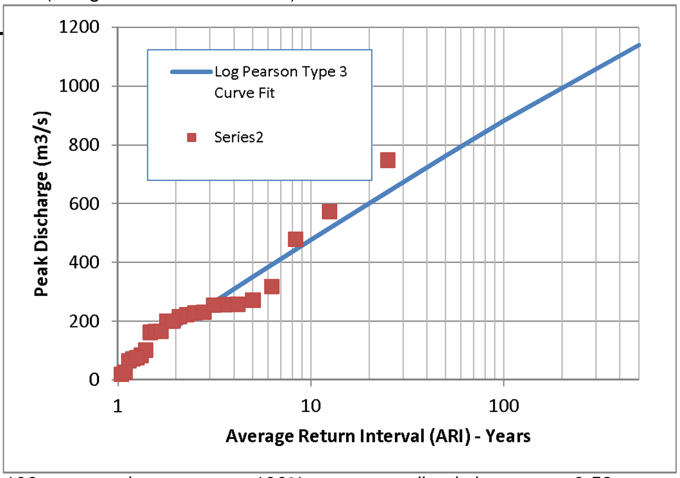
Golder

Catchment Area (km2)	2583	Latitude	-22.5054
Qld NRW WaterShed		Longitude	147.0989
Peak Series Table Report		Distance (k	56

*** 120306A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	181
5	351
10	476
20	601
50	763
100	882
500	1139



calc'd 100yr regression error	100%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.83	weighted skew	-0.76
selected skew	-0.58	count	24

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
29/05/1969	100	1.95	18.72	1.27	24	1.04
23/12/1969	1200	3.44	71.83	1.86	21	1.19
22/02/1971	1452	5.95	256.3	2.41	7	3.57
26/03/1972	808	5.62	222.85	2.35	11	2.27
13/02/1973	900	3.69	83.65	1.92	19	1.32
29/01/1974	2200	7.62	478.68	2.68	3	8.33
19/03/1975	1100	5.96	257.41	2.41	6	4.17
22/01/1976	1200	4.92	162.23	2.21	17	1.47
17/05/1977	200	6.48	318.69	2.50	4	6.25
2/02/1978	942	8.97	748.09	2.87	1	25.00
12/03/1979	1000	3.29	65.09	1.81	22	1.14
12/02/1980	1420	2.24	26.74	1.43	23	1.09
21/01/1981	2000	5.68	228.48	2.36	10	2.50
3/03/1982	2011	4.05	101.95	2.01	18	1.39
3/05/1983	1700	8.17	573.52	2.76	2	12.50
28/07/1984	300	5.54	215.52	2.33	12	2.08
4/06/1985	2315	5.7	230.43	2.36	9	2.78
28/11/1985	31	5.37	200.22	2.30	14	1.79
24/10/1986	1026	4.95	164.78	2.22	16	1.56
31/12/1987	2307	5.94	255.19	2.41	8	3.13
18/05/1989	1005	4.96	165.43	2.22	15	1.67
26/03/1990	1958	5.38	200.61	2.30	13	1.92
11/02/1991	759	6.09	272.07	2.43	5	5.00
6/02/1992	1613	3.53	75.86	1.88	20	1.25

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

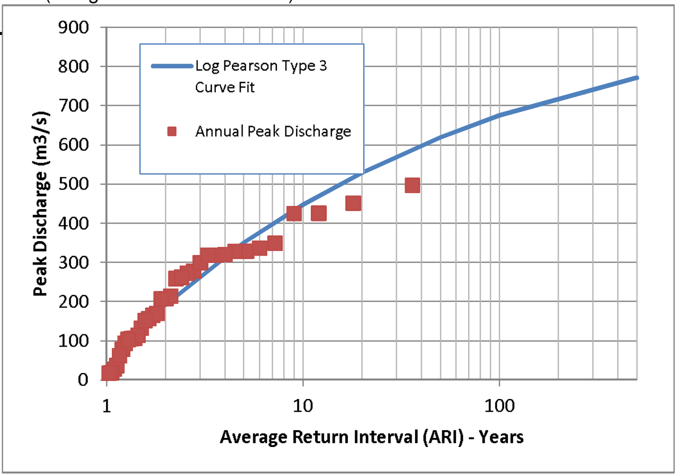
Golder

Catchment Area (km2)	8048	Latitude	-21.9565
Qld NRW WaterShed		Longitude	146.9422
Peak Series Table Report		Distance (k	6.8

*** 120309A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	191
5	349
10	446
20	529
50	620
100	675
500	771



calc'd 100yr regression error	296%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.15	weighted skew	-1.02
selected skew	-1.02	count	35

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)	
19/05/1977	1857	5.58	278.31	2.44	13	2.77	
4/02/1978	1203	7.1	497.06	2.70	1	36.00	
12/03/1979	2233	5.91	318.52	2.50	10	3.60	
15/02/1980	409	2.45	27.66	1.44	33	1.09	
23/01/1981	2222	4.38	156.76	2.20	22	1.64	
5/03/1982	2200	3.48	77.95	1.89	30	1.20	
5/05/1983	1800	6.66	425.4	2.63	4	9.00	
31/01/1984	1100	5.41	258.72	2.41	16	2.25	
7/06/1985	1130	4.48	165.44	2.22	21	1.71	
30/11/1985	1240	4.13	132.5	2.12	24	1.50	
31/01/1987	203	6.14	349.08	2.54	5	7.20	
3/01/1988	600	4.53	169.88	2.23	20	1.80	
21/05/1989	544	3.89	106.23	2.03	26	1.38	
28/03/1990	25	5.99	328.96	2.52	7	5.14	
13/02/1991	2323	5.53	272.64	2.44	14	2.57	
9/02/1992	154	2.9	36.54	1.56	32	1.13	
2/09/1993	2115	2.27	18.38	1.26	34	1.06	
12/03/1994	1700	5.99	328.33	2.52	8	4.50	
26/02/1995	215	4.93	207.98	2.32	18	2.00	
12/01/1996	745	5.92	320.28	2.51	9	4.00	
6/02/1997	645	6.05	336.75	2.53	6	6.00	
3/09/1998	0	3.75	93.46	1.97	29	1.24	
8/01/1999	545	5	214.23	2.33	17	2.12	
26/02/2000	0	5.44	262.29	2.42	15	2.40	
3/02/2001	730	3.89	105.74	2.02	27	1.33	
14/02/2002	1920	2.23	17.67	1.25	35	1.03	
13/02/2003	2000	6.66	425.53	2.63	3	12.00	
19/01/2004	0	4.32	151.6	2.18	23	1.57	
14/02/2005	1730	3.97	113.94	2.06	25	1.44	
2006			103.5455	2.02	28	1.29	unverified daily data
2007			61.62685	1.79	31	1.16	unverified daily data
2008			451.3519	2.65	2	18.00	unverified daily data
2009			206.8778	2.32	19	1.89	unverified daily data
2010			299.3424	2.48	12	3.00	unverified daily data
2011	1730	3.97	318.2605	2.50	11	3.27	unverified daily data

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

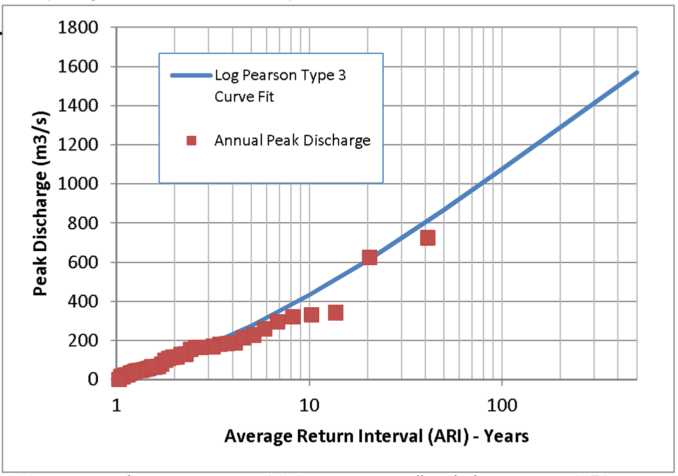
Golder

Catchment Area (km2)	409	Latitude	-22.7975
Qld NRW WaterShed		Longitude	147.5803
Peak Series Table Report		Distance (k	93

*** 130207A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	104
5	276
10	433
20	610
50	868
100	1074
500	1568



calc'd 100yr regression error	-19%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.99	weighted skew	-1.70
selected skew	-0.58	count	40

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
1/12/1965	300	2.93	79.83	1.90	24	1.71
8/11/1966	2200	3.26	99.6	2.00	23	1.78
4/11/1967	500	3.72	130.38	2.12	18	2.28
26/05/1969	2200	4.47	187.78	2.27	10	4.10
24/02/1970	530	4.4	181.97	2.26	12	3.42
30/11/1970	230	4.78	214.48	2.33	9	4.56
11/05/1972	230	3.51	114.82	2.06	21	1.95
10/01/1973	330	2.72	67.89	1.83	25	1.64
14/01/1974	432	7.88	624.73	2.80	2	20.50
30/03/1975	2330	5.66	296.26	2.47	6	6.83
2/02/1976	2230	4.98	228.79	2.36	8	5.13
1/03/1977	358	4.22	163.83	2.21	16	2.56
1/02/1978	552	8.39	725.51	2.86	1	41.00
18/02/1979	420	4.25	169.83	2.23	13	3.15
7/02/1980	2330	2.19	46.64	1.67	31	1.32
2/01/1981	210	4.25	169.83	2.23	13	3.15
13/03/1982	300	1.57	24.39	1.39	37	1.11
28/04/1983	2015	5.9	322.84	2.51	5	8.20
3/12/1983	316	2.1	43.47	1.64	33	1.24
14/11/1984	1950	2.67	65.5	1.82	26	1.58
24/02/1986	701	2.39	53.73	1.73	29	1.41
23/10/1986	316	4.2	164.85	2.22	15	2.73
23/08/1988	815	1.59	25.15	1.40	36	1.14
16/05/1989	1718	3.42	108.92	2.04	22	1.86
15/11/1989	200	1.36	15.86	1.20	39	1.05
7/01/1991	39	4.46	184.57	2.27	11	3.73
18/12/1991	1930	1.35	15.93	1.20	38	1.08
28/02/1993	2045	1.81	33.85	1.53	35	1.17
5/03/1994	330	5.99	332.52	2.52	4	10.25
4/01/1995	1900	2.3	50.49	1.70	30	1.37
9/01/1996	800	6.08	342.61	2.53	3	13.67
3/02/1997	2000	2.5	57.75	1.76	28	1.46
22/04/1998	2320	2.19	46.62	1.67	32	1.28
4/01/1999	200	5.3	260.73	2.42	7	5.86
22/02/2000	900	2.66	64.87	1.81	27	1.52
20/11/2000	430	3.54	115.89	2.06	20	2.05
26/02/2002	2120	0.49	0.36	-0.44	40	1.03
10/02/2003	700	4.07	153.81	2.19	17	2.41
11/01/2004	2252	3.74	129.81	2.11	19	2.16
17/12/2004	530	1.88	36.39	1.56	34	1.21

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

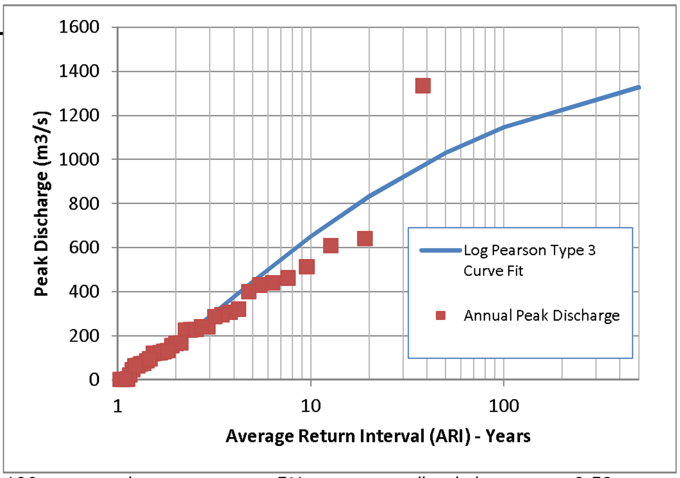
Catchment Area (km2)	758	Latitude	-22.9769
Qld NRW WaterShed		Longitude	147.5839
Peak Series Table Report		Distance (k	114

*** 130208A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	164
5	446
10	650
20	832
50	1030
100	1147
500	1328



calc'd 100yr regression error	-5%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.43	weighted skew	-1.25
selected skew	-1.25	count	37

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
16/12/1965	615	3.26	241.64	2.38	13	2.92
19/01/1967	900	1.25	47.15	1.67	32	1.19
16/02/1968	1200	3.75	307.04	2.49	10	3.80
30/01/1970	2300	3.15	227.91	2.36	16	2.38
21/02/1971	1700	3.14	226.68	2.36	17	2.24
4/12/1971	1300	0.48	4.08	0.61	34	1.12
15/01/1973	1810	1.52	73.14	1.86	29	1.31
14/01/1974	430	5.75	642.61	2.81	2	19.00
30/03/1975	2330	3.85	321.22	2.51	9	4.22
20/01/1976	1930	4.76	463.06	2.67	5	7.60
10/03/1977	1953	3.16	229.14	2.36	15	2.53
2/02/1978	1100	7.8	1335.94	3.13	1	38.00
18/02/1979	500	3.67	295.9	2.47	11	3.45
7/02/1980	1552	3.06	129.28	2.11	22	1.73
23/02/1981	700	2.93	120.62	2.08	25	1.52
2/02/1982	1401	3.45	155.94	2.19	20	1.90
2/05/1983	2312	6.59	610.89	2.79	3	12.67
3/12/1983	547	5.57	440.91	2.64	6	6.33
3/06/1985	1856	2.96	74.78	1.87	28	1.36
13/11/1985	724	4.56	287.98	2.46	12	3.17
30/01/1987	546	3.34	122.17	2.09	24	1.58
23/08/1988	1130	2.87	65.34	1.82	30	1.27
16/05/1989	1705	5.51	431.23	2.63	7	5.43
26/03/1990	618	3.63	166.16	2.22	19	2.00
5/01/1991	0	3.06	85.95	1.93	27	1.41
16/10/1991	615	2.01	2.22	0.35	36	1.06
31/08/1993	900	2	2.15	0.33	37	1.03
8/03/1994	315	6.01	514.28	2.71	4	9.50
5/02/1995	915	2.4	22.77	1.36	33	1.15
9/01/1996	230	2.86	64.33	1.81	31	1.23
14/02/1997	515	3.64	167.66	2.22	18	2.11
29/08/1998	1645	3.35	124.15	2.09	23	1.65
31/01/1999	845	3.14	96.07	1.98	26	1.46
22/02/2000	900	4.22	241.52	2.38	14	2.71
20/11/2000	415	3.42	133.72	2.13	21	1.81
5/08/2003	1220	2.06	2.68	0.43	35	1.09
15/01/2004	840	5.32	401.28	2.60	8	4.75

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

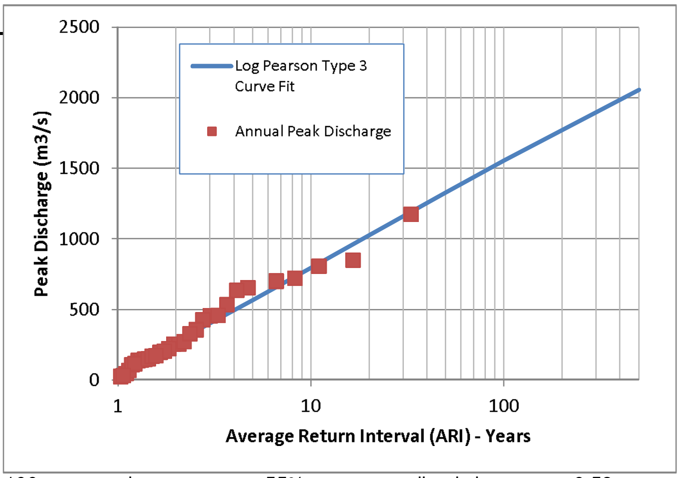
Catchment Area (km2)	4421	Latitude	-23.1856
Qld NRW WaterShed		Longitude	147.8948
Peak Series Table Report		Distance (k	135

*** 130210A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	272
5	567
10	794
20	1024
50	1330
100	1557
500	2057



calc'd 100yr regression error	55%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.60	weighted skew	-0.60
selected skew	-0.60	count	32

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
14/01/1973	1600	5.29	137.99	2.14	26	1.27
21/12/1973	400	10.85	849.68	2.93	2	16.50
1/04/1975	1530	9.37	533.72	2.73	9	3.67
22/01/1976	400	10.21	701.24	2.85	5	6.60
12/03/1977	329	9.99	654.51	2.82	7	4.71
2/02/1978	1625	11.99	1173.93	3.07	1	33.00
13/03/1979	2300	5.37	141.38	2.15	25	1.32
12/02/1980	0	2.83	45.9	1.66	30	1.10
8/02/1981	1508	5.5	146.92	2.17	24	1.38
3/02/1982	411	3.48	67.6	1.83	29	1.14
22/05/1983	130	10.21	701.24	2.85	5	6.60
3/12/1983	1953	7.15	255.11	2.41	17	1.94
4/06/1985	830	6.43	196.36	2.29	20	1.65
26/11/1985	2359	4.55	107.71	2.03	28	1.18
31/01/1987	647	7.15	255.41	2.41	16	2.06
24/08/1988	300	4.64	115.49	2.06	27	1.22
18/05/1989	1250	8.91	454.53	2.66	11	3.00
26/03/1990	2223	6.76	222.67	2.35	18	1.83
10/02/1991	715	8.75	428.09	2.63	12	2.75
16/11/1991	2200	2.07	24.7	1.39	32	1.03
3/03/1993	158	2.58	31.58	1.50	31	1.06
9/03/1994	200	10.67	807.26	2.91	3	11.00
23/02/1995	1515	5.53	150.28	2.18	23	1.43
10/01/1996	1315	9.9	635.53	2.80	8	4.13
27/02/1997	1845	6.52	203.8	2.31	19	1.74
31/08/1998	1730	8.93	457.98	2.66	10	3.30
4/01/1999	2145	10.3	721.37	2.86	4	8.25
23/02/2000	330	7.35	272.84	2.44	15	2.20
21/11/2000	150	8.2	355.85	2.55	13	2.54
12/02/2003	1050	5.98	168.52	2.23	22	1.50
16/01/2004	345	7.93	328	2.52	14	2.36
11/02/2005	1015	6.1	173.28	2.24	21	1.57

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

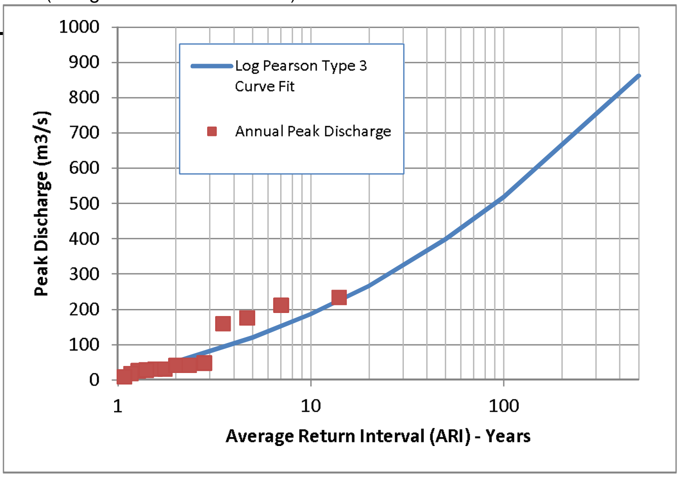
Catchment Area (km2)	438	Latitude	-22.6725
Qld NRW WaterShed		Longitude	147.7261
Peak Series Table Report		Distance (k	77

*** 130211A&B 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	51
5	120
10	186
20	266
50	399
100	518
500	863



calc'd 100yr regression error	29%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.29	weighted skew	-0.09
selected skew	-0.09	count	13

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
14/01/1973	400	1.7	26.11	1.42	11	1.27
9/01/1974	520	3.76	176.08	2.25	3	4.67
10/01/1975	800	3.64	159.72	2.20	4	3.50
2/02/1978	634	4	212.03	2.33	2	7.00
12/03/1979	0	1.84	31.07	1.49	9	1.56
7/02/1980	31	1.85	31.44	1.50	8	1.75
20/01/1981	0	2.09	41.02	1.61	7	2.00
21/01/1982	30	1.45	18.22	1.26	12	1.17
1/05/1983	1700	4.13	233.99	2.37	1	14.00
14/11/1983	2004	2.07	41.16	1.61	6	2.33
11/12/1984	900	1.73	28.19	1.45	10	1.40
24/02/1986	1220	2.23	47.87	1.68	5	2.80
29/01/1987	2000	1.09	8.95	0.95	13	1.08

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

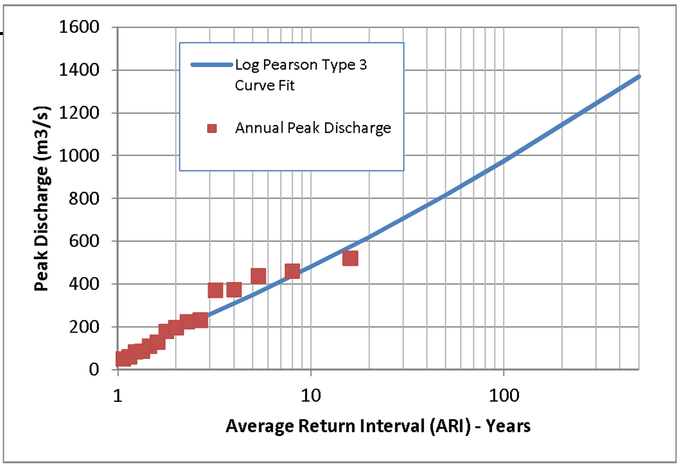
Catchment Area (km2)	1108	Latitude	-23.8364
Qld NRW WaterShed		Longitude	147.595
Peak Series Table Report		Distance (k	205

*** 130212A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	187
5	350
10	480
20	618
50	816
100	976
500	1371



calc'd 100yr regression error	55%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.21	weighted skew	-0.36
selected skew	-0.21	count	15

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
9/01/1974	300	6	178.69	2.25	9	1.78
19/03/1975	900	4.8	86.61	1.94	12	1.33
23/12/1975	130	7.55	371.06	2.57	5	3.20
11/03/1977	1500	8.09	461.04	2.66	2	8.00
2/02/1978	134	8.41	520.67	2.72	1	16.00
27/12/1978	1047	4	50.84	1.71	15	1.07
11/02/1980	1024	6.51	231.98	2.37	6	2.67
22/05/1981	1557	6.44	224.11	2.35	7	2.29
3/03/1982	1201	4.25	59.92	1.78	14	1.14
3/05/1983	900	7.56	374.32	2.57	4	4.00
30/01/1984	1815	7.96	438.2	2.64	3	5.33
16/12/1984	806	5.16	109.71	2.04	11	1.45
6/12/1985	38	4.74	83.09	1.92	13	1.23
31/01/1987	1311	6.18	196.45	2.29	8	2.00
1/03/1988	618	5.43	129.5	2.11	10	1.60

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

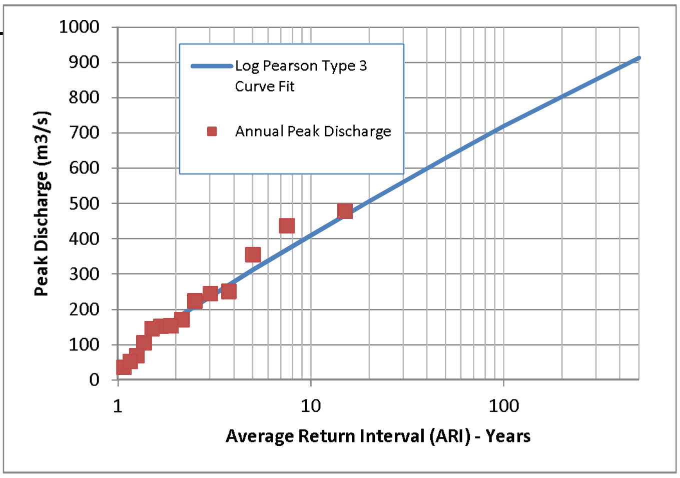
Catchment Area (km2)	1498	Latitude	-24.4753
Qld NRW WaterShed		Longitude	147.1431
Peak Series Table Report		Distance (k	275

*** 130213A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	173
5	312
10	411
20	507
50	630
100	720
500	913



calc'd 100yr regression error	26%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.51	weighted skew	-0.54
selected skew	-0.54	count	14

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
9/01/1974	1100	7.51	479.07	2.68	1	15.00
4/01/1975	530	5.8	251.52	2.40	4	3.75
26/01/1976	14	5.15	170.87	2.23	7	2.14
11/03/1977	1600	6.66	355.53	2.55	3	5.00
10/07/1978	1855	5	152.46	2.18	9	1.67
27/12/1978	749	5.01	153.64	2.19	8	1.88
11/02/1980	56	3.43	35.49	1.55	14	1.07
28/05/1981	556	7.24	437.54	2.64	2	7.50
2/03/1982	757	4.94	145.51	2.16	10	1.50
3/05/1983	301	5.74	245.02	2.39	5	3.00
29/01/1984	1203	5.54	224.07	2.35	6	2.50
19/12/1984	1840	4.55	105.75	2.02	11	1.36
5/02/1986	924	4.08	68.99	1.84	12	1.25
30/11/1986	958	3.81	52.62	1.72	13	1.15

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

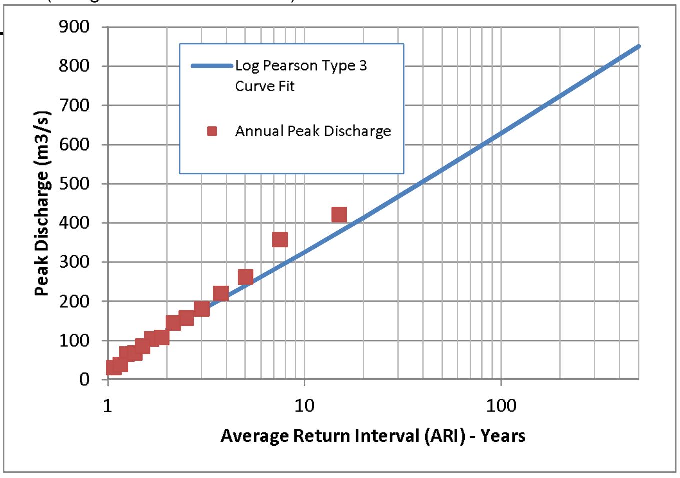
Catchment Area (km2)	401	Latitude	-23.4411
Qld NRW WaterShed		Longitude	147.9622
Peak Series Table Report		Distance (k	210

*** 130214A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	129
5	240
10	325
20	413
50	535
100	629
500	851



calc'd 100yr regression error	16%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.17	weighted skew	-0.34
selected skew	-0.34	count	14

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
28/01/1974	800	6.95	421.83	2.63	1	15.00
25/02/1975	2230	5.95	157.55	2.20	6	2.50
20/01/1976	1000	6.62	221	2.34	4	3.75
11/03/1977	245	6.22	181	2.26	5	3.00
1/02/1978	1307	7.68	357.31	2.55	2	7.50
18/02/1979	1150	5.2	104.13	2.02	9	1.67
7/01/1980	438	3.35	30.9	1.49	14	1.07
22/05/1981	131	5.8	144.75	2.16	7	2.14
29/11/1981	1220	4.36	65.46	1.82	12	1.25
2/05/1983	1300	6.98	262.56	2.42	3	5.00
27/07/1984	900	5.3	107.98	2.03	8	1.88
4/06/1985	230	4.43	68.08	1.83	11	1.36
5/12/1985	900	4.83	85.56	1.93	10	1.50
30/01/1987	2004	3.65	38.59	1.59	13	1.15

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

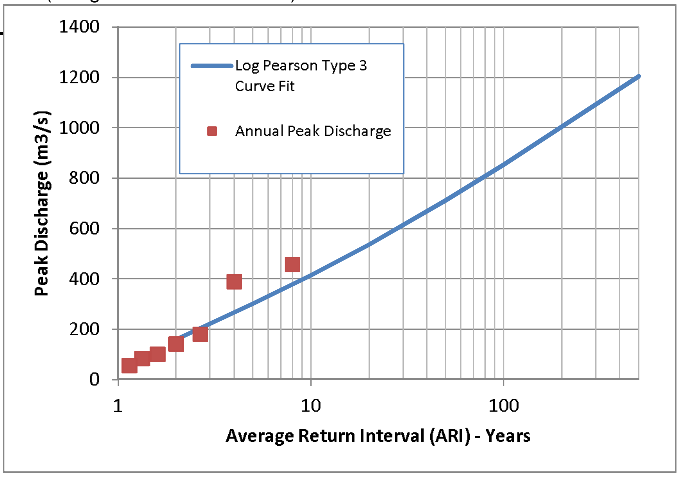
Catchment Area (km2)	563	Latitude	-24.4753
Qld NRW WaterShed		Longitude	147.1431
Peak Series Table Report		Distance (k	118

*** 130218A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	159
5	301
10	414
20	536
50	711
100	853
500	1205



calc'd 100yr regression error	20%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.33	weighted skew	-0.21
selected skew	-0.21	count	7

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
8/03/1985	1031	4.14	181.27	2.26	3	2.67
13/11/1985	505	6.24	458.04	2.66	1	8.00
30/01/1987	400	3.28	100.55	2.00	5	1.60
30/12/1987	430	3.08	84.29	1.93	6	1.33
16/05/1989	1347	5.79	389.34	2.59	2	4.00
25/03/1990	1814	3.74	141.75	2.15	4	2.00
5/01/1991	651	2.68	56	1.75	7	1.14

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

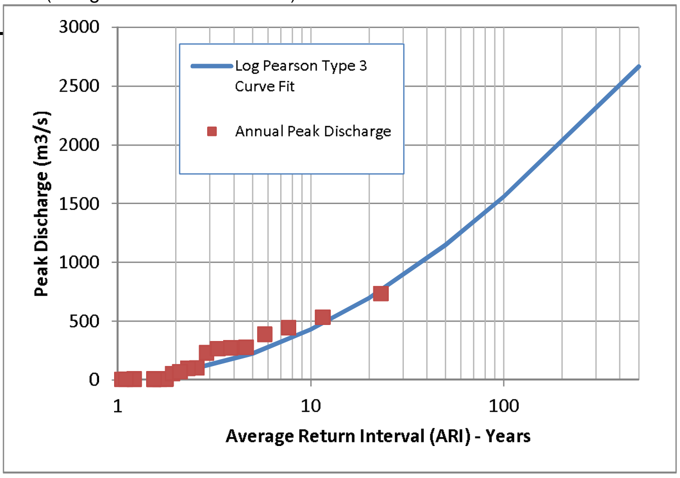
Catchment Area (km2)	551	Latitude	-21.62916517
Qld NRW WaterShed		Longitude	148.1219
Peak Series Table Report		Distance (k	47

*** 130402A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	56
5	225
10	427
20	696
50	1149
100	1558
500	2667



calc'd 100yr regression error	-38%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.11	weighted skew	-0.11
selected skew	-0.58	count	22

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
15/10/1964	1200	2.07	7.67	0.88	15	1.53
26/01/1966	200	3.75	7.68	0.89	14	1.64
9/12/1966	2330	1.72	7.66	0.88	19	1.21
8/12/1967	2300	0.93	7.66	0.88	19	1.21
19/01/1970	1800	5.3	7.69	0.89	13	1.77
21/02/1971	700	2.1	7.67	0.88	15	1.53
24/12/1971	2100	3.23	7.67	0.88	15	1.53
14/09/1973	727	2	7.67	0.88	15	1.53
29/01/1974	401	6.2	534.37	2.73	2	11.50
14/01/1975	100	4.4	231.17	2.36	8	2.88
20/01/1976	642	4.66	266.33	2.43	7	3.29
15/05/1977	1959	2.52	56.14	1.75	12	1.92
31/01/1978	1259	5.44	389.03	2.59	4	5.75
10/03/1979	317	7.08	735.91	2.87	1	23.00
7/01/1980	1200	1.29	5.07	0.71	22	1.05
20/01/1981	334	4.69	273.2	2.44	6	3.83
23/01/1982	115	1.34	6.58	0.82	21	1.10
21/05/1983	219	5.73	445.1	2.65	3	7.67
1/12/1983	2345	2.98	103.46	2.01	9	2.56
13/03/1985	319	2.92	98.6	1.99	10	2.30
23/10/1985	1115	2.54	70.47	1.85	11	2.09
24/01/1987	2203	4.64	278.43	2.44	5	4.60

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

Golder

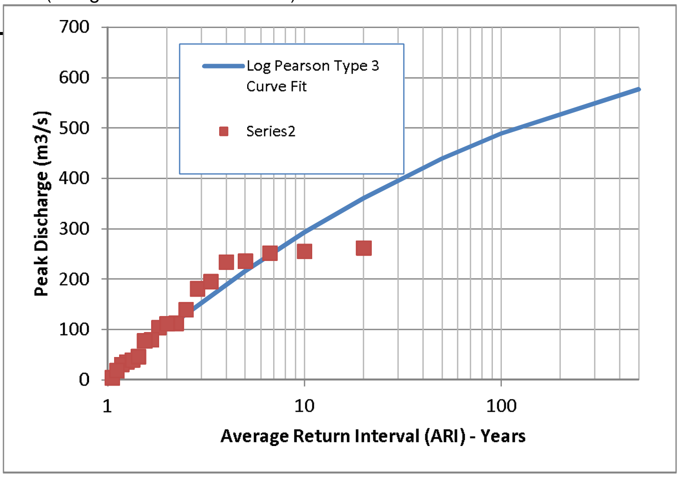
Catchment Area (km2)	344	Latitude	-22.5192
Qld NRW WaterShed		Longitude	148.3106
Peak Series Table Report		Distance (k	58

*** 130409A 100 140 Type=A

Phillips Creek Tayglen

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	103
5	216
10	293
20	361
50	439
100	489
500	577



calc'd 100yr regression error	29%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.23	weighted skew	-1.01
selected skew	-1.01	count	19

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
20/12/1968	400	1.98	35.77	1.55	16	1.25
16/12/1969	2330	4.56	235.94	2.37	4	5.00
5/02/1971	500	4.82	262.17	2.42	1	20.00
19/02/1972	200	3.05	104.03	2.02	11	1.82
22/01/1973	1900	1.87	30.85	1.49	17	1.18
25/08/1974	2200	1.12	4.41	0.64	19	1.05
26/02/1975	2345	4.54	233.97	2.37	5	4.00
20/01/1976	730	3.97	180.9	2.26	7	2.86
10/03/1977	1840	3.15	112.35	2.05	9	2.22
2/02/1978	1415	3.47	139.28	2.14	8	2.50
21/12/1978	2119	4.13	195.2	2.29	6	3.33
7/02/1980	37	1.59	18.79	1.27	18	1.11
8/02/1981	211	3.14	111.5	2.05	10	2.00
21/01/1982	800	2.06	39.59	1.60	15	1.33
1/05/1983	1216	4.75	254.99	2.41	2	10.00
14/11/1983	2350	4.72	251.93	2.40	3	6.67
11/12/1984	935	2.73	79.66	1.90	12	1.67
24/02/1986	1111	2.7	77.55	1.89	13	1.54
29/01/1987	500	2.19	46.22	1.66	14	1.43

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

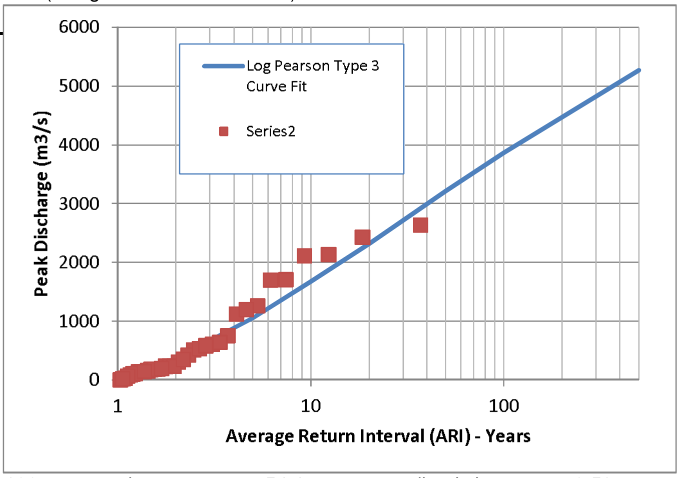
Golder

Catchment Area (km2)	4092	Latitude	-22.1742
Qld NRW WaterShed		Longitude	148.3811
Peak Series Table Report		Distance (k	39

*** 130410A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	369
5	1058
10	1669
20	2323
50	3208
100	3865
500	5265



calc'd 100yr regression error	-54%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.89	weighted skew	-0.82
selected skew	-0.82	count	36

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
11/10/1968	2300	1.45	2.71	0.43	36	1.03
20/01/1970	900	5.88	511.34	2.71	15	2.47
9/02/1971	100	3.07	101.62	2.01	31	1.19
19/02/1972	1020	3.79	187.69	2.27	23	1.61
19/02/1973	1100	4.13	232.5	2.37	21	1.76
29/01/1974	1620	8.97	1260.83	3.10	7	5.29
10/01/1975	1422	5.35	423.89	2.63	16	2.31
21/01/1976	100	6	533.18	2.73	14	2.64
16/05/1977	635	3.53	156.25	2.19	26	1.42
1/02/1978	646	10.16	1702.76	3.23	6	6.17
11/03/1979	410	10.82	2113.38	3.32	4	9.25
8/02/1980	459	3.74	178.7	2.25	25	1.48
7/02/1981	937	6.43	608.01	2.78	12	3.08
24/01/1982	200	2.85	83.35	1.92	32	1.16
21/05/1983	1217	8.56	1123.86	3.05	9	4.11
2/12/1983	1400	4.66	307.33	2.49	18	2.06
14/03/1985	15	3.37	137.16	2.14	29	1.28
5/12/1985	826	3.42	142.44	2.15	28	1.32
29/01/1987	1408	3.78	183.54	2.26	24	1.54
2/03/1988	1456	11.43	2638.23	3.42	1	37.00
6/04/1989	419	10.85	2137.31	3.33	3	12.33
28/03/1990	2009	4.17	234.72	2.37	20	1.85
8/01/1991	1227	11.2	2429.43	3.39	2	18.50
20/12/1991	1800	3.09	110.25	2.04	30	1.23
5/03/1994	745	7.18	752.78	2.88	10	3.70
11/03/1995	245	2.1	30.05	1.48	34	1.09
5/01/1996	2215	4.18	235.8	2.37	19	1.95
28/02/1997	1600	8.79	1197.74	3.08	8	4.63
30/08/1998	730	10.17	1706.19	3.23	5	7.40
4/01/1999	1600	6.28	581.09	2.76	13	2.85
22/02/2000	645	3.43	143.92	2.16	27	1.37
29/12/2000	1730	6.59	637.86	2.80	11	3.36
18/01/2002	715	2.67	67.6	1.83	33	1.12
2/03/2003	1100	3.86	194.7	2.29	22	1.68
13/12/2003	1450	4.91	349.68	2.54	17	2.18
8/01/2005	1010	1.84	20.14	1.30	35	1.06

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

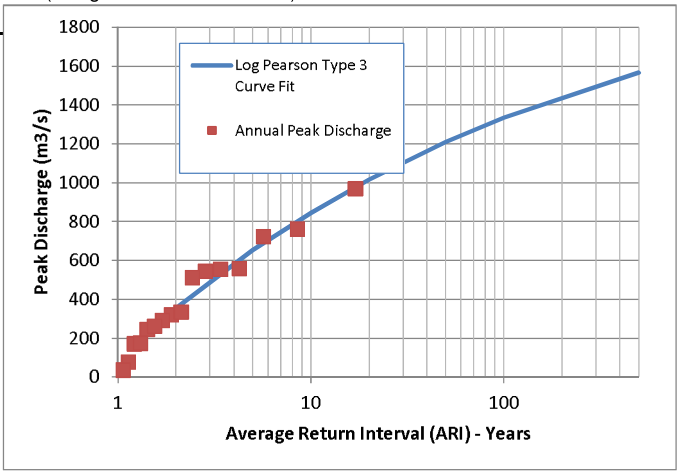
Golder

Catchment Area (km2)	1306	Latitude	-21.8389
Qld NRW WaterShed		Longitude	148.5308
Peak Series Table Report		Distance (k	53

*** 130411A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	354
5	653
10	845
20	1016
50	1210
100	1337
500	1567



calc'd 100yr regression error	8%	generalised skew	-0.58
calc'd station skew of log peak discharge	-1.11	weighted skew	-0.91
selected skew	-0.91	count	16

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
16/01/1973	830	4.76	77.19	1.89	15	1.13
2/03/1974	427	10.5	543.93	2.74	6	2.83
29/12/1974	1233	7.65	245.23	2.39	12	1.42
6/03/1976	1130	10.58	555.07	2.74	5	3.40
10/03/1977	1429	8.52	320.05	2.51	9	1.89
1/02/1978	641	10.61	559.25	2.75	4	4.25
10/03/1979	1300	11.92	762.4	2.88	2	8.50
7/01/1980	2043	10.26	511.83	2.71	7	2.43
7/02/1981	424	8.68	335.07	2.53	8	2.13
23/01/1982	1253	3.42	35.73	1.55	16	1.06
20/05/1983	2350	11.69	723.96	2.86	3	5.67
3/12/1983	1100	6.6	171.04	2.23	14	1.21
13/03/1985	926	8.2	291.23	2.46	10	1.70
5/12/1985	2000	7.85	261.44	2.42	11	1.55
25/01/1987	803	6.67	174.23	2.24	13	1.31
2/03/1988	1155	13.05	969.13	2.99	1	17.00

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

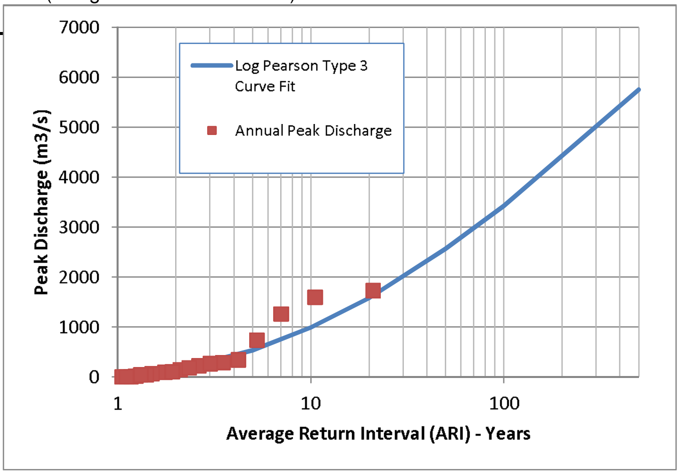
Golder

Catchment Area (km2)	1214	Latitude	-21.8555
Qld NRW WaterShed		Longitude	147.9726
Peak Series Table Report		Distance (k	14

*** 130414A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	139
5	533
10	988
20	1580
50	2559
100	3430
500	5754



calc'd 100yr regression error	-68%	generalised skew	-0.58
calc'd station skew of log peak discharge	-0.38	weighted skew	-0.45
selected skew	-0.58	count	20

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
2/12/1983	508	2.08	147.09	2.17	10	2.10
13/03/1985	814	1.68	98.06	1.99	12	1.75
23/10/1985	1235	2.68	98.06	1.99	12	1.75
25/01/1987	232	3.59	224.84	2.35	8	2.63
2/03/1988	330	8.59	1597.66	3.20	2	10.50
5/04/1989	1430	7.61	1264.66	3.10	3	7.00
20/11/1989	800	3.35	184.96	2.27	9	2.33
8/01/1991	30	8.88	1733.91	3.24	1	21.00
20/12/1991	445	2.8	104.48	2.02	11	1.91
11/01/1993	1545	1.82	3.25	0.51	20	1.05
5/03/1994	630	2.51	65.93	1.82	14	1.50
9/02/1995	2145	1.96	8.47	0.93	18	1.17
2/12/1995	1130	2.38	48.78	1.69	15	1.40
28/02/1997	849	5.83	739.24	2.87	4	5.25
30/08/1998	415	3.9	291.89	2.47	6	3.50
4/01/1999	630	3.78	267.67	2.43	7	3.00
19/12/1999	1000	1.94	22.52	1.35	17	1.24
29/12/2000	830	4.15	346.35	2.54	5	4.20
4/01/2002	545	1.5	6.18	0.79	19	1.11
19/11/2004	100	2.28	47.03	1.67	16	1.31

Log Pearson Type 3 Fit using Qld NRW WaterShed Peak Series Data

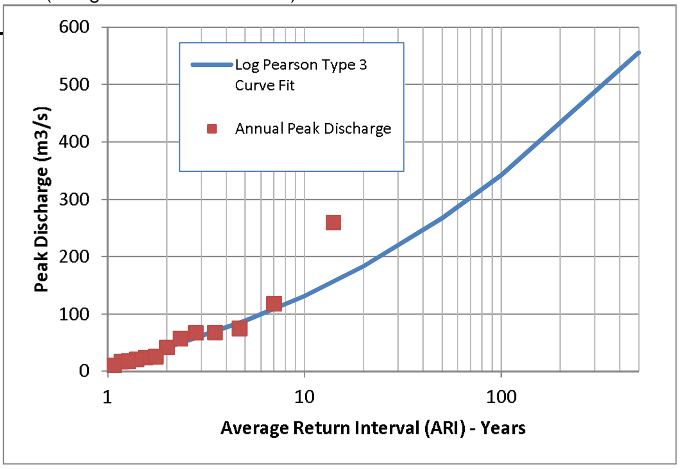
Golder

Catchment Area (km2)	388	Latitude	-22.7136
Qld NRW WaterShed		Longitude	148.3863933
Peak Series Table Report		Distance (k	81

*** 130415A 100 140 Type=A

Log Pearson Type 3 Curve Fit (using selected skew below)

ARI (years)	(m3/s)
2	41
5	88
10	131
20	183
50	267
100	342
500	556



calc'd 100yr regression error	123%	generalised skew	-0.58
calc'd station skew of log peak discharge	0.45	weighted skew	0.00
selected skew	0.00	count	13

Date	Time (hr)	Stage	Annual Peak Discharge (m3/s)	log - annual peak discharge	rank	weibull plotting position - ARI (years)
28/12/1974	1230	3.13	67.69	1.83	4	3.50
15/02/1976	515	2.44	41.46	1.62	7	2.00
28/02/1977	514	3.12	67.28	1.83	5	2.80
1/02/1978	1030	4.11	117.9	2.07	2	7.00
10/03/1979	2247	1.9	24.29	1.39	9	1.56
7/02/1980	239	1.96	25.49	1.41	8	1.75
19/01/1981	2152	3.31	74.87	1.87	3	4.67
22/01/1982	107	1.64	16.97	1.23	12	1.17
4/05/1983	2341	5.97	259.93	2.41	1	14.00
14/11/1983	1825	1.81	20.98	1.32	10	1.40
4/01/1985	2352	1.36	10.43	1.02	13	1.08
23/10/1985	650	1.68	17.71	1.25	11	1.27
29/01/1987	715	2.9	57.14	1.76	6	2.33

APPENDIX C

Rational Method Calculations

Rational Method Calculatins
Carmichael Mine - Railway

$Q = C I A / 360$
$C = Fy * C10$, see attached ref. Assume medium density bush with low permeability soil.
Bransby Williams: $t=58.5*L/(A^{0.1*} Se^{0.2})$ - A (km^2), Se (m/km), L (km)

Crossing Chainage, km	area, km²	A, catchment area, ha	Catchment U/S Elevation	Catchment D/S Elevation	Catchment drainage length, km	Catchment slope	Se, Catchment slope, m/km	t, time of concentration, min	I10, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I50, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I100, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	C10, runoff coefficient, see attached reference	C50, calc'd runoff coefficient dependent upon ARI	C100, calc'd runoff coefficient dependent upon ARI	50 yr ARI flow, m3/s	100 yr ARI flow, m3/s
												Frequency Factor ->	1.15	1.20		
1.7	4.10	410	252.0	227.0	2.9	0.9%	9	94	43	59	65	0.40	0.46	0.48	32.1	35.8
7.8	12.52	1252	231.8	218.0	6.1	0.2%	2	238	22	30	33	0.40	0.46	0.48	49.3	55.2
9.0	2.16	216	220.0	216.3	1.9	0.2%	2	90	45	60	67	0.40	0.46	0.48	17.4	19.4
17.1	36.50	3650	230.0	210.0	8.3	0.2%	2	284	19	26	29	0.40	0.46	0.48	125.1	140.1
18.8	2.71	271	228.0	210.0	2.5	0.7%	7	90	44	60	67	0.40	0.46	0.48	21.8	24.3
21.1	4.16	416	217.5	209.0	2.0	0.4%	4	78	49	67	74	0.49	0.56	0.59	45.2	50.4
42.1	5.02	502	216.5	198.0	3.3	0.6%	6	115	38	51	57	0.40	0.46	0.48	34.2	38.1
44.1	1.13	113	210.5	200.0	1.3	0.8%	8	47	67	91	102	0.70	0.81	0.84	24.1	26.8
47.3	59.67	5967	228.0	196.0	13.1	0.2%	2	424	14	19	21	0.40	0.46	0.48	151.4	169.8
53.6	27.86	2786	230.0	196.0	8.7	0.4%	4	276	19	26	29	0.40	0.46	0.48	97.7	109.4
56.6	1.31	131	206.0	196.2	1.3	0.7%	7	50	65	89	99	0.70	0.81	0.84	27.1	30.2
57.3	1.05	105	202.0	194.0	1.4	0.6%	6	58	60	81	91	0.70	0.81	0.84	19.9	22.2
58.2	1.46	146	202.0	194.0	1.4	0.6%	6	55	62	84	94	0.70	0.81	0.84	28.7	31.9
70.2	21.90	2190	260.0	202.0	6.6	0.9%	9	182	27	36	40	0.40	0.46	0.48	105.6	118.1
74.1	3.34	334	228.0	216.2	3.0	0.4%	4	117	37	50	56	0.40	0.46	0.48	22.5	25.1
75.5	0.76	76	230.0	218.0	1.5	0.8%	8	59	59	80	89	0.66	0.76	0.79	13.4	15.0
76.0	0.93	93	230.0	218.0	1.5	0.8%	8	58	60	81	90	0.66	0.76	0.79	16.7	18.6
76.8	17.71	1771	249.7	218.0	5.6	0.6%	6	175	27	37	42	0.40	0.46	0.48	88.0	98.3
77.7	6.62	662	262.0	222.5	3.9	1.0%	10	119	37	50	56	0.40	0.46	0.48	43.9	49.0
80.4	5.58	558	266.0	224.0	3.8	1.1%	11	117	37	50	56	0.40	0.46	0.48	37.5	41.9
82.3	1.44	144	242.0	224.0	2.3	0.8%	8	88	45	61	68	0.49	0.56	0.59	14.4	16.1
83.3	8.46	846	274.0	223.7	5.8	0.9%	9	179	27	37	41	0.40	0.46	0.48	41.3	46.2
85.4	109.70	10970	234.6	213.4	11.8	0.2%	2	383	15	21	23	0.40	0.46	0.48	299.9	336.3
87.6	2.15	215	221.8	214.3	2.3	0.3%	3	100	41	56	63	0.40	0.46	0.48	16.0	17.9

Rational Method Calculatins

Carmichael Mine - Railway

Q = C I A / 360

*C = Fy * C10, see attached ref. Assume medium density bush with low permeability soil.*

Bransby Williams: $t=58.5*L/(A^{0.1*}Se^{0.2})$ *- A* (km^2)*, Se (m/km), L (km)*

Crossing Chainage, km	area, km²	A, catchment area, ha	Catchment U/S Elevation	Catchment D/S Elevation	Catchment drainage length, km	Catchment slope	Se, Catchment slope, m/km	t, time of concentration, min	I10, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I50, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I100, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	C10, runoff coefficient, see attached reference	C50, calc'd runoff coefficient dependent upon ARI	C100, calc'd runoff coefficient dependent upon ARI	50 yr ARI flow, m3/s	100 yr ARI flow, m3/s
												Frequency Factor ->	1.15	1.20		
91.0	6.69	669	222.0	212.5	4.0	0.2%	2	163	29	39	44	0.40	0.46	0.48	35.2	39.3
93.4	99.36	9936	274.0	210.0	16.0	0.4%	4	449	13	18	20	0.40	0.46	0.48	241.9	271.4
94.4	42.80	4280	286.0	210.0	11.6	0.7%	7	319	17	24	26	0.40	0.46	0.48	134.2	150.4
98.2	0.63	63	223.5	215.5	1.1	0.7%	7	45	69	94	105	0.70	0.81	0.84	13.8	15.4
99.2	1.08	108	223.5	215.5	1.3	0.6%	6	52	64	86	96	0.70	0.81	0.84	21.7	24.2
100.4	10.81	1081	228.5	212.0	6.2	0.3%	3	234	22	30	33	0.40	0.46	0.48	43.1	48.2
101.2	1.66	166	214.0	213.1	1.7	0.1%	1	110	39	53	59	0.40	0.46	0.48	11.7	13.0
102.1	0.39	39	213.6	213.1	0.9	0.1%	1	65	56	76	84	0.66	0.76	0.79	6.5	7.3
104.2	1.74	174	214.0	213.4	2.2	0.0%	0	158	30	40	45	0.40	0.46	0.48	9.4	10.5
107.0	3.85	385	216.7	214.0	2.5	0.1%	1	126	35	48	53	0.40	0.46	0.48	24.6	27.4
110.5	30.10	3010	222.3	212.0	9.7	0.1%	1	398	15	20	22	0.40	0.46	0.48	80.0	89.8
112.5	12.50	1250	218.0	214.0	5.5	0.1%	1	266	20	27	30	0.40	0.46	0.48	45.1	50.5
115.8	9.87	987	212.0	210.0	2.1	0.1%	1	99	42	57	63	0.40	0.46	0.48	74.6	83.2
125.5	1.20	120	220.0	217.0	1.6	0.2%	2	78	49	67	74	0.49	0.56	0.59	13.0	14.5
129.6	0.31	31	226.0	222.0	0.7	0.6%	6	33	83	112	125	0.70	0.81	0.84	8.0	8.9
130.3	0.41	41	226.0	224.0	1.0	0.2%	2	59	60	81	90	0.66	0.76	0.79	7.3	8.2
131.4	3.92	392	228.0	224.0	2.2	0.2%	2	100	41	56	63	0.40	0.46	0.48	29.3	32.7
133.7	5.42	542	232.0	224.0	3.7	0.2%	2	155	30	41	46	0.40	0.46	0.48	29.5	33.0
135.0	2.04	204	234.7	224.0	2.2	0.5%	5	87	45	62	69	0.49	0.56	0.59	20.5	22.9
136.4	14.44	1444	235.0	224.0	4.3	0.3%	3	158	30	40	45	0.40	0.46	0.48	77.5	86.6
138.2	0.57	57	240.5	232.0	0.6	1.5%	15	21	104	141	158	0.70	0.81	0.84	18.7	20.9
139.4	0.31	31	253.7	242.5	1.0	1.1%	11	41	74	100	111	0.70	0.81	0.84	7.3	8.1
140.7	0.37	37	260.7	259.0	0.7	0.2%	2	40	75	101	113	0.70	0.81	0.84	8.7	9.7
141.2	0.20	20	260.0	258.4	0.3	0.6%	6	14	124	170	190	0.70	0.81	0.84	7.7	8.6

Rational Method Calculatins

Carmichael Mine - Railway

Q = C I A / 360

*C = Fy * C10, see attached ref. Assume medium density bush with low permeability soil.*

Bransby Williams: $t=58.5 \cdot L/(A^{0.1} \cdot Se^{0.2})$ *- A (km²), Se (m/km), L (km)*

Crossing Chainage, km	area, km²	A, catchment area, ha	Catchment U/S Elevation	Catchment D/S Elevation	Catchment drainage length, km	Catchment slope	Se, Catchment slope, m/km	t, time of concentration, min	I10, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I50, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I100, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	C10, runoff coefficient, see attached reference	C50, calc'd runoff coefficient dependent upon ARI	C100, calc'd runoff coefficient dependent upon ARI	50 yr ARI flow, m3/s	100 yr ARI flow, m3/s
												Frequency Factor ->	1.15	1.20		
142.6	1.05	105	258.0	254.7	0.6	0.5%	5	26	93	127	141	0.70	0.81	0.84	31.1	34.6
143.6	0.35	35	258.0	256.0	0.6	0.3%	3	31	87	118	131	0.70	0.81	0.84	9.6	10.7
144.2	0.36	36	258.0	256.0	0.6	0.3%	3	31	87	118	131	0.70	0.81	0.84	10.0	11.1
146.6	0.27	27	264.0	261.9	0.8	0.3%	3	44	70	96	106	0.70	0.81	0.84	6.1	6.8
147.6	0.41	41	264.5	262.0	0.7	0.4%	4	35	81	109	122	0.70	0.81	0.84	10.4	11.5
149.3	4.39	439	266.0	258.7	2.7	0.3%	3	112	38	52	58	0.40	0.46	0.48	30.5	34.0
150.7	1.45	145	266.0	262.5	1.4	0.3%	3	63	57	77	86	0.66	0.76	0.79	24.5	27.3
154.6	2.85	285	266.0	264.5	2.1	0.1%	1	118	37	50	56	0.40	0.46	0.48	19.0	21.2
155.0	1.99	199	266.0	264.4	1.7	0.1%	1	93	44	59	66	0.40	0.46	0.48	15.7	17.5
157.1	3.30	330	267.7	264.0	1.9	0.2%	2	84	47	64	71	0.49	0.56	0.59	34.2	38.1
158.6	2.81	281	266.3	262.0	2.2	0.2%	2	104	40	55	61	0.40	0.46	0.48	20.5	22.9
159.1	5.98	598	272.0	262.0	3.2	0.3%	3	126	35	48	53	0.40	0.46	0.48	38.1	42.5
160.8	0.77	77	270.8	266.0	1.1	0.4%	4	49	66	89	100	0.70	0.81	0.84	16.0	17.8
162.1	16.45	1645	288.0	264.9	6.7	0.3%	3	229	22	30	34	0.40	0.46	0.48	66.6	74.5
165.8	20.50	2050	362.0	276.7	9.3	0.9%	9	257	20	28	31	0.40	0.46	0.48	75.9	85.0
168.6	0.60	60	299.0	290.5	1.6	0.5%	5	71	53	71	80	0.58	0.67	0.70	8.3	9.3
170.6	0.33	33	325.2	314.0	0.9	1.2%	12	35	80	108	120	0.70	0.81	0.84	8.4	9.4
172.0	2.13	213	406.0	316.0	1.4	6.4%	64	33	83	113	125	0.70	0.81	0.84	56.1	62.5
173.6	0.88	88	398.0	331.0	1.1	6.0%	60	29	89	120	134	0.70	0.81	0.84	24.6	27.4
174.1	0.16	16	419.0	335.3	0.6	14.8%	148	15	120	165	184	0.70	0.81	0.84	6.1	6.8
174.7	0.37	37	416.6	337.0	0.6	13.7%	137	14	123	168	188	0.70	0.81	0.84	14.4	16.1
175.3	2.45	245	396.0	338.0	1.4	4.1%	41	36	80	108	120	0.70	0.81	0.84	61.7	68.7
176.7	0.22	22	374.0	360.8	0.7	1.9%	19	26	94	128	143	0.70	0.81	0.84	6.5	7.2
177.0	0.25	25	376.0	360.0	0.8	2.1%	21	28	90	123	136	0.70	0.81	0.84	7.1	7.9

Rational Method Calculatins

Carmichael Mine - Railway

Q = C I A / 360

*C = Fy * C10, see attached ref. Assume medium density bush with low permeability soil.*

Bransby Williams: $t=58.5*L/(A^{0.1*} Se^{0.2}) - A\ (km^2),\ Se\ (m/km),\ L\ (km)$

Crossing Chainage, km	area, km²	A, catchment area, ha	Catchment U/S Elevation	Catchment D/S Elevation	Catchment drainage length, km	Catchment slope	Se, Catchment slope, m/km	t, time of concentration, min	I10, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I50, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	I100, rainfall intensity for duration equal to tc, see attached IFD table, mm/hr	C10, runoff coefficient, see attached reference	C50, calc'd runoff coefficient dependent upon ARI	C100, calc'd runoff coefficient dependent upon ARI	50 yr ARI flow, m3/s	100 yr ARI flow, m3/s
												Frequency Factor ->	1.15	1.20		
177.7	0.22	22	378.0	358.4	0.9	2.2%	22	33	83	112	125	0.70	0.81	0.84	5.8	6.4
178.4	1.04	104	384.9	342.5	1.6	2.7%	27	48	67	91	101	0.70	0.81	0.84	21.9	24.4
178.8	0.11	11	354.0	342.5	0.4	2.9%	29	15	119	163	183	0.70	0.81	0.84	4.2	4.7
180.0	0.26	26	336.3	316.9	1.2	1.6%	16	46	69	93	104	0.70	0.81	0.84	5.6	6.2
181.0	3.30	330	371.1	298.7	3.1	2.3%	23	87	46	62	69	0.49	0.56	0.59	33.4	37.3

Rainfall Intensity Frequency Duration data for; Adani Eastern Railway, Qld

Carmichael Mine - Railway

Geographic Location: 22.12183 Deg. South 147.687 Deg. East

AUSIFD 21-Jul 2011

DURATION	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5	103	132	168	189	217	255	284
6	95.5	123	156	176	203	238	265
10	79.5	102	129	145	167	196	218
20	61.2	78.2	97.9	109	125	146	162
30	50.8	64.8	80.8	90.1	103	120	132
60	34.1	43.5	54.2	60.4	68.9	80	88.6
120	20.8	26.6	33.4	37.3	42.7	49.8	55.3
180	15.1	19.3	24.4	27.4	31.5	36.9	41.1
360	8.51	11	14.1	16	18.5	21.8	24.4
720	4.92	6.38	8.34	9.54	11.1	13.2	14.9
1440	2.97	3.89	5.16	5.95	6.99	8.4	9.5
2880	1.8	2.37	3.21	3.74	4.43	5.37	6.12
4320	1.27	1.67	2.3	2.7	3.22	3.93	4.5

CRC Forge Output

DESIGN RAINFALL ESTIMATES

Entries are mm of rainfall per hour.

Row Heading - Duration of event

Column Headings - AEP (1 in X)

Above 24 hours duration and events rarer than AEP (1 in 50) entries are derived from CRCFORGE estimates only.

Other entries have been derived by applying AR&R ratios to the CRCFORGE 24 hour AEP (1 in 50) value.

Areal Reduction Factors (ARFs) have already been applied and are as shown in the companion output file: '* Data Summary.txt'.

Below 24 hours duration the relevant 24 hour ARF has been conservatively applied.

	5	10	20	50	100	200	500	1000	2000
15 min	97.56	109.4	125.5	146.7	166.7	187.4	216.3	239.4	263.7
30 min	70.57	78.8	90.05	104.9	119.2	133.9	154.6	171.1	188.5
1 hour	49.21	54.68	62.24	72.17	82.01	92.15	106.4	117.7	129.7
3 hours	21.42	24.12	27.76	32.6	37.05	41.62	48.06	53.18	58.58
6 hours	12.55	14.25	16.52	19.56	22.23	24.97	28.83	31.91	35.14
12 hours	7.37	8.441	9.854	11.76	13.37	15.02	17.34	19.19	21.13
18 hours	5.605	6.442	7.544	9.034	10.27	11.54	13.32	14.74	16.23
24 hours	4.603	5.305	6.225	7.474	8.494	9.543	11.02	12.19	13.43
48 hours	2.871	3.308	3.882	4.661	5.262	5.863	6.683	7.319	7.978
72 hours	2.156	2.484	2.915	3.5	3.937	4.379	4.977	5.445	5.92
96 hours	1.716	1.977	2.32	2.786	3.125	3.475	3.949	4.312	4.677
120 hours	1.428	1.646	1.932	2.319	2.604	2.897	3.285	3.588	3.903

Rainfall Intensity Frequency Duration data for; Adani Minesite Qld
Carmichael Mine - Railway

Geographic Location: 22 Deg. South 146.325 Deg. East

AUSIFD		21-Jul	2011				
DURATION min	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5	88	115	153	176	206	246	277
6	82.1	107	143	164	192	230	259
10	68.3	89.2	118	136	159	190	214
20	52.2	68	89.9	103	120	143	161
30	43.4	56.4	74.4	85.2	99.3	118	133
60	29.5	38.3	50.3	57.5	67	79.6	89.3
120	18.4	23.9	31.3	35.7	41.5	49.3	55.3
180	13.6	17.6	23.1	26.3	30.6	36.2	40.6
360	7.99	10.4	13.5	15.4	17.8	21.1	23.7
720	4.81	6.23	8.11	9.24	10.7	12.7	14.2
1440	3.04	3.94	5.15	5.86	6.8	8.05	9.02
2880	1.94	2.51	3.3	3.77	4.38	5.19	5.83
4320	1.41	1.83	2.41	2.76	3.21	3.81	4.28

CRC Forge Output
DESIGN RAINFALL ESTIMATES

Entries are mm of rainfall per hour.

Row Heading - Duration of event

Column Headings - AEP (1 in X)

Above 24 hours duration and events rarer than AEP (1 in 50) entries are derived from CRCFORGE estimates only.

Other entries have been derived by applying AR&R ratios to the CRCFORGE 24 hour AEP (1 in 50) value.

Areal Reduction Factors (ARFs) have already been applied and are as shown in the companion output file: '* Data Summary.txt'.

Below 24 hours duration the relevant 24 hour ARF has been conservatively applied.

	5	10	20	50	100	200	500	1000	2000
15 min	109.9	126.3	147.7	176.4	199.6	222.9	255.2	280.8	307.3
30 min	79.94	91.76	107.2	127.7	144.6	161.4	184.8	203.4	222.5
1 hour	56.09	64.27	74.95	89.19	100.9	112.7	129	142	155.4
3 hours	24.78	28.28	32.87	38.97	44.11	49.26	56.39	62.05	67.91
6 hours	14.66	16.69	19.35	22.89	25.91	28.93	33.12	36.45	39.88
12 hours	8.69	9.868	11.42	13.48	15.25	17.03	19.5	21.46	23.48
18 hours	6.712	7.637	8.854	10.47	11.85	13.23	15.15	16.67	18.24
24 hours	5.574	6.352	7.373	8.729	9.88	11.03	12.63	13.9	15.21
48 hours	3.363	3.833	4.449	5.267	5.929	6.596	7.491	8.2	8.908
72 hours	2.473	2.818	3.271	3.873	4.35	4.84	5.484	5.984	6.482
96 hours	1.953	2.226	2.584	3.059	3.432	3.808	4.311	4.695	5.083
120 hours	1.605	1.829	2.123	2.514	2.816	3.119	3.52	3.826	4.132

IDF table - Average values

Carmichael Mine - Railway

DURATION min	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5	95.5	123.5	160.5	182.5	211.5	250.5	280.5
6	88.8	115	149.5	170	197.5	234	262
10	73.9	95.6	123.5	140.5	163	193	216
20	56.7	73.1	93.9	106	122.5	144.5	161.5
30	47.1	60.6	77.6	87.65	101.15	119	132.5
60	31.8	40.9	52.25	58.95	67.95	79.8	88.95
120	19.6	25.25	32.35	36.5	42.1	49.55	55.3
180	14.35	18.45	23.75	26.85	31.05	36.55	40.85
360	8.25	10.7	13.8	15.7	18.15	21.45	24.05
720	4.865	6.305	8.225	9.39	10.9	12.95	14.55
1440	3.005	3.915	5.155	5.905	6.895	8.225	9.26
2880	1.87	2.44	3.255	3.755	4.405	5.28	5.975
4320	1.34	1.75	2.355	2.73	3.215	3.87	4.39

log of table for interpolation

0.6990	1.9800	2.0917	2.2055	2.2613	2.3253	2.3988	2.4479
0.7782	1.9484	2.0607	2.1746	2.2304	2.2956	2.3692	2.4183
1.0000	1.8686	1.9805	2.0917	2.1477	2.2122	2.2856	2.3345
1.3010	1.7536	1.8639	1.9727	2.0253	2.0881	2.1599	2.2082
1.4771	1.6730	1.7825	1.8899	1.9428	2.0050	2.0755	2.1222
1.7782	1.5024	1.6117	1.7181	1.7705	1.8322	1.9020	1.9491
2.0792	1.2923	1.4023	1.5099	1.5623	1.6243	1.6950	1.7427
2.2553	1.1569	1.2660	1.3757	1.4289	1.4921	1.5629	1.6112
2.5563	0.9165	1.0294	1.1399	1.1959	1.2589	1.3314	1.3811
2.8573	0.6871	0.7997	0.9151	0.9727	1.0374	1.1123	1.1629
3.1584	0.4778	0.5927	0.7122	0.7712	0.8385	0.9151	0.9666
3.4594	0.2718	0.3874	0.5126	0.5746	0.6439	0.7226	0.7763
3.6355	0.1271	0.2430	0.3720	0.4362	0.5072	0.5877	0.6425

Rational Method Runoff Coefficient Reference Table

Carmichael Mine - Railway

Source: Queensland Government. 2008. *Queensland Urban Drainage Manual.*

Table 4.05.2 Table of frequency factors

A.R.I. (years)	Frequency Factor (F_y)
1	0.80
2	0.85
5	0.95
10	1.00
20	1.05
50	1.15
100	1.20

Table 4.05.3 (a) Table of C_{10} Values

Intensity (mm/hr) $^1I_{10}$	FRACTION IMPERVIOUS f_i 0.00	0.20	0.40	0.60	0.80	0.90	1.00
39-44	Refer to Table 4.05.3(b)	0.44	0.55	0.67	0.78	0.84	0.90
45-49		0.49	0.60	0.70	0.80	0.85	0.90
50-54		0.55	0.64	0.72	0.81	0.86	0.90
55-59		0.60	0.68	0.75	0.83	0.86	0.90
60-64		0.65	0.72	0.78	0.84	0.87	0.90
65-69		0.71	0.76	0.80	0.85	0.88	0.90
70-90		0.74	0.78	0.82	0.86	0.88	0.90

$^1I_{10}$ = One hour rainfall intensity for a 1 in 10 year ARI

C_{10} = Coefficient of discharge for a 1 in 10 year ARI

f_i = Fraction impervious

Table 4.05.3 (b) C_{10} values for Zero Fraction Impervious [1]

Land description	Dense bushland			Medium density bush, or Good grass cover, or High density pasture, or Zero tillage cropping			Light cover bushland, or Poor grass cover, or Low density pasture, or Low cover bare fallows		
Intensity (mm/hr) $^1I_{10}$	Soil permeability			Soil permeability			Soil permeability		
	High	Med	Low	High	Med	Low	High	Med	Low
39–44	0.08	0.24	0.32	0.16	0.32	0.40	0.24	0.40	0.48
45–49	0.10	0.29	0.39	0.20	0.39	0.49	0.29	0.49	0.59
50–54	0.12	0.35	0.46	0.23	0.46	0.58	0.35	0.58	0.69
55–59	0.13	0.40	0.53	0.27	0.53	0.66	0.40	0.66	0.70
60–64	0.15	0.44	0.59	0.30	0.59	0.70	0.44	0.70	0.70
65–69	0.17	0.50	0.66	0.33	0.66	0.70	0.50	0.70	0.70
70–90	0.18	0.53	0.70	0.35	0.70	0.70	0.53	0.70	0.70

Note: [1] Developed from Qld. Department of Natural Resources & Mines (2005). Coefficients are not suitable for soils compacted by construction activities.

APPENDIX D

Historic Flood Data Sheets

Satellite Photographed Historic Flood Flows

Carmichael Mine Railway

	date	Flow at Belyando River, Station 120301B, m^3/s	Flow at Mistake Creek, Station 120309A, m^3/s
Average Daily Flows	1-May-83	422	388
	2-May-83	1167	412
	3-May-83	1959	414
	4-May-83	1918	408
	5-May-83	1469	421
Landsat photo, 6 May 1983 ->	6-May-83	1353	394
	7-May-83	1398	293
	8-May-83	1051	209
	9-May-83	680	182

	Belyando River	Mistake Creek
A, Area at gauged catchment, km^2	35471	7414
Ac, Area at rail crossing, km^2	22000	7900
Ac/A, area ratio	0.62	1.07
Flow on day of photo		
flow at gauge, m^3/s	1353	394
n, area ration factor from regression analysis	0.5	0.5
Area prorated flow to rail crossing Qc = Q * (Ac/A)^n, m^3/s	1066	407
Flow on day of peak		
flow at gauge, m^3/s	2018	425
Area prorated flow to rail crossing Qc = Q * (Ac/A)^n, m^3/s	1589	439
Estimated ARI for peak flow, years	20	10

*Note flow on day of peak is taken from peak series rather than the average daily flows as shown above.

Satellite Photographed Historic Flood Flows

Carmichael Mine Railway

	date	Flow at Belyando River, Station 120301B, m^3/s	Flow at Mistake Creek, Station 120309A, m^3/s
Average Daily Flows	20-Jan-08	977	331
	21-Jan-08	978	451
	22-Jan-08	1748	447
	23-Jan-08	4114	416
	24-Jan-08	3961	366
	25-Jan-08	3143	319
	26-Jan-08	2215	300
	27-Jan-08	1597	286
Landsat photo, 28 Jan 2008 ->	28-Jan-08	1250	272
	29-Jan-08	1016	255

	Belyando River	Mistake Creek
A, Area at gauged catchment, km^2	35471	7414
Ac, Area at rail crossing, km^2	22000	7900
Ac/A, area ratio	0.62	1.07
Flow on day of photo		
flow at gauge, m^3/s	1250	272
n, area ration factor from regression analysis	0.5	0.5
Area prorated flow to rail crossing Qc = Q * (Ac/A)^n, m^3/s	985	280
Flow on day of peak		
flow at gauge, m^3/s	4114	451
Area prorated flow to rail crossing Qc = Q * (Ac/A)^n, m^3/s	3240	466
Estimated ARI for peak flow, years	100	10

Satellite Photographed Historic Flood Flows

Carmichael Mine Railway

	date	Flow at Belyando River, Station 120301B, m³/s	Flow at Mistake Creek, Station 120309A, m³/s
Average Daily Flows	30-Dec-10	632	235
	31-Dec-10	927	286
	1-Jan-11	1029	318
	2-Jan-11	917	305
	3-Jan-11	800	253
Landsat photo, 4 Jan 2011 ->	4-Jan-11	735	212
	5-Jan-11	658	207
	6-Jan-11	568	214
	7-Jan-11	508	220

	Belyando River	Mistake Creek
A, Area at gauged catchment, km^2	35471	7414
Ac, Area at rail crossing, km^2	22000	7900
Ac/A, area ratio	0.62	1.07
Flow on day of photo		
flow at gauge, m^3/s	735	212
n, area ration factor from regression analysis	0.5	0.5
Area prorated flow to rail crossing Qc = Q * (Ac/A)^n, m^3/s	579	219
Flow on day of peak		
flow at gauge, m^3/s	1029	318
Area prorated flow to rail crossing Qc = Q * (Ac/A)^n, m^3/s	810	329
Estimated ARI for peak flow, years	10	5

APPENDIX E

Flood Level Calculations

Existing Flood Level Summary - 50 year ARI

Carmichael Mine Project - Railway

			See normal depth calculations, attached.						
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s
b2		*d9*	*d15*	*d14*	*d16*	*d17*	*d18*	*d19*	*d20*
1.7		32.1	224.00	224.35	383	81.8	0.35	0.21	0.4
4.7	Eight Mile Creek	230.5	218.40	219.40	1015	519.7	1.00	0.51	0.4
7.8		49.3	214.91	215.55	353	115.9	0.64	0.33	0.4
9.0		17.4	214.56	214.97	277	61.4	0.41	0.22	0.3
10.4	North Creek	364.9	214.51	216.25	850	555.6	1.74	0.65	0.7
17.1		125.1	207.00	207.20	1835	346.8	0.20	0.19	0.4
18.8		21.8	207.61	207.82	352	50.9	0.21	0.14	0.4
21.1		45.2	205.96	206.35	531	105.1	0.40	0.20	0.4
27.9	Ogenbeena Creek	546.7	197.14	200.06	1428	1300.7	2.92	0.91	0.4
30.8	Ogenbeena Creek (lower crossing)	552.3	195.60	198.28	882	1079.3	2.68	1.22	0.5
31.4	Belyando River (31.4, 31.9, 34.9)	2572.1	192.31	198.07	5454	5631.5	5.76	1.03	0.5
41.6	East Tributary of Belyando River	310.5	192.92	193.86	1040	684.1	0.94	0.66	0.5
42.1		34.2	193.53	194.33	324	114.1	0.79	0.35	0.3
44.1		24.1	198.15	198.55	208	46.3	0.40	0.22	0.5
47.3		151.4	193.31	194.25	1457	400.5	0.93	0.27	0.4
53.6		97.7	192.77	193.65	292	161.8	0.87	0.55	0.6
56.6		27.1	193.20	193.74	153	47.0	0.54	0.31	0.6
57.3		19.9	192.40	192.78	128	36.4	0.38	0.28	0.5
58.2		28.7	193.54	194.11	159	60.8	0.56	0.38	0.5
58.8	Mistake Creek (58.8, 59.4, 60.2, 62.1)	640.0	188.21	190.16	3083	1758.8	1.95	0.57	0.4
67.3	Gowrie Creek	346.0	192.02	194.10	1005	645.0	2.09	0.64	0.5
70.2		105.6	198.67	200.20	327	177.6	1.53	0.54	0.6
74.1		22.5	210.81	211.29	223	50.8	0.48	0.23	0.4
75.5		13.4	213.91	214.15	339	42.5	0.24	0.13	0.3
76.0		16.7	213.86	214.15	444	58.6	0.29	0.13	0.3
76.8		88.0	214.48	215.47	200	115.7	0.99	0.58	0.8
77.7		43.9	218.83	219.48	205	77.0	0.64	0.38	0.6
80.4		37.5	221.71	222.59	103	48.8	0.88	0.47	0.8
82.3		14.4	221.23	221.42	263	37.4	0.20	0.14	0.4
83.3		41.3	220.27	221.25	243	72.9	0.98	0.30	0.6

Golder Associates

RailCrossings_normaldepth11.xlsx

Existing Flood Level Summary - 50 year ARI

Carmichael Mine Project - Railway

			See normal depth calculations, attached.						
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s
85.4		299.9	210.65	211.74	1057	653.4	1.09	0.62	0.5
87.6		16.0	211.27	211.54	293	44.5	0.28	0.15	0.4
91.0		35.2	209.95	210.31	734	126.8	0.37	0.17	0.3
93.4		241.9	206.57	207.69	912	439.8	1.12	0.48	0.5
94.4		134.2	206.67	207.67	425	201.6	1.00	0.47	0.7
98.2		13.8	213.14	213.38	493	57.6	0.24	0.12	0.2
99.2		21.7	211.63	212.04	389	59.8	0.41	0.15	0.4
100.4		43.1	208.90	209.47	463	105.5	0.57	0.23	0.4
101.2		11.7	209.49	209.78	562	64.1	0.29	0.11	0.2
102.1		6.5	209.04	209.40	76	13.4	0.36	0.18	0.5
102.5	Logan Creek (102.5, 103.5)	1006.3	203.15	209.86	1382	1851.8	6.71	1.34	0.5
104.2		9.4	209.88	210.06	1074	82.2	0.19	0.08	0.1
107.0		24.6	210.74	210.98	1609	152.4	0.24	0.09	0.2
110.5		80.0	208.97	209.44	1932	376.6	0.46	0.19	0.2
112.5		45.1	209.84	210.12	2023	271.8	0.28	0.13	0.2
115.8		74.6	207.00	207.66	385	189.4	0.66	0.49	0.4
119.4	Diamond Creek	457.5	206.26	207.35	2553	1474.8	1.09	0.58	0.3
125.5		13.0	213.92	214.18	312	49.6	0.26	0.16	0.3
129.6		8.0	220.17	220.38	512	49.2	0.21	0.10	0.2
130.3		7.3	220.29	220.53	355	37.0	0.24	0.10	0.2
131.4		29.3	219.65	219.92	702	111.6	0.27	0.16	0.3
133.7		29.5	220.09	220.65	516	99.1	0.56	0.19	0.3
135.0		20.5	220.73	221.21	203	54.9	0.48	0.27	0.4
136.4		77.5	221.01	221.75	576	184.8	0.74	0.32	0.4
138.2		18.7	228.64	228.93	245	31.9	0.29	0.13	0.6
139.4		7.3	248.53	248.86	43	8.9	0.33	0.21	0.8
140.7		8.7	255.72	255.98	112	15.5	0.26	0.14	0.6
141.2		7.7	252.71	253.11	56	12.0	0.41	0.21	0.6
142.6		31.1	252.30	252.68	276	58.7	0.38	0.21	0.5
143.6		9.6	253.80	254.00	403	34.8	0.19	0.09	0.3
144.2		10.0	253.77	254.02	178	24.9	0.25	0.14	0.4

Golder Associates

RailCrossings_normaldepth11.xlsx

Existing Flood Level Summary - 50 year ARI

Carmichael Mine Project - Railway

			See normal depth calculations, attached.						
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s
146.6		6.1	257.80	258.02	342	26.5	0.23	0.08	0.2
147.6		10.4	258.18	258.51	436	40.2	0.33	0.09	0.3
149.3		30.5	255.08	255.40	395	71.2	0.32	0.18	0.4
150.7		24.5	259.59	259.93	316	61.4	0.34	0.19	0.4
154.6		19.0	260.75	261.08	806	112.0	0.34	0.14	0.2
155.0		15.7	260.85	261.10	466	71.0	0.25	0.15	0.2
157.1		34.2	260.83	261.20	490	99.1	0.37	0.20	0.3
158.6		20.5	259.88	260.13	497	69.4	0.25	0.14	0.3
159.1		38.1	258.98	259.40	321	84.5	0.42	0.26	0.5
160.8		16.0	262.48	262.70	538	53.0	0.22	0.10	0.3
162.1		66.6	261.21	262.11	330	114.1	0.89	0.35	0.6
163.7	Grosvenor Creek	237.9	262.73	265.29	362	292.6	2.56	0.81	0.8
165.8		75.9	272.95	273.35	922	167.5	0.40	0.18	0.5
168.6		8.3	288.80	289.06	317	27.4	0.26	0.09	0.3
170.6		8.4	317.92	318.08	157	16.2	0.16	0.10	0.5
172.0		56.1	311.96	313.29	80	44.0	1.33	0.55	1.3
173.6		24.6	323.23	323.75	50	17.1	0.52	0.34	1.4
174.1		6.1	330.48	330.83	17	3.0	0.36	0.18	2.0
174.7		14.4	329.85	330.09	134	12.7	0.24	0.09	1.1
175.3		61.7	331.11	331.58	168	54.9	0.46	0.33	1.1
176.7		6.5	356.62	356.77	134	10.8	0.15	0.08	0.6
177.0		7.1	354.99	355.17	145	12.7	0.17	0.09	0.6
177.7		5.8	344.89	345.08	141	10.2	0.18	0.07	0.6
178.4		21.9	334.00	334.51	86	22.1	0.51	0.26	1.0
178.8		4.2	336.49	336.68	69	6.9	0.20	0.10	0.6
180.0		5.6	312.44	312.78	23	4.5	0.34	0.20	1.2
181.0		33.4	294.88	295.46	135	34.8	0.58	0.26	1.0

Existing Flood Level Summary - 100 year ARI

Carmichael Mine Project - Railway

			See normal depth calculations, attached.						
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s
b2		*e9*	*e15*	*e14*	*e16*	*e17*	*e18*	*e19*	*e20*
1.7		35.8	224.00	224.37	392	88.3	0.37	0.23	0.4
4.7	Eight Mile Creek	306.3	218.40	219.52	1171	652.8	1.12	0.56	0.5
7.8		55.2	214.91	215.58	360	125.0	0.67	0.35	0.4
9.0		19.4	214.56	214.99	295	67.2	0.43	0.23	0.3
10.4	North Creek	467.7	214.51	216.35	850	644.9	1.84	0.76	0.7
17.1		140.1	207.00	207.22	1853	372.8	0.22	0.20	0.4
18.8		24.3	207.61	207.83	360	54.9	0.22	0.15	0.4
21.1		50.4	205.96	206.37	554	114.2	0.41	0.21	0.4
27.9	Ogenbeena Creek	710.8	197.14	200.22	1439	1527.5	3.08	1.06	0.5
30.8	Ogenbeena Creek (lower crossing)	718.2	195.60	198.70	1541	1579.7	3.10	1.03	0.5
31.4	Belyando River (31.4, 31.9, 34.9)	3336.0	192.31	198.27	5815	6753.1	5.96	1.16	0.5
41.6	East Tributary of Belyando River	397.6	192.92	193.97	1067	801.7	1.05	0.75	0.5
42.1		38.1	193.53	194.36	356	126.5	0.83	0.36	0.3
44.1		26.8	198.15	198.57	214	50.0	0.42	0.23	0.5
47.3		169.8	193.31	194.27	1462	429.7	0.95	0.29	0.4
53.6		109.4	192.77	193.69	298	174.6	0.92	0.59	0.6
56.6		30.2	193.20	193.77	158	50.8	0.57	0.32	0.6
57.3		22.2	192.40	192.80	130	39.2	0.40	0.30	0.6
58.2		31.9	193.54	194.14	166	66.0	0.59	0.40	0.5
58.8	Mistake Creek (58.8, 59.4, 60.2, 62.1)	697.0	188.21	190.21	3385	1921.3	2.00	0.57	0.4
67.3	Gowrie Creek	435.2	192.02	194.20	1029	747.2	2.19	0.73	0.6
70.2		118.1	198.67	200.24	332	191.0	1.57	0.57	0.6
74.1		25.1	210.81	211.31	241	56.0	0.50	0.23	0.4
75.5		15.0	213.91	214.16	345	45.6	0.25	0.13	0.3
76.0		18.6	213.86	214.16	455	63.3	0.30	0.14	0.3
76.8		98.3	214.48	215.52	209	126.0	1.04	0.60	0.8
77.7		49.0	218.83	219.51	216	84.0	0.68	0.39	0.6
80.4		41.9	221.71	222.63	107	53.0	0.92	0.49	0.8
82.3		16.1	221.23	221.44	268	40.2	0.21	0.15	0.4
83.3		46.2	220.27	221.28	257	79.8	1.01	0.31	0.6

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RailCrossings_normaldepth11.xlsx

Existing Flood Level Summary - 100 year ARI

Carmichael Mine Project - Railway

			See normal depth calculations, attached.						
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s
85.4		336.3	210.65	211.79	1101	711.6	1.15	0.65	0.5
87.6		17.9	211.27	211.56	313	48.8	0.29	0.16	0.4
91.0		39.3	209.95	210.33	754	136.9	0.38	0.18	0.3
93.4		271.4	206.57	207.73	945	477.9	1.16	0.51	0.6
94.4		150.4	206.67	207.70	434	217.5	1.04	0.50	0.7
98.2		15.4	213.14	213.39	499	61.8	0.25	0.12	0.2
99.2		24.2	211.63	212.06	418	65.7	0.43	0.16	0.4
100.4		48.2	208.90	209.49	480	114.5	0.59	0.24	0.4
101.2		13.0	209.49	209.79	570	68.8	0.29	0.12	0.2
102.1		7.3	209.04	209.41	80	14.6	0.37	0.18	0.5
102.5	Logan Creek (102.5, 103.5)	1301.6	203.15	210.10	1438	2195.5	6.95	1.53	0.6
104.2		10.5	209.88	210.07	1082	87.9	0.19	0.08	0.1
107.0		27.4	210.74	210.99	1657	164.8	0.24	0.10	0.2
110.5		89.8	208.97	209.45	1999	408.8	0.48	0.20	0.2
112.5		50.5	209.84	210.13	2037	291.5	0.29	0.14	0.2
115.8		83.2	207.00	207.69	394	204.0	0.69	0.52	0.4
119.4	Diamond Creek	620.2	206.26	207.47	2663	1800.3	1.21	0.68	0.3
125.5		14.5	213.92	214.19	318	53.3	0.27	0.17	0.3
129.6		8.9	220.17	220.39	572	54.9	0.22	0.10	0.2
130.3		8.2	220.29	220.53	360	39.7	0.25	0.11	0.2
131.4		32.7	219.65	219.94	718	120.3	0.28	0.17	0.3
133.7		33.0	220.09	220.67	520	106.3	0.57	0.20	0.3
135.0		22.9	220.73	221.23	207	59.1	0.50	0.29	0.4
136.4		86.6	221.01	221.78	595	200.2	0.77	0.34	0.4
138.2		20.9	228.64	228.95	255	34.7	0.31	0.14	0.6
139.4		8.1	248.53	248.88	44	9.5	0.35	0.22	0.9
140.7		9.7	255.72	255.99	116	16.7	0.27	0.14	0.6
141.2		8.6	252.71	253.13	58	13.1	0.43	0.22	0.7
142.6		34.6	252.30	252.70	309	65.6	0.40	0.21	0.5
143.6		10.7	253.80	254.00	425	38.0	0.20	0.09	0.3
144.2		11.1	253.77	254.03	181	26.8	0.26	0.15	0.4

Golder Associates

RailCrossings_normaldepth11.xlsx

Existing Flood Level Summary - 100 year ARI

Carmichael Mine Project - Railway

			See normal depth calculations, attached.						
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s
146.6		6.8	257.80	258.03	350	28.5	0.23	0.08	0.2
147.6		11.5	258.18	258.52	476	44.3	0.34	0.09	0.3
149.3		34.0	255.08	255.41	402	76.5	0.33	0.19	0.4
150.7		27.3	259.59	259.94	325	66.4	0.35	0.20	0.4
154.6		21.2	260.75	261.09	808	119.7	0.35	0.15	0.2
155.0		17.5	260.85	261.11	466	75.8	0.26	0.16	0.2
157.1		38.1	260.83	261.21	490	105.9	0.38	0.22	0.4
158.6		22.9	259.88	260.14	498	74.2	0.26	0.15	0.3
159.1		42.5	258.98	259.42	333	91.7	0.44	0.28	0.5
160.8		17.8	262.48	262.70	552	57.2	0.23	0.10	0.3
162.1		74.5	261.21	262.14	348	124.8	0.93	0.36	0.6
163.7	Grosvenor Creek	306.6	262.73	265.47	433	365.8	2.74	0.84	0.8
165.8		85.0	272.95	273.37	938	180.4	0.42	0.19	0.5
168.6		9.3	288.80	289.07	338	30.1	0.27	0.09	0.3
170.6		9.4	317.92	318.09	163	17.5	0.17	0.11	0.5
172.0		62.5	311.96	313.35	90	49.2	1.39	0.55	1.3
173.6		27.4	323.23	323.78	52	18.4	0.55	0.36	1.5
174.1		6.8	330.48	330.85	18	3.3	0.37	0.19	2.1
174.7		16.1	329.85	330.10	143	13.9	0.25	0.10	1.2
175.3		68.7	331.11	331.60	174	59.4	0.49	0.34	1.2
176.7		7.2	356.62	356.77	136	11.6	0.16	0.09	0.6
177.0		7.9	354.99	355.17	146	13.6	0.18	0.09	0.6
177.7		6.4	344.89	345.08	144	10.9	0.19	0.08	0.6
178.4		24.4	334.00	334.53	89	23.9	0.53	0.27	1.0
178.8		4.7	336.49	336.69	72	7.5	0.21	0.10	0.6
180.0		6.2	312.44	312.80	24	4.9	0.36	0.21	1.3
181.0		37.3	294.88	295.48	140	37.8	0.60	0.27	1.0

Existing water level calculation - Carmichael Mine Railway

Chainage 1.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

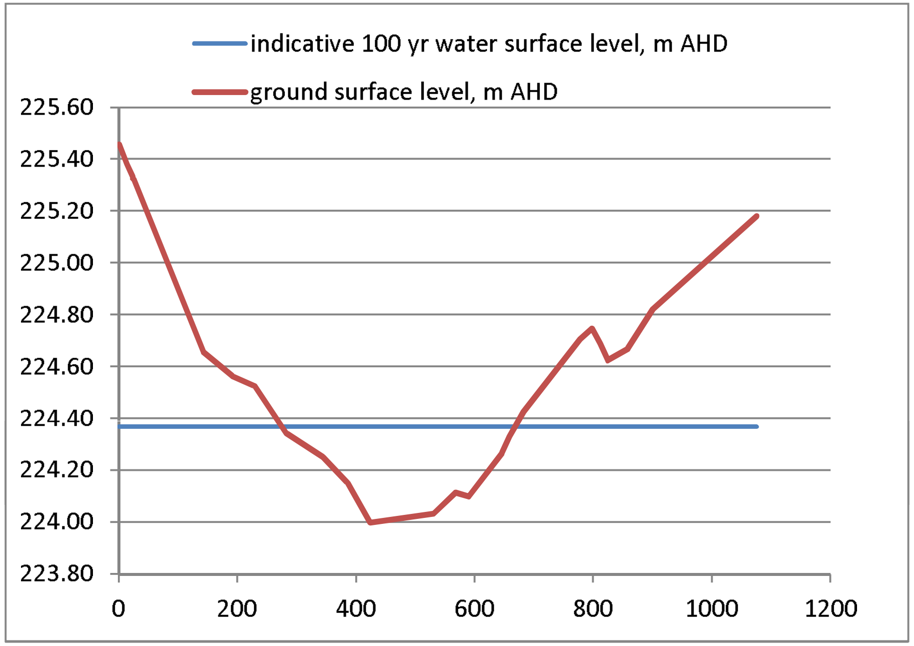
Input

ARI	50 yr	100 yr
flow from hydrologic calc's, m3/s	32.1	35.8
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05

Results

water level calc'd based on Manning's Eq., m AHD	224.35	224.37
min. ground level, m AHD	224.00	224.00
top width, m	383.16	392.35
area, m^2	81.85	88.28
max. depth of water, m	0.35	0.37
avg. depth of water, m	0.21	0.23
avg. velocity, m/s	0.39	0.41

Cross-section



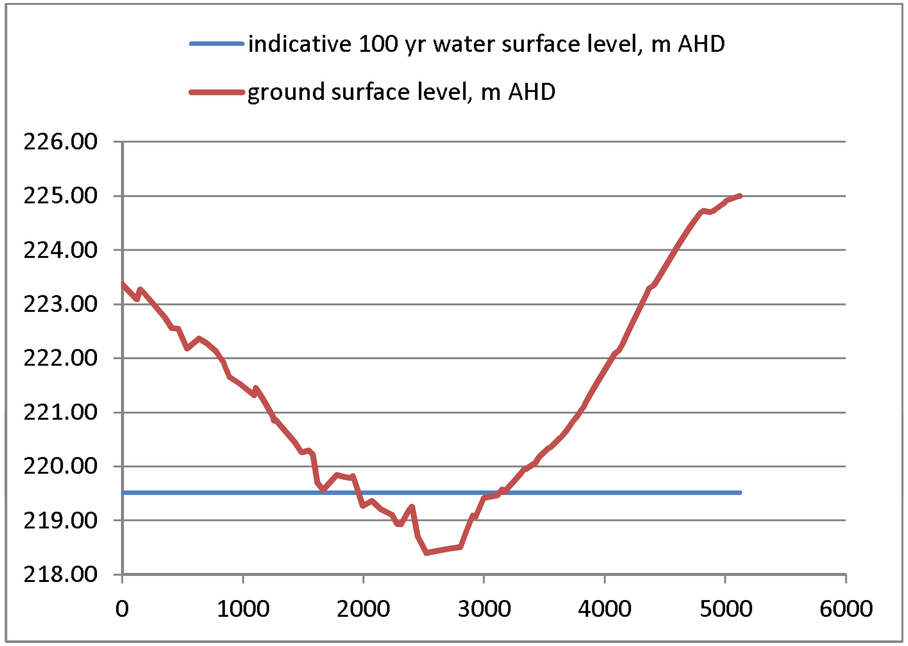
Existing water level calculation - Carmichael Mine Railway

Chainage 4.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	230.5	306.3
slope estimated from LIDAR, m/m	0.0012	0.0012
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	219.40	219.52
min. ground level, m AHD	218.40	218.40
top width, m	1014.74	1171.29
area, m^2	519.67	652.76
max. depth of water, m	1.00	1.12
avg. depth of water, m	0.51	0.56
avg. velocity, m/s	0.44	0.47

Cross-section



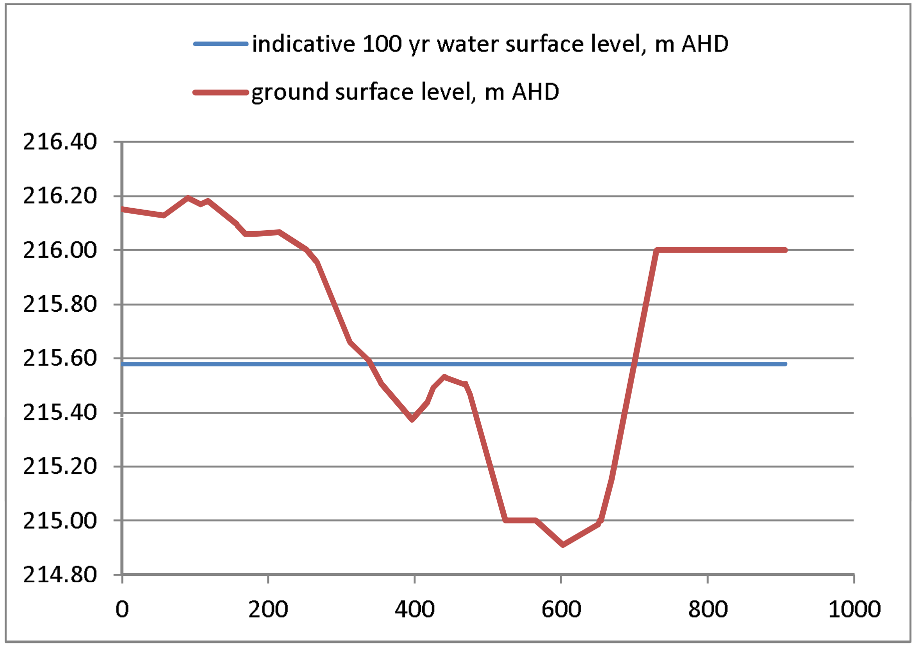
Existing water level calculation - Carmichael Mine Railway

Chainage 7.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	49.3	55.2
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	215.55	215.58
min. ground level, m AHD	214.91	214.91
top width, m	353.48	360.39
area, m^2	115.90	124.96
max. depth of water, m	0.64	0.67
avg. depth of water, m	0.33	0.35
avg. velocity, m/s	0.43	0.44

Cross-section

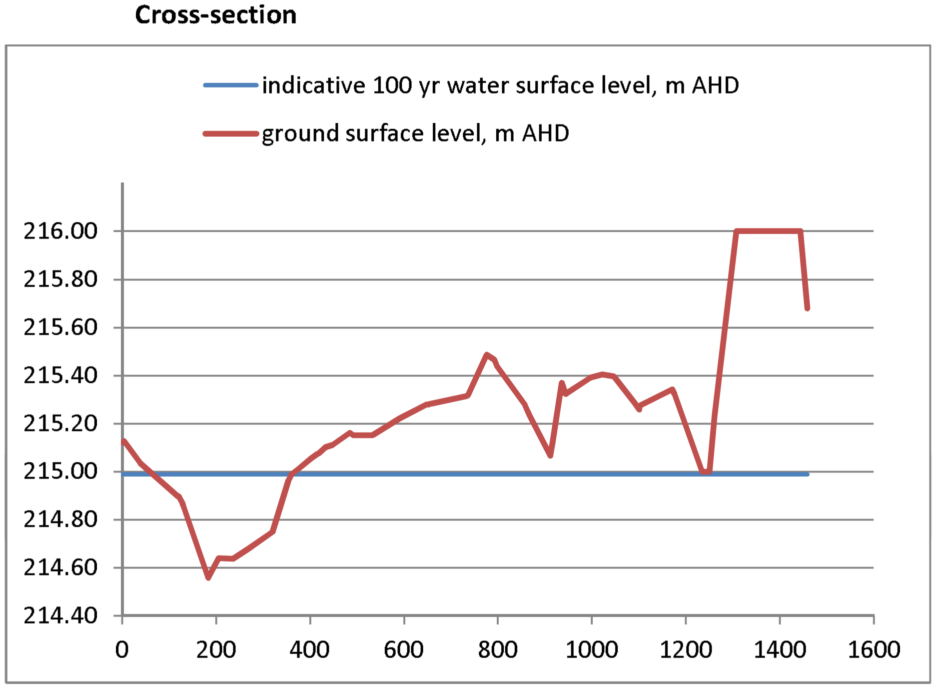


Existing water level calculation - Carmichael Mine Railway

Chainage 9

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	17.4	19.4
slope estimated from LIDAR, m/m	0.0015	0.0015
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	214.97	214.99
min. ground level, m AHD	214.56	214.56
top width, m	277.23	294.68
area, m^2	61.39	67.17
max. depth of water, m	0.41	0.43
avg. depth of water, m	0.22	0.23
avg. velocity, m/s	0.28	0.29



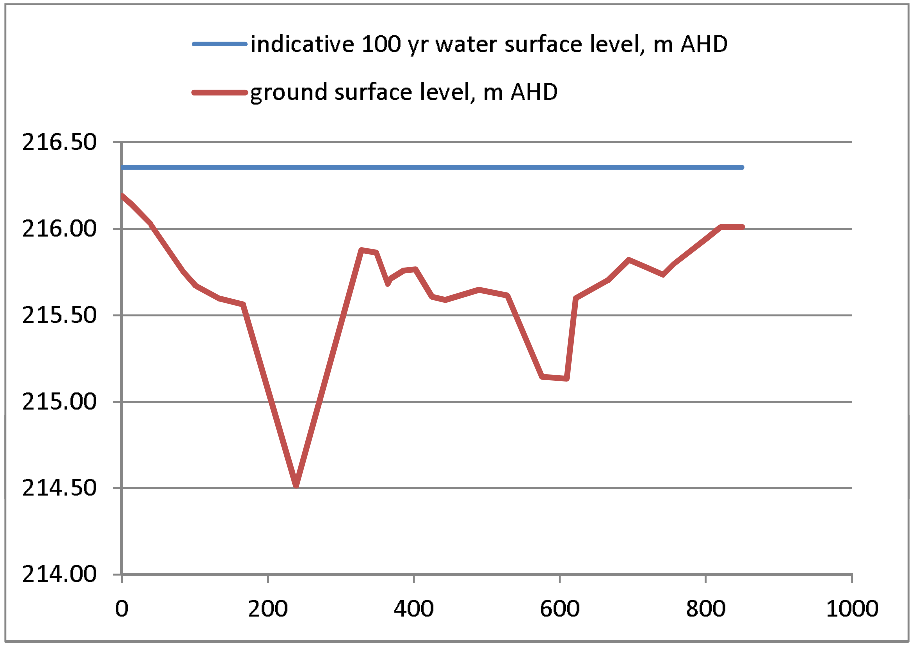
Existing water level calculation - Carmichael Mine Railway

Chainage 10.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	364.9	467.7
slope estimated from LIDAR, m/m	0.0019	0.0019
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	216.25	216.35
min. ground level, m AHD	214.51	214.51
top width, m	849.68	849.68
area, m^2	555.60	644.90
max. depth of water, m	1.74	1.84
avg. depth of water, m	0.65	0.76
avg. velocity, m/s	0.66	0.73

Cross-section

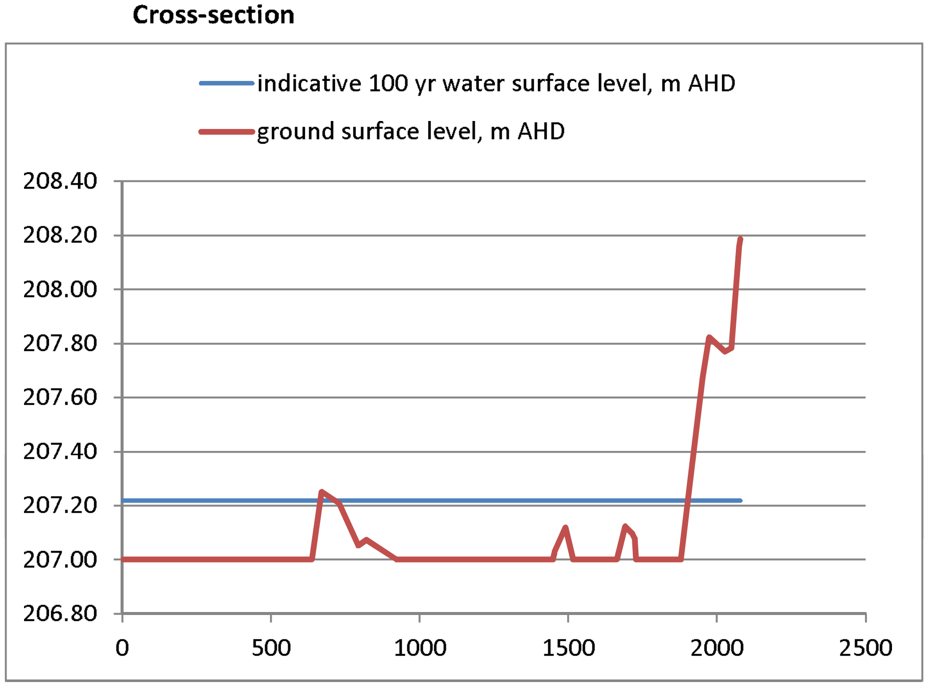


Existing water level calculation - Carmichael Mine Railway

Chainage 17.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	125.1	140.1
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	207.20	207.22
min. ground level, m AHD	207.00	207.00
top width, m	1834.69	1852.97
area, m^2	346.80	372.80
max. depth of water, m	0.20	0.22
avg. depth of water, m	0.19	0.20
avg. velocity, m/s	0.36	0.38



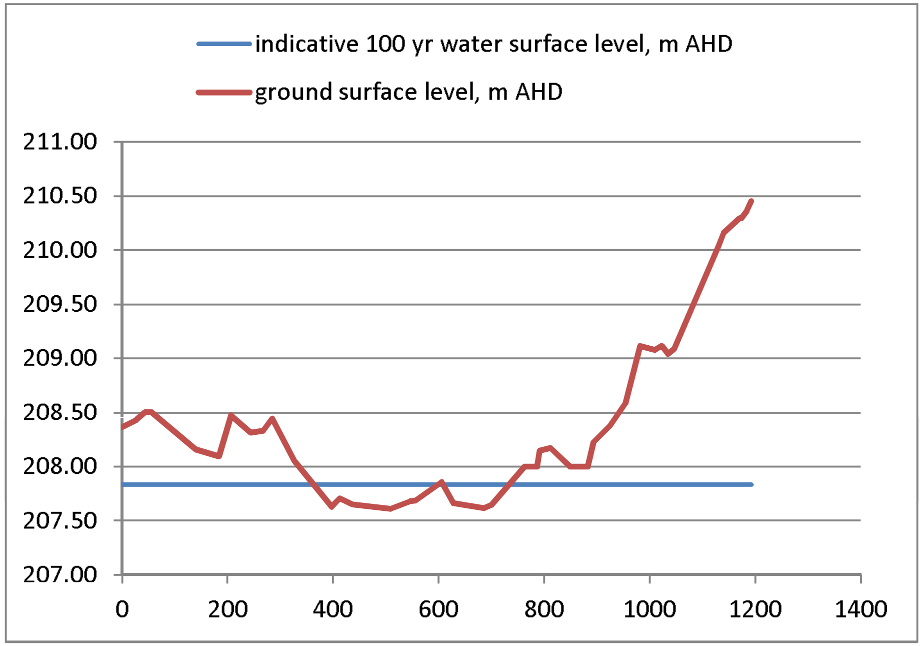
Existing water level calculation - Carmichael Mine Railway

Chainage 18.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	21.8	24.3
slope estimated from LIDAR, m/m	0.006	0.006
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	207.82	207.83
min. ground level, m AHD	207.61	207.61
top width, m	352.00	360.22
area, m^2	50.95	54.89
max. depth of water, m	0.21	0.22
avg. depth of water, m	0.14	0.15
avg. velocity, m/s	0.43	0.44

Cross-section



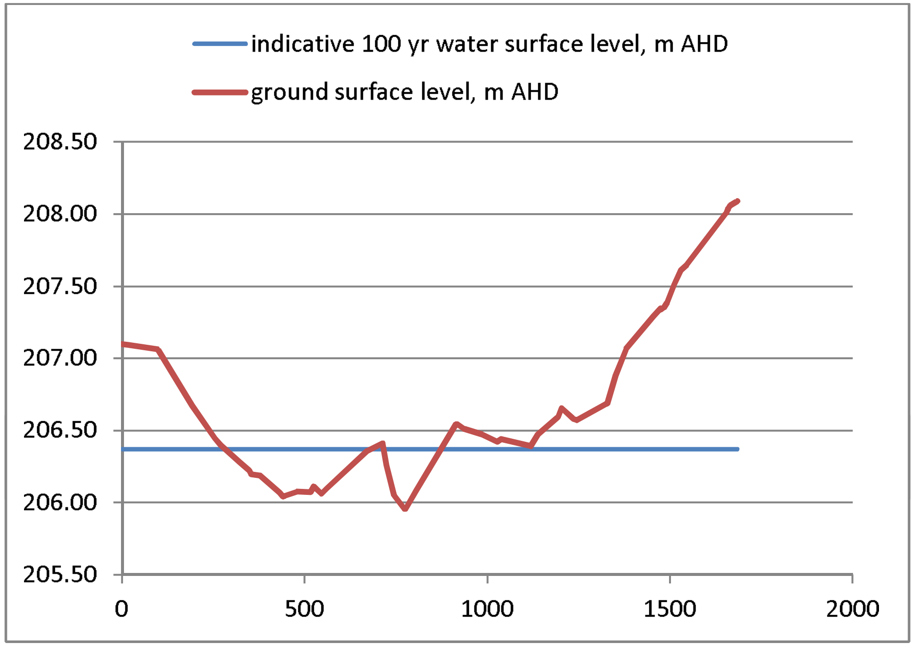
Existing water level calculation - Carmichael Mine Railway

Chainage 21.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	45.2	50.4
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	206.35	206.37
min. ground level, m AHD	205.96	205.96
top width, m	530.70	554.25
area, m^2	105.11	114.21
max. depth of water, m	0.40	0.41
avg. depth of water, m	0.20	0.21
avg. velocity, m/s	0.43	0.44

Cross-section



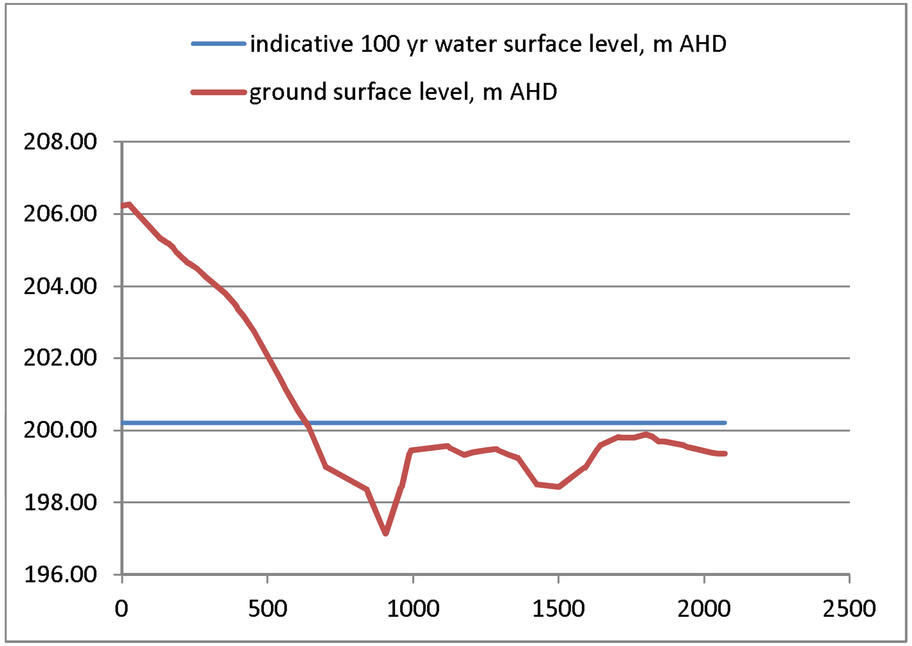
Existing water level calculation - Carmichael Mine Railway

Chainage 27.9

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	546.7	710.8
slope estimated from LIDAR, m/m	0.0005	0.0005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	200.06	200.22
min. ground level, m AHD	197.14	197.14
top width, m	1427.53	1439.07
area, m^2	1300.69	1527.53
max. depth of water, m	2.92	3.08
avg. depth of water, m	0.91	1.06
avg. velocity, m/s	0.42	0.47

Cross-section



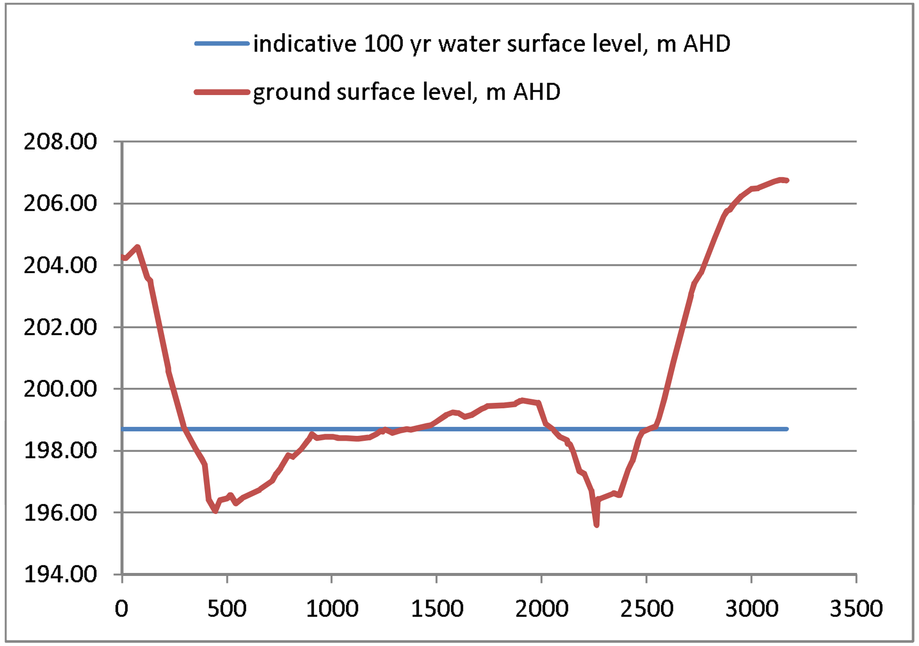
Existing water level calculation - Carmichael Mine Railway

Chainage 30.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	552.3	718.2
slope estimated from LIDAR, m/m	0.0005	0.0005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	198.28	198.70
min. ground level, m AHD	195.60	195.60
top width, m	881.63	1540.86
area, m^2	1079.33	1579.66
max. depth of water, m	2.68	3.10
avg. depth of water, m	1.22	1.03
avg. velocity, m/s	0.51	0.45

Cross-section



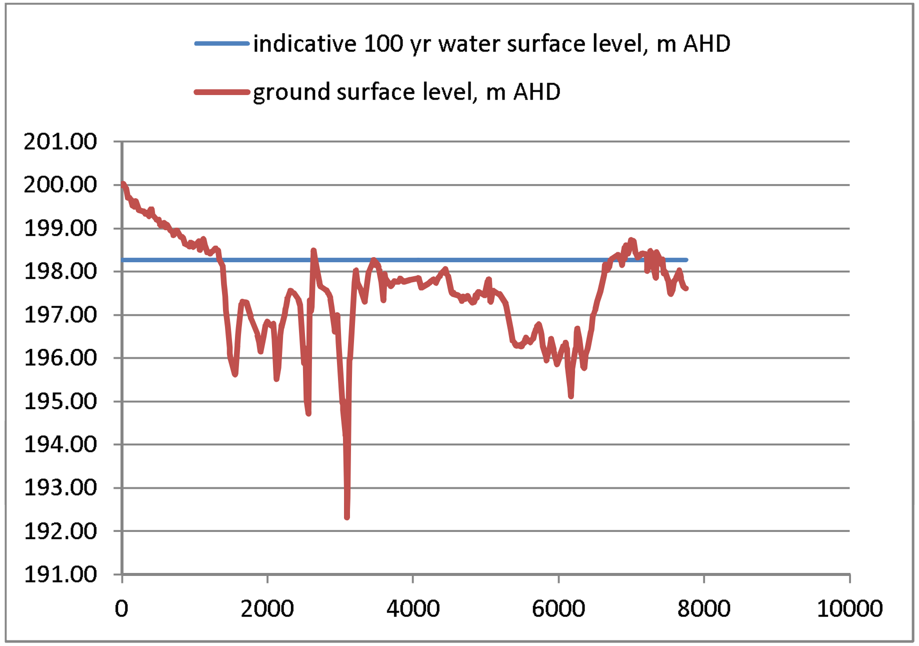
Existing water level calculation - Carmichael Mine Railway

Chainage 31.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	2572.1	3336.0
slope estimated from LIDAR, m/m	0.0005	0.0005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	198.07	198.27
min. ground level, m AHD	192.31	192.31
top width, m	5454.36	5815.37
area, m^2	5631.52	6753.11
max. depth of water, m	5.76	5.96
avg. depth of water, m	1.03	1.16
avg. velocity, m/s	0.46	0.49

Cross-section



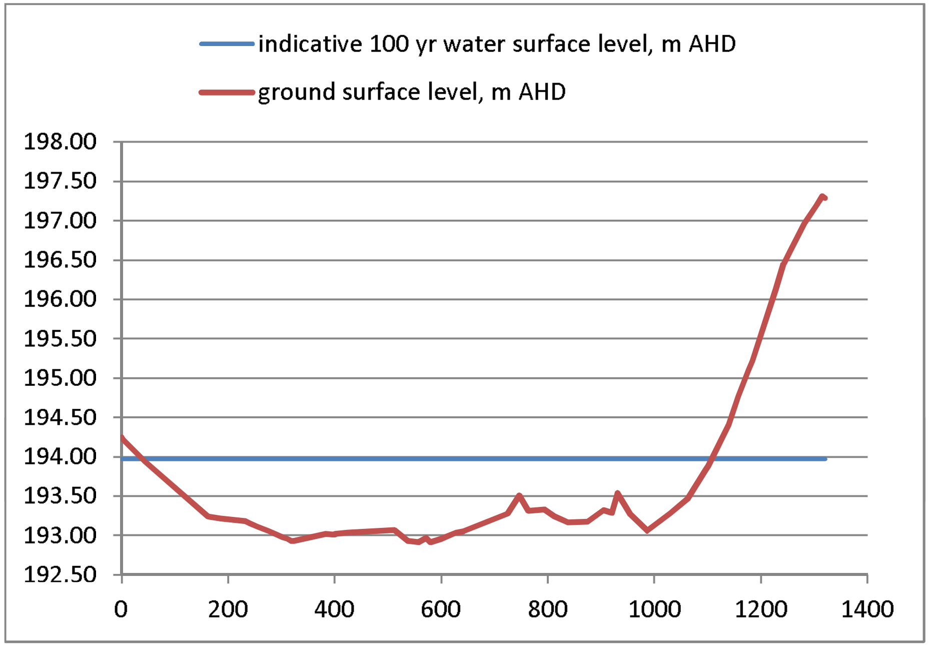
Existing water level calculation - Carmichael Mine Railway

Chainage 41.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	310.5	397.6
slope estimated from LIDAR, m/m	0.0009	0.0009
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	193.86	193.97
min. ground level, m AHD	192.92	192.92
top width, m	1039.76	1067.00
area, m^2	684.12	801.71
max. depth of water, m	0.94	1.05
avg. depth of water, m	0.66	0.75
avg. velocity, m/s	0.45	0.50

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 42.1

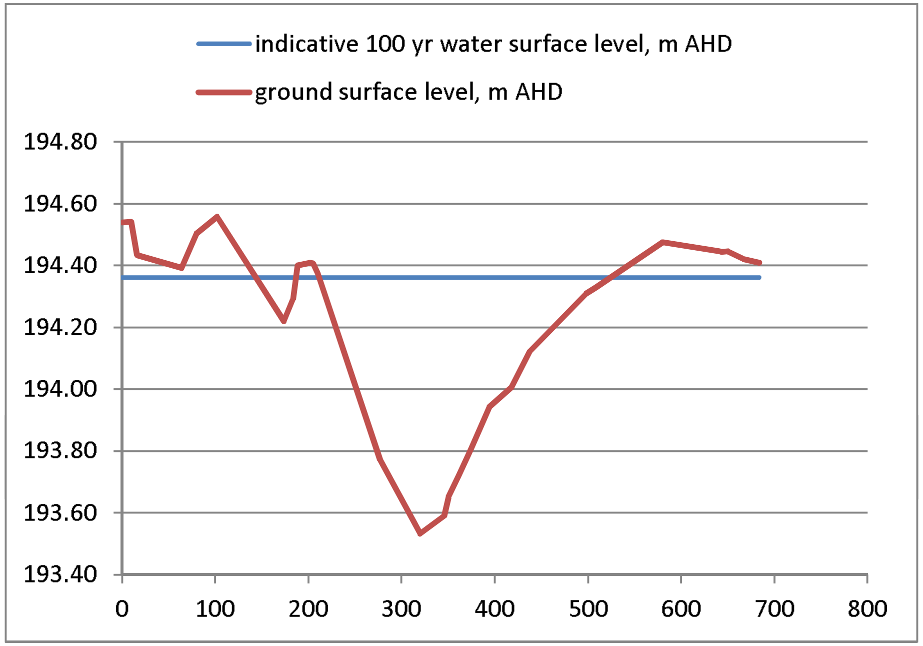
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	34.2	38.1
slope estimated from LIDAR, m/m	0.0009	0.0009
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	194.33	194.36
min. ground level, m AHD	193.53	193.53
top width, m	323.94	355.50
area, m^2	114.13	126.51
max. depth of water, m	0.79	0.83
avg. depth of water, m	0.35	0.36
avg. velocity, m/s	0.30	0.30

Cross-section



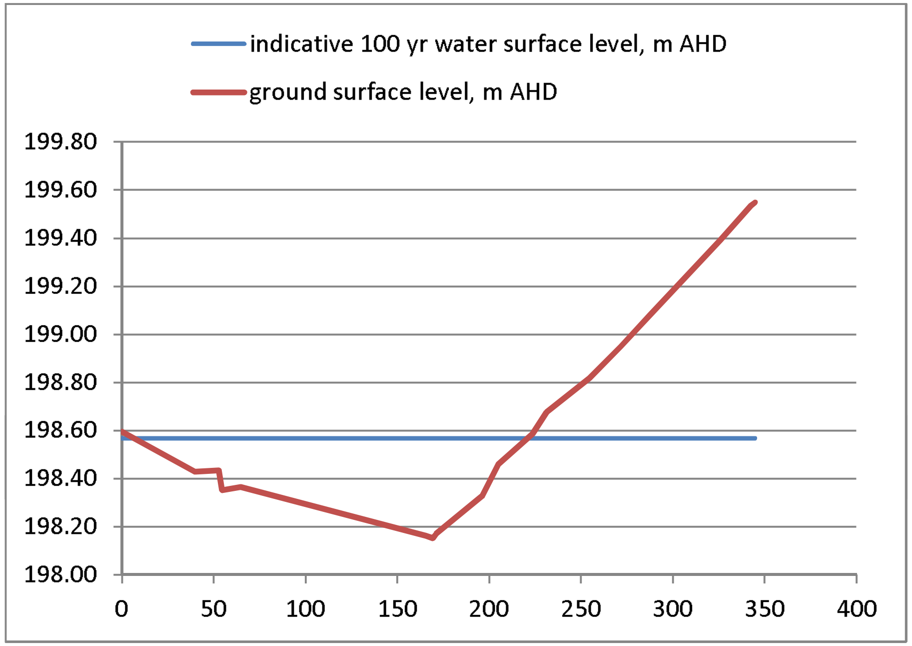
Existing water level calculation - Carmichael Mine Railway

Chainage 44.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	24.1	26.8
slope estimated from LIDAR, m/m	0.005	0.005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	198.55	198.57
min. ground level, m AHD	198.15	198.15
top width, m	207.61	214.45
area, m^2	46.30	50.04
max. depth of water, m	0.40	0.42
avg. depth of water, m	0.22	0.23
avg. velocity, m/s	0.52	0.54

Cross-section

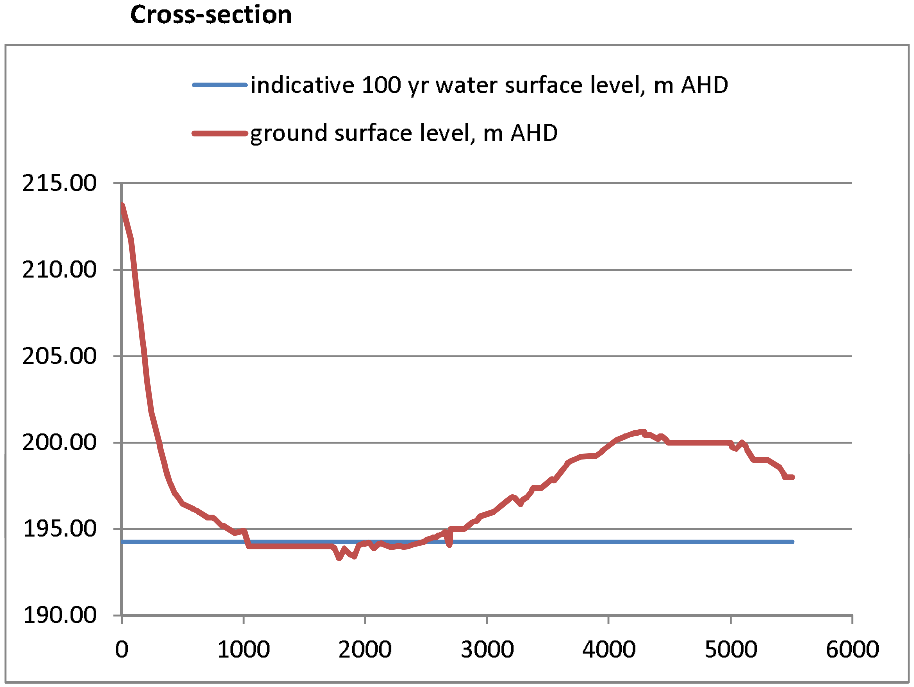


Existing water level calculation - Carmichael Mine Railway

Chainage 47.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	151.4	169.8
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	194.25	194.27
min. ground level, m AHD	193.31	193.31
top width, m	1457.09	1462.48
area, m^2	400.46	429.69
max. depth of water, m	0.93	0.95
avg. depth of water, m	0.27	0.29
avg. velocity, m/s	0.38	0.40



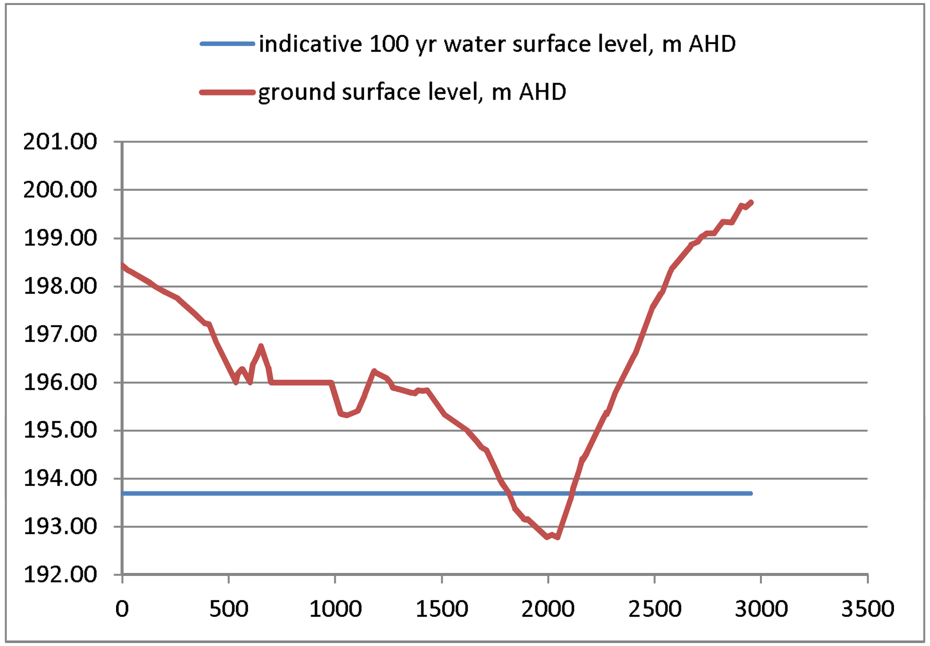
Existing water level calculation - Carmichael Mine Railway

Chainage 53.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	97.7	109.4
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	193.65	193.69
min. ground level, m AHD	192.77	192.77
top width, m	291.68	297.98
area, m^2	161.76	174.64
max. depth of water, m	0.87	0.92
avg. depth of water, m	0.55	0.59
avg. velocity, m/s	0.60	0.63

Cross-section



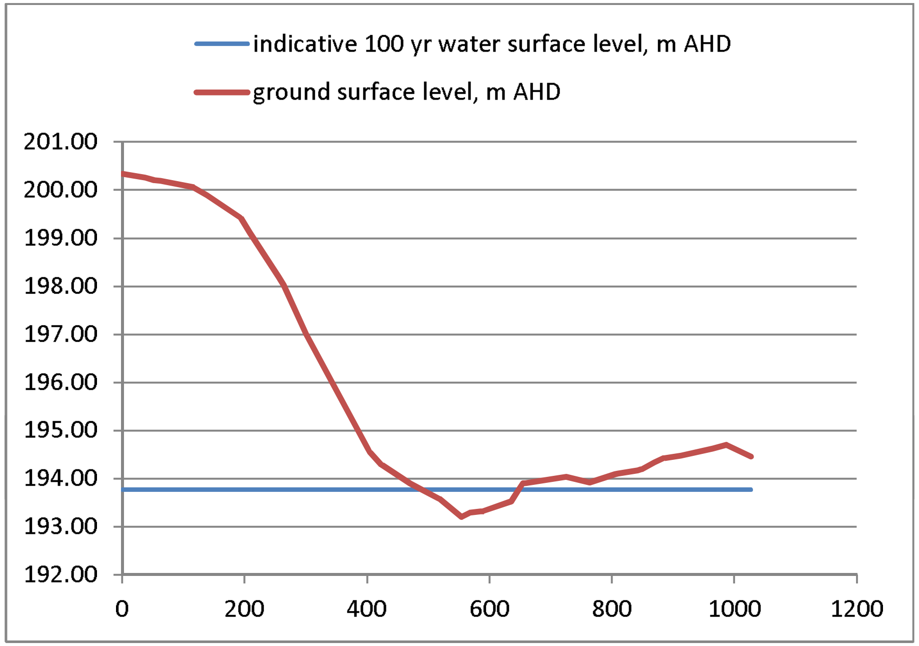
Existing water level calculation - Carmichael Mine Railway

Chainage 56.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	27.1	30.2
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	193.74	193.77
min. ground level, m AHD	193.20	193.20
top width, m	152.72	157.69
area, m^2	47.03	50.82
max. depth of water, m	0.54	0.57
avg. depth of water, m	0.31	0.32
avg. velocity, m/s	0.58	0.59

Cross-section



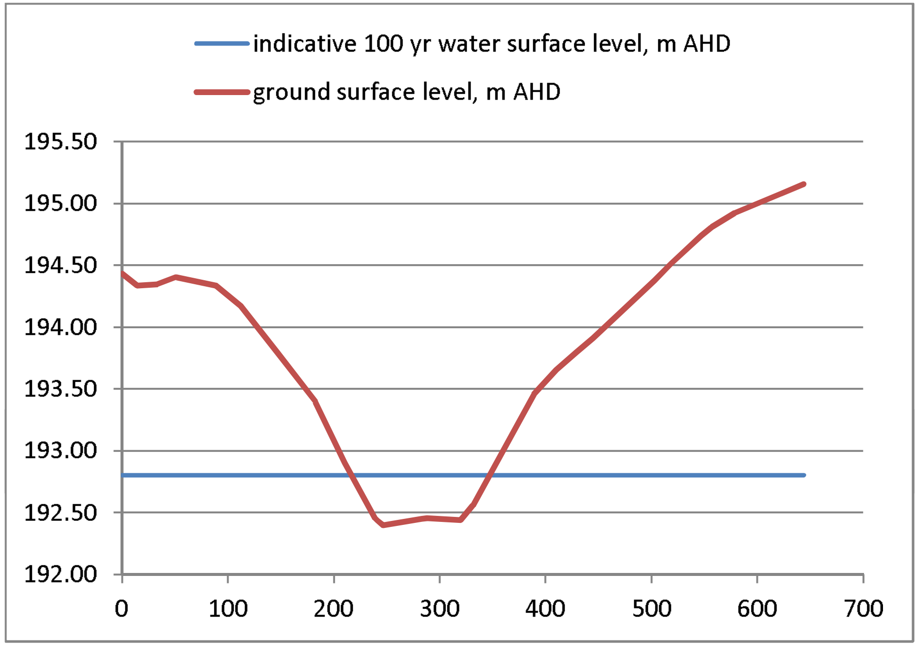
Existing water level calculation - Carmichael Mine Railway

Chainage 57.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	19.9	22.2
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	192.78	192.80
min. ground level, m AHD	192.40	192.40
top width, m	127.64	130.38
area, m^2	36.37	39.15
max. depth of water, m	0.38	0.40
avg. depth of water, m	0.28	0.30
avg. velocity, m/s	0.55	0.57

Cross-section



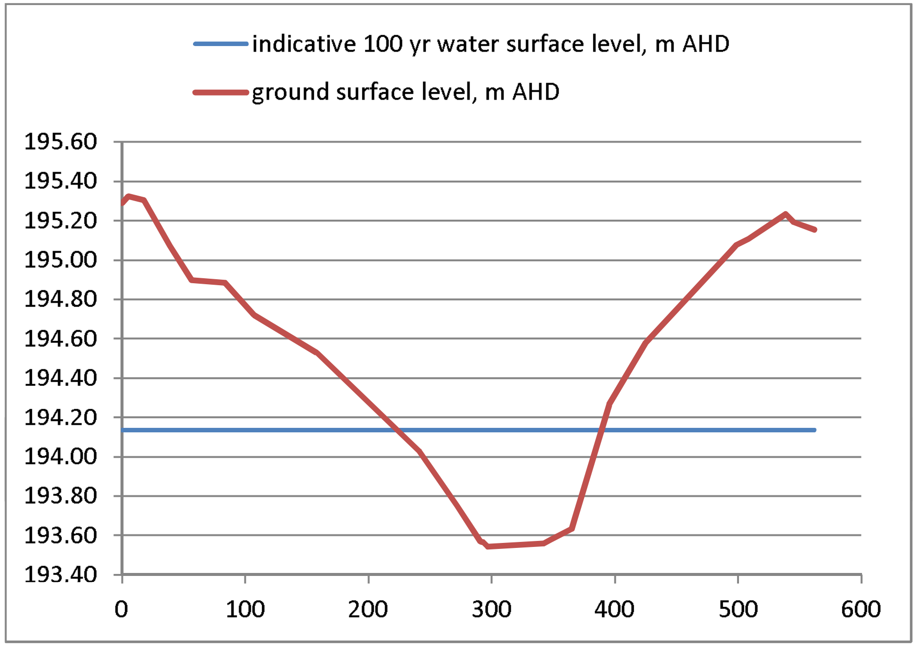
Existing water level calculation - Carmichael Mine Railway

Chainage 58.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	28.7	31.9
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	194.11	194.14
min. ground level, m AHD	193.54	193.54
top width, m	159.13	166.00
area, m^2	60.82	66.03
max. depth of water, m	0.56	0.59
avg. depth of water, m	0.38	0.40
avg. velocity, m/s	0.47	0.48

Cross-section



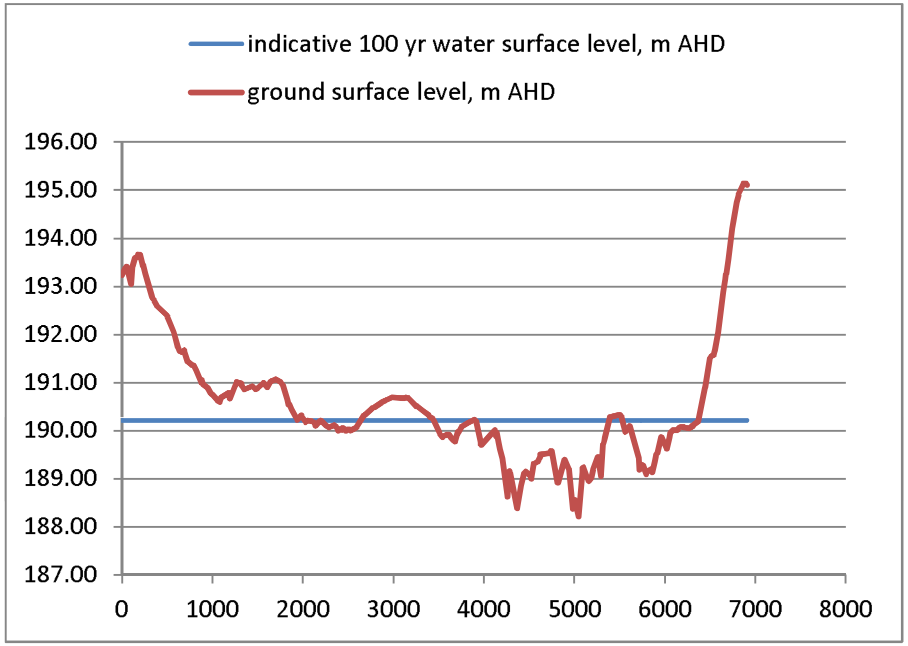
Existing water level calculation - Carmichael Mine Railway

Chainage 58.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	640.0	697.0
slope estimated from LIDAR, m/m	0.0007	0.0007
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	190.16	190.21
min. ground level, m AHD	188.21	188.21
top width, m	3083.44	3385.35
area, m^2	1758.84	1921.27
max. depth of water, m	1.95	2.00
avg. depth of water, m	0.57	0.57
avg. velocity, m/s	0.36	0.36

Cross-section



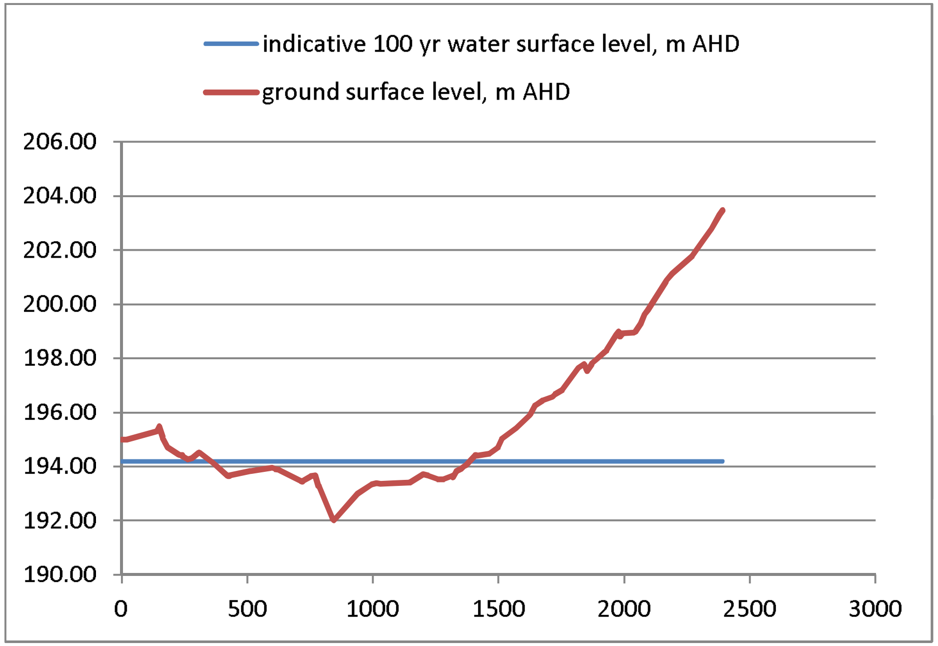
Existing water level calculation - Carmichael Mine Railway

Chainage 67.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	346.0	435.2
slope estimated from LIDAR, m/m	0.0013	0.0013
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	194.10	194.20
min. ground level, m AHD	192.02	192.02
top width, m	1005.38	1029.26
area, m^2	645.02	747.24
max. depth of water, m	2.09	2.19
avg. depth of water, m	0.64	0.73
avg. velocity, m/s	0.54	0.58

Cross-section



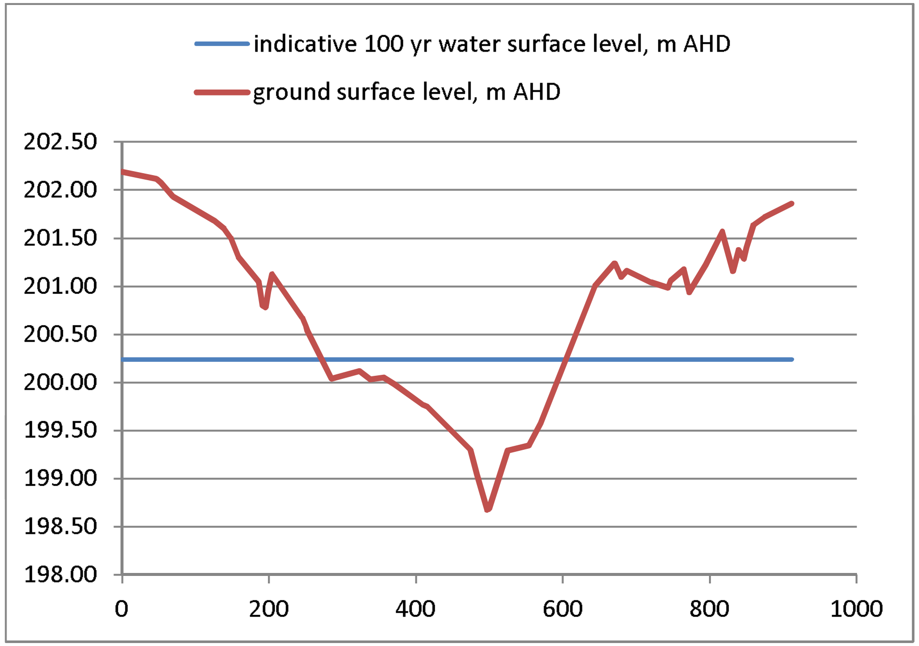
Existing water level calculation - Carmichael Mine Railway

Chainage 70.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	105.6	118.1
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	200.20	200.24
min. ground level, m AHD	198.67	198.67
top width, m	327.48	332.26
area, m^2	177.56	190.96
max. depth of water, m	1.53	1.57
avg. depth of water, m	0.54	0.57
avg. velocity, m/s	0.59	0.62

Cross-section



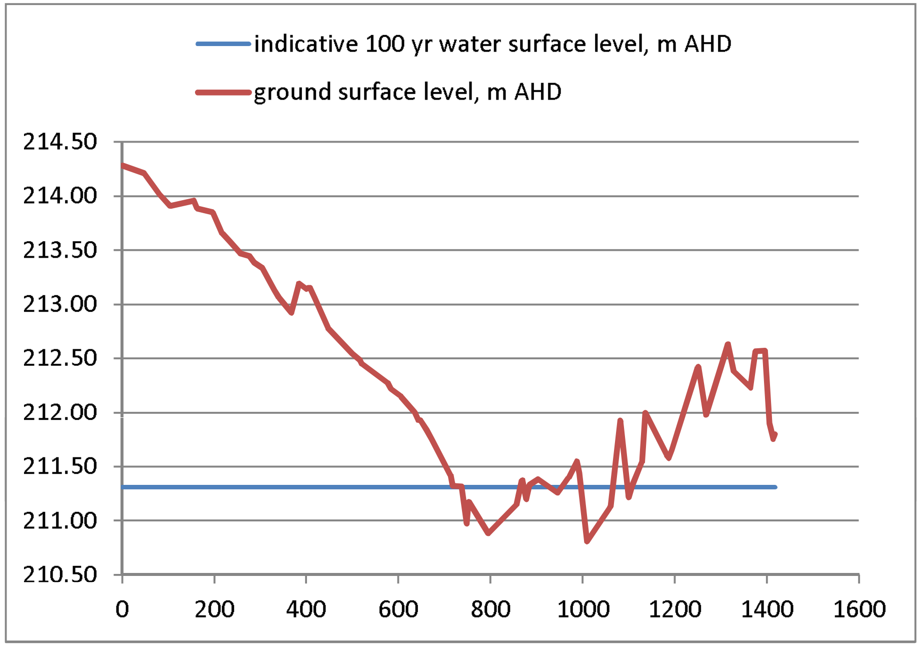
Existing water level calculation - Carmichael Mine Railway

Chainage 74.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	22.5	25.1
slope estimated from LIDAR, m/m	0.0035	0.0035
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	211.29	211.31
min. ground level, m AHD	210.81	210.81
top width, m	222.60	241.34
area, m^2	50.82	56.04
max. depth of water, m	0.48	0.50
avg. depth of water, m	0.23	0.23
avg. velocity, m/s	0.44	0.45

Cross-section



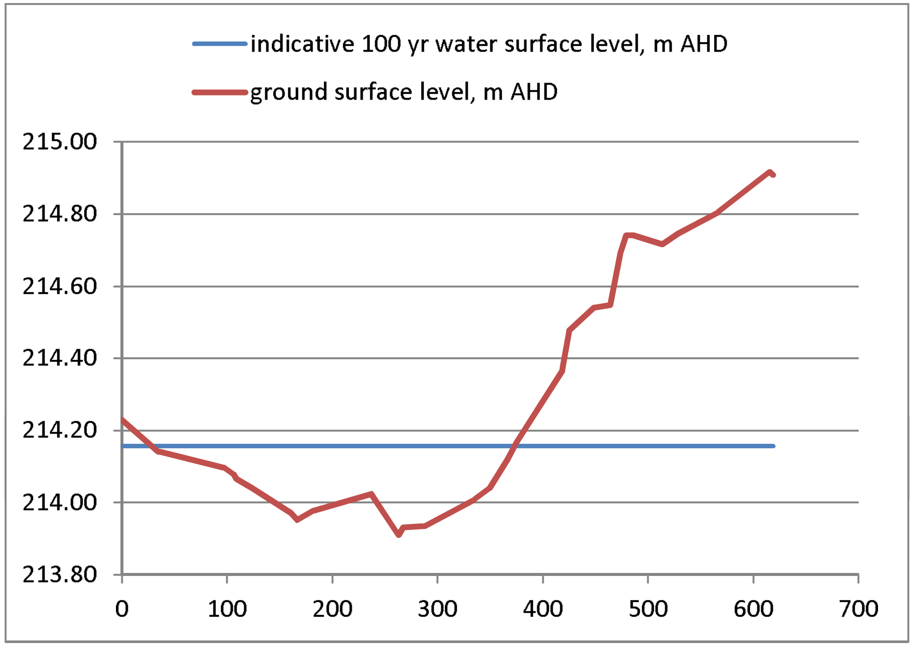
Existing water level calculation - Carmichael Mine Railway

Chainage 75.5

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	13.4	15.0
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	214.15	214.16
min. ground level, m AHD	213.91	213.91
top width, m	339.44	344.69
area, m^2	42.48	45.61
max. depth of water, m	0.24	0.25
avg. depth of water, m	0.13	0.13
avg. velocity, m/s	0.32	0.33

Cross-section



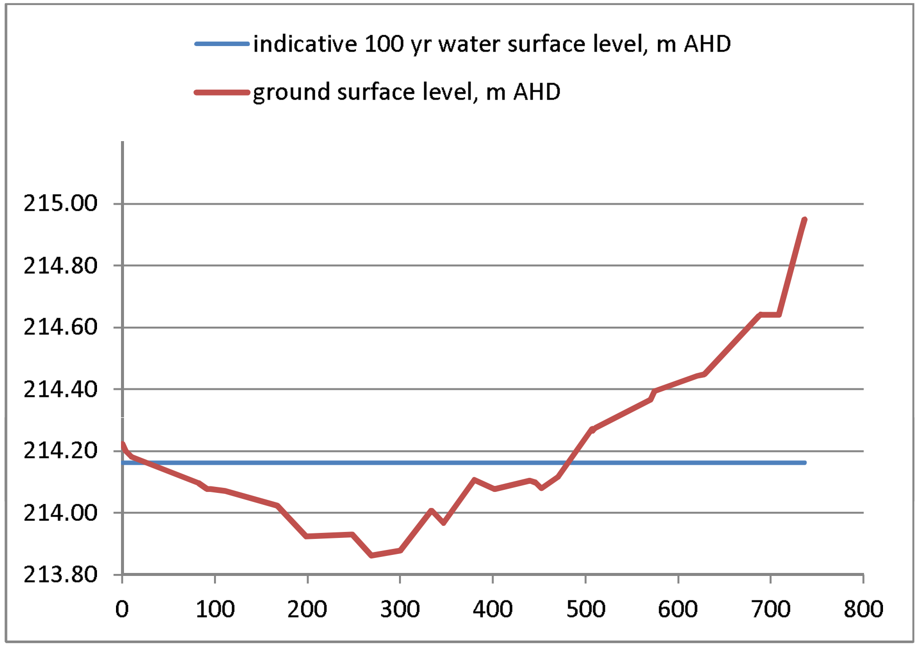
Existing water level calculation - Carmichael Mine Railway

Chainage 76

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	16.7	18.6
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	214.15	214.16
min. ground level, m AHD	213.86	213.86
top width, m	443.76	454.92
area, m^2	58.63	63.26
max. depth of water, m	0.29	0.30
avg. depth of water, m	0.13	0.14
avg. velocity, m/s	0.28	0.29

Cross-section



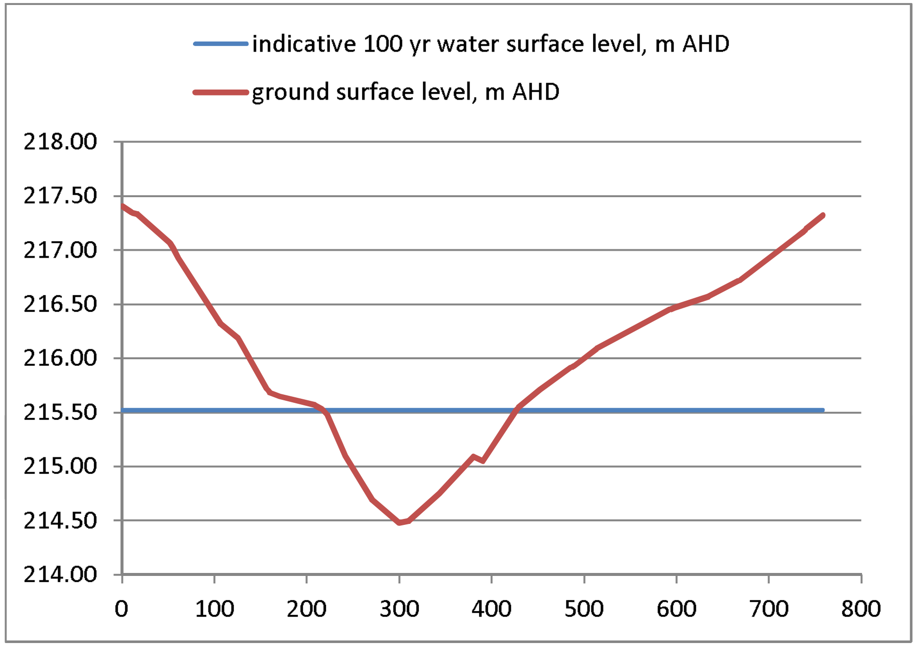
Existing water level calculation - Carmichael Mine Railway

Chainage 76.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	88.0	98.3
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	215.47	215.52
min. ground level, m AHD	214.48	214.48
top width, m	200.00	209.31
area, m^2	115.70	125.96
max. depth of water, m	0.99	1.04
avg. depth of water, m	0.58	0.60
avg. velocity, m/s	0.76	0.78

Cross-section



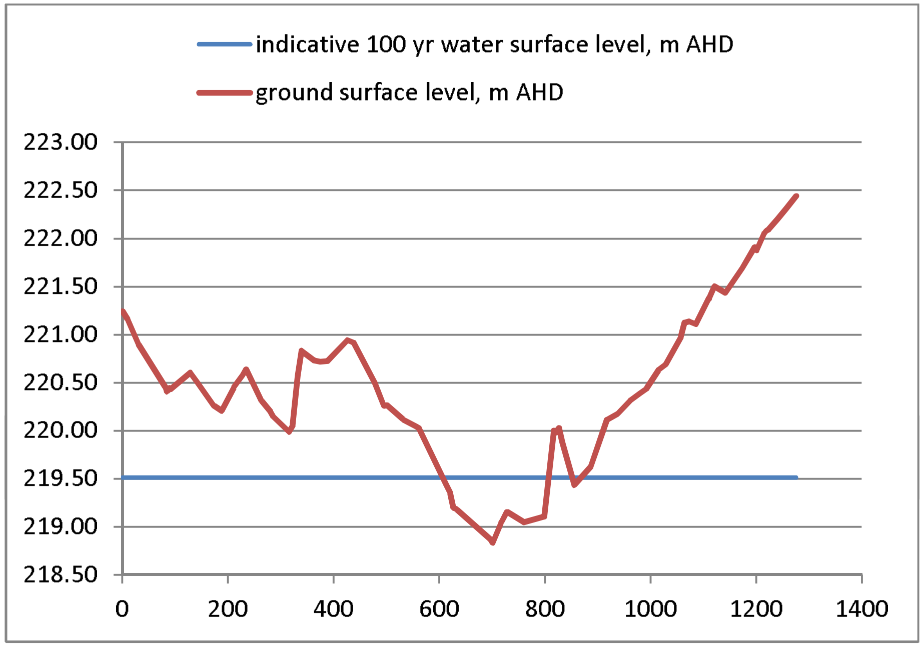
Existing water level calculation - Carmichael Mine Railway

Chainage 77.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	43.9	49.0
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	219.48	219.51
min. ground level, m AHD	218.83	218.83
top width, m	205.10	215.84
area, m^2	77.03	83.97
max. depth of water, m	0.64	0.68
avg. depth of water, m	0.38	0.39
avg. velocity, m/s	0.57	0.58

Cross-section



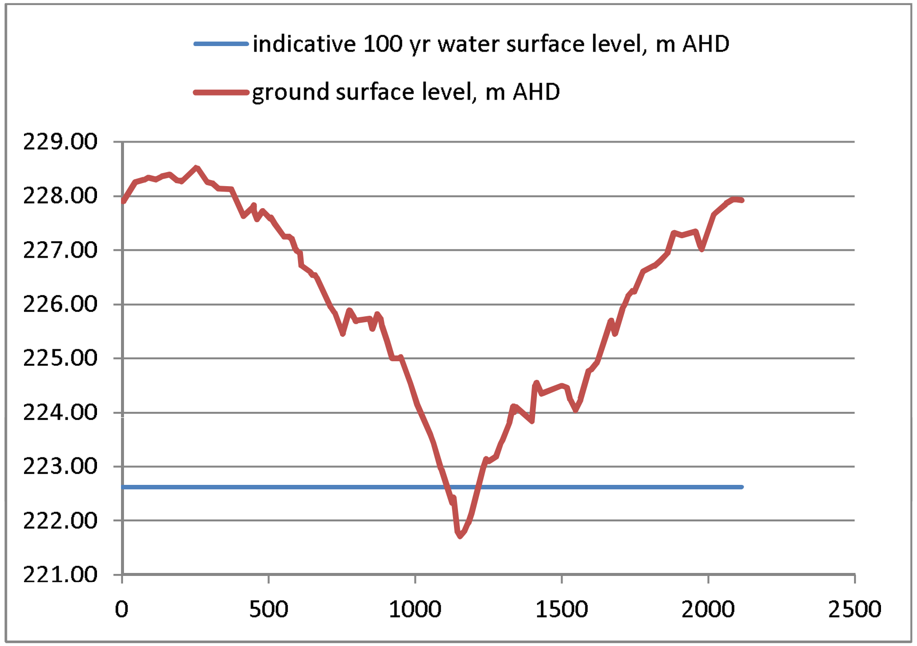
Existing water level calculation - Carmichael Mine Railway

Chainage 80.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

	ARI 50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	37.5	41.9
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	222.59	222.63
min. ground level, m AHD	221.71	221.71
top width, m	102.94	107.30
area, m^2	48.82	53.01
max. depth of water, m	0.88	0.92
avg. depth of water, m	0.47	0.49
avg. velocity, m/s	0.77	0.79

Cross-section



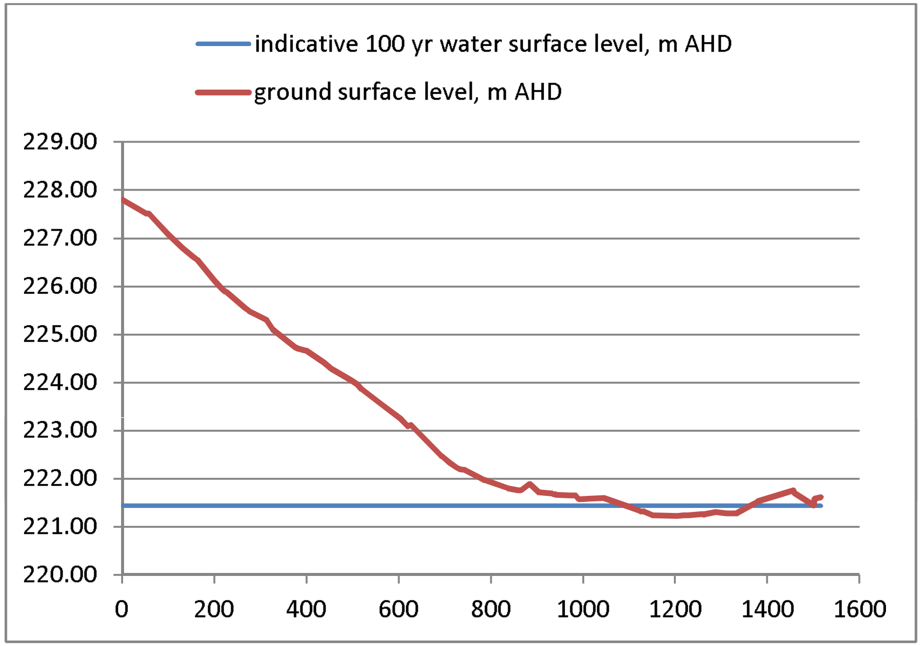
Existing water level calculation - Carmichael Mine Railway

Chainage 82.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	14.4	16.1
slope estimated from LIDAR, m/m	0.005	0.005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	221.42	221.44
min. ground level, m AHD	221.23	221.23
top width, m	262.97	268.21
area, m^2	37.40	40.24
max. depth of water, m	0.20	0.21
avg. depth of water, m	0.14	0.15
avg. velocity, m/s	0.39	0.40

Cross-section



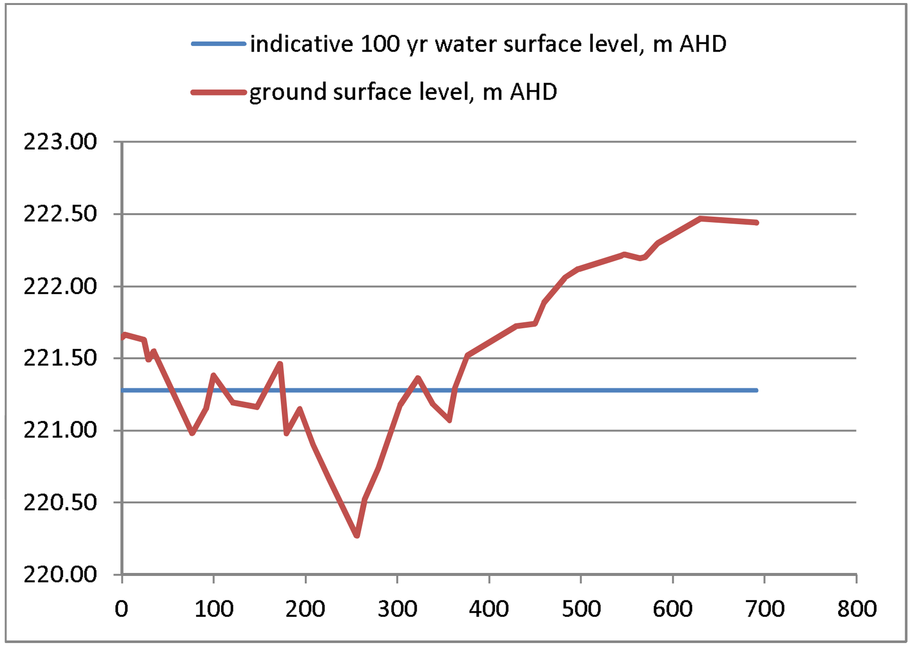
Existing water level calculation - Carmichael Mine Railway

Chainage 83.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	41.3	46.2
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	221.25	221.28
min. ground level, m AHD	220.27	220.27
top width, m	242.55	257.41
area, m^2	72.88	79.79
max. depth of water, m	0.98	1.01
avg. depth of water, m	0.30	0.31
avg. velocity, m/s	0.57	0.58

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 85.4

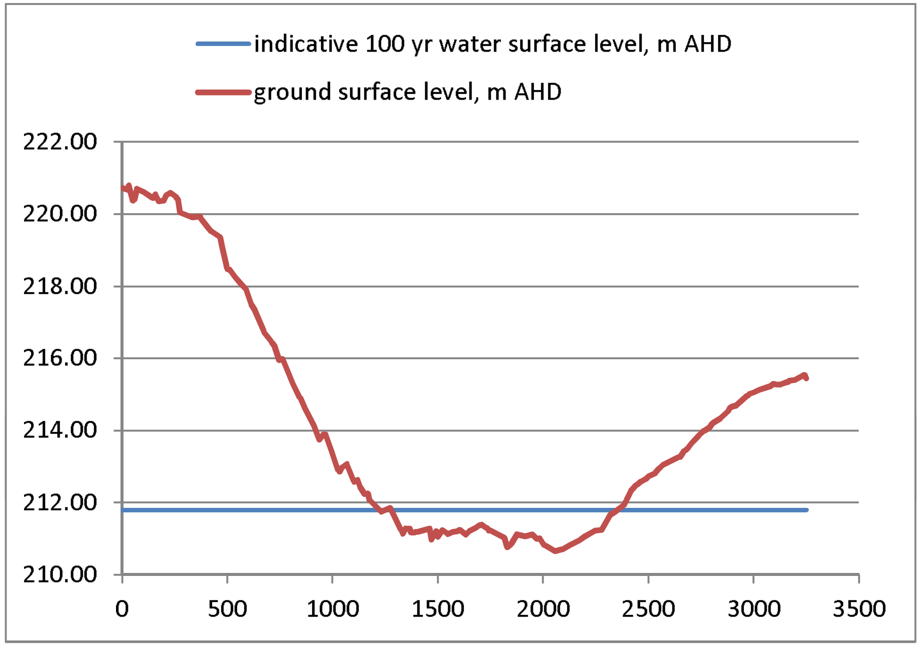
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	299.9	336.3
slope estimated from LIDAR, m/m	0.001	0.001
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	211.74	211.79
min. ground level, m AHD	210.65	210.65
top width, m	1056.64	1101.40
area, m^2	653.42	711.57
max. depth of water, m	1.09	1.15
avg. depth of water, m	0.62	0.65
avg. velocity, m/s	0.46	0.47

Cross-section



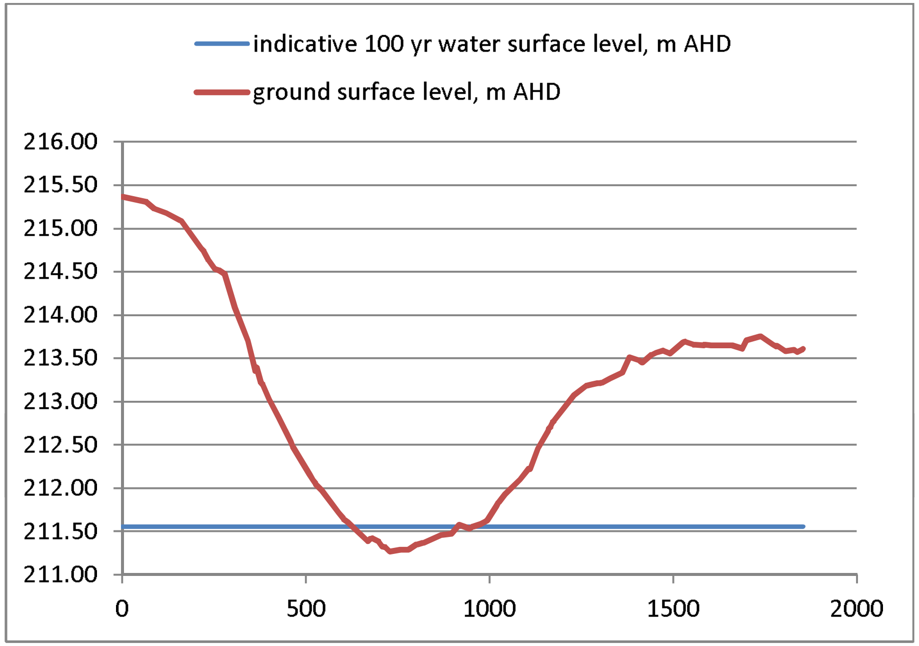
Existing water level calculation - Carmichael Mine Railway

Chainage 87.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	16.0	17.9
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	211.54	211.56
min. ground level, m AHD	211.27	211.27
top width, m	293.09	313.02
area, m^2	44.54	48.82
max. depth of water, m	0.28	0.29
avg. depth of water, m	0.15	0.16
avg. velocity, m/s	0.36	0.37

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 91

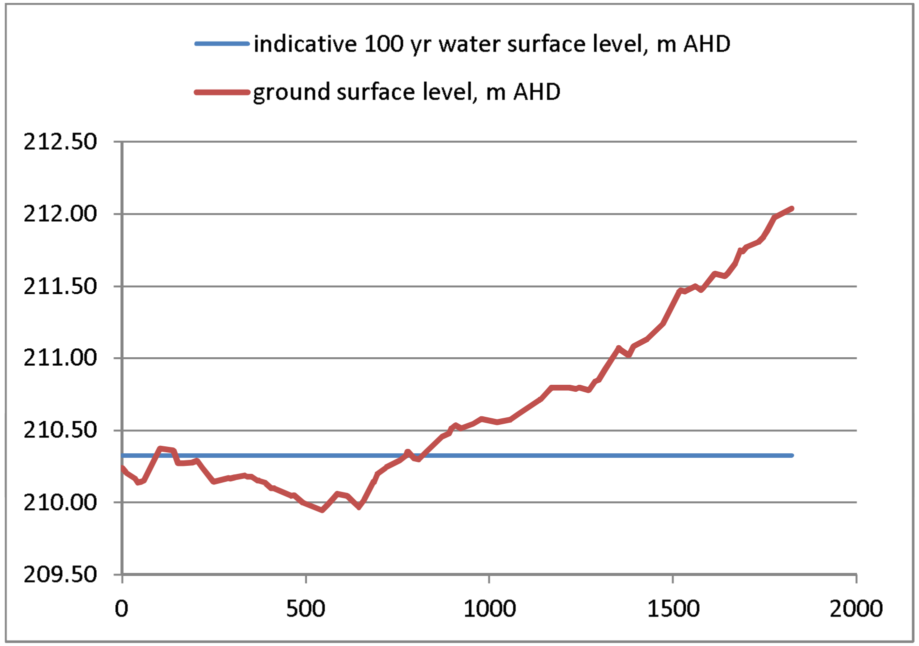
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	35.2	39.3
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	210.31	210.33
min. ground level, m AHD	209.95	209.95
top width, m	734.03	753.92
area, m^2	126.82	136.91
max. depth of water, m	0.37	0.38
avg. depth of water, m	0.17	0.18
avg. velocity, m/s	0.28	0.29

Cross-section



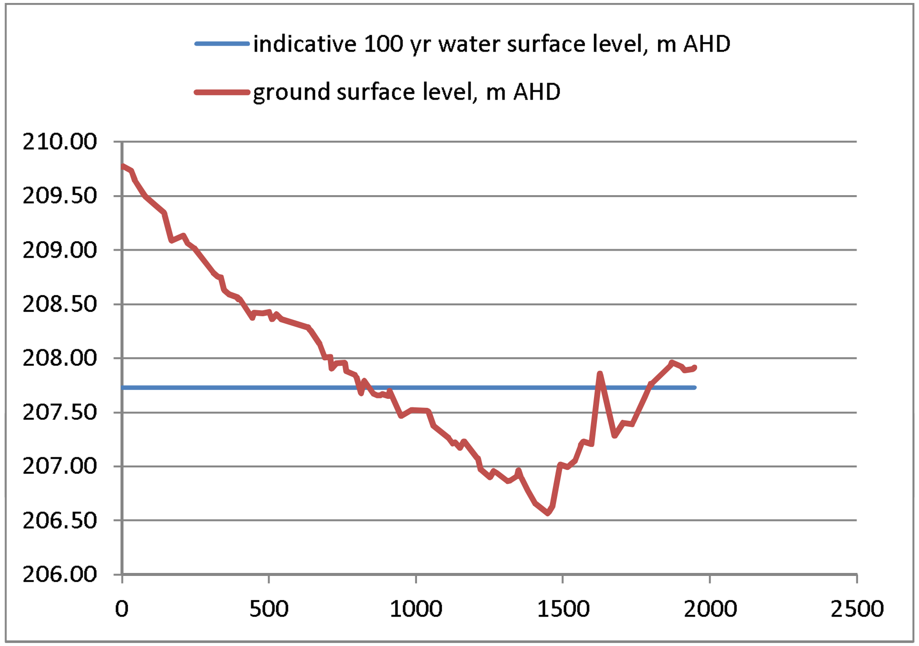
Existing water level calculation - Carmichael Mine Railway

Chainage 93.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	241.9	271.4
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	207.69	207.73
min. ground level, m AHD	206.57	206.57
top width, m	912.49	944.89
area, m^2	439.80	477.92
max. depth of water, m	1.12	1.16
avg. depth of water, m	0.48	0.51
avg. velocity, m/s	0.55	0.57

Cross-section



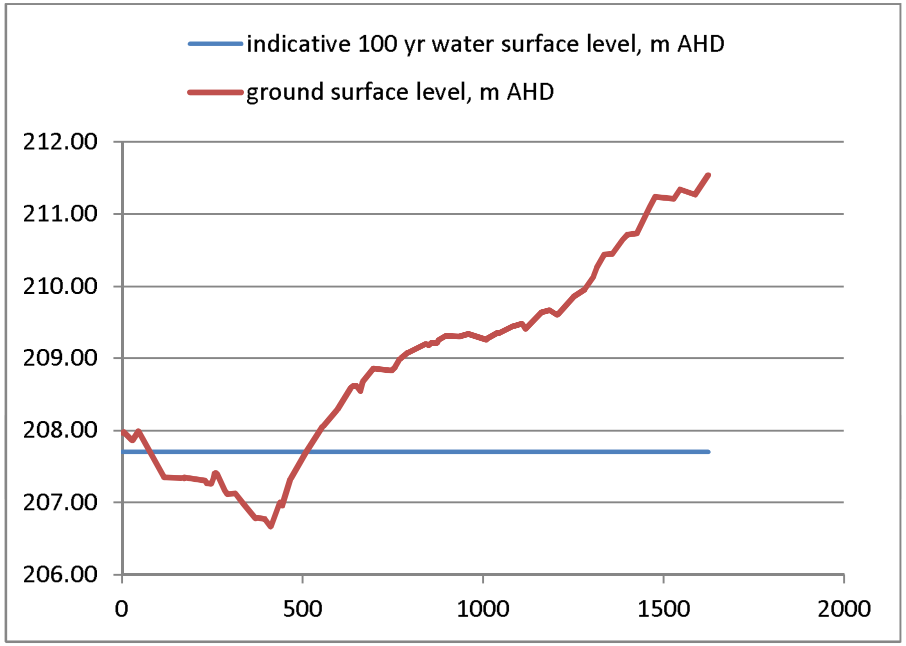
Existing water level calculation - Carmichael Mine Railway

Chainage 94.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

	ARI 50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	134.2	150.4
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	207.67	207.70
min. ground level, m AHD	206.67	206.67
top width, m	425.23	433.84
area, m^2	201.57	217.54
max. depth of water, m	1.00	1.04
avg. depth of water, m	0.47	0.50
avg. velocity, m/s	0.67	0.69

Cross-section



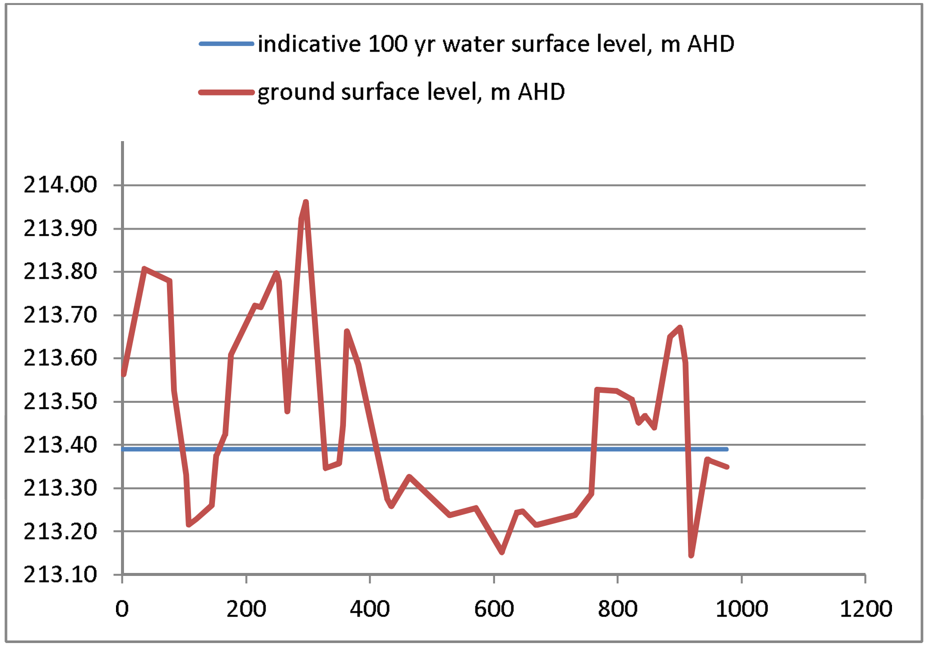
Existing water level calculation - Carmichael Mine Railway

Chainage 98.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	13.8	15.4
slope estimated from LIDAR, m/m	0.0025	0.0025
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	213.38	213.39
min. ground level, m AHD	213.14	213.14
top width, m	492.64	498.73
area, m^2	57.64	61.80
max. depth of water, m	0.24	0.25
avg. depth of water, m	0.12	0.12
avg. velocity, m/s	0.24	0.25

Cross-section



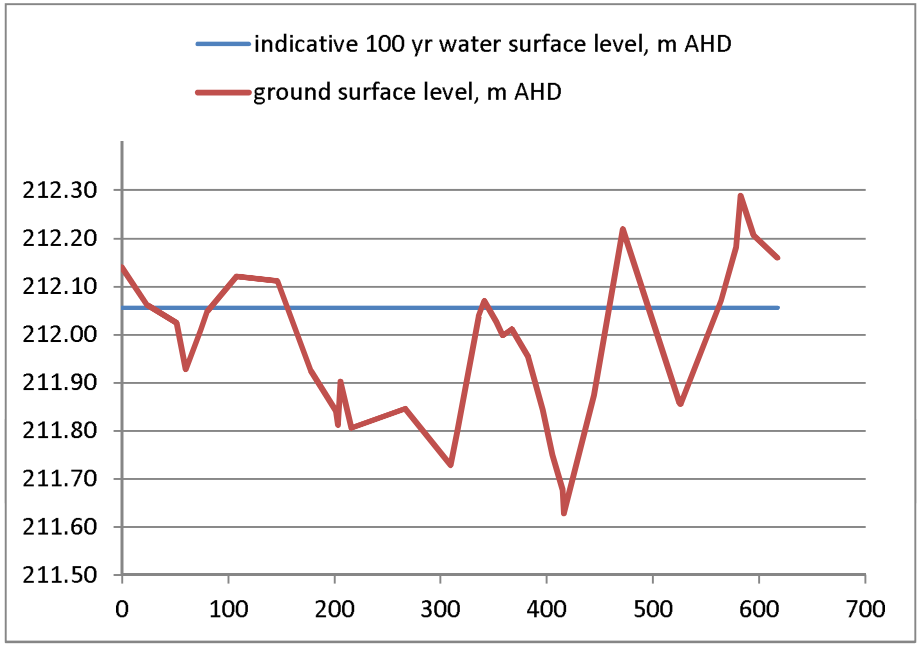
Existing water level calculation - Carmichael Mine Railway

Chainage 99.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	21.7	24.2
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	212.04	212.06
min. ground level, m AHD	211.63	211.63
top width, m	388.62	418.22
area, m^2	59.79	65.71
max. depth of water, m	0.41	0.43
avg. depth of water, m	0.15	0.16
avg. velocity, m/s	0.36	0.37

Cross-section

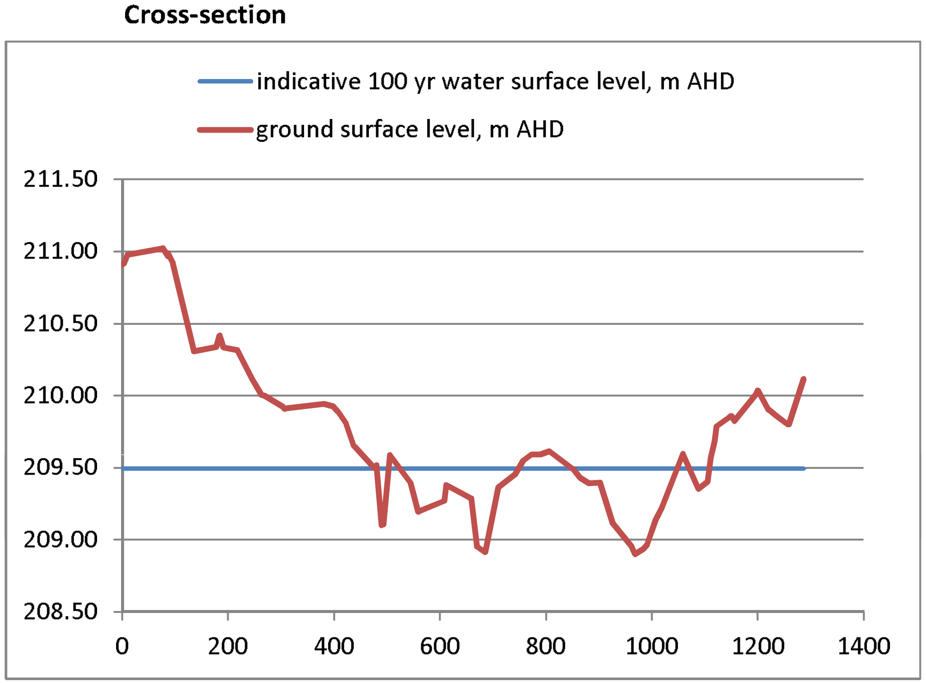


Existing water level calculation - Carmichael Mine Railway

Chainage 100.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	43.1	48.2
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	209.47	209.49
min. ground level, m AHD	208.90	208.90
top width, m	462.64	480.36
area, m^2	105.45	114.53
max. depth of water, m	0.57	0.59
avg. depth of water, m	0.23	0.24
avg. velocity, m/s	0.41	0.42



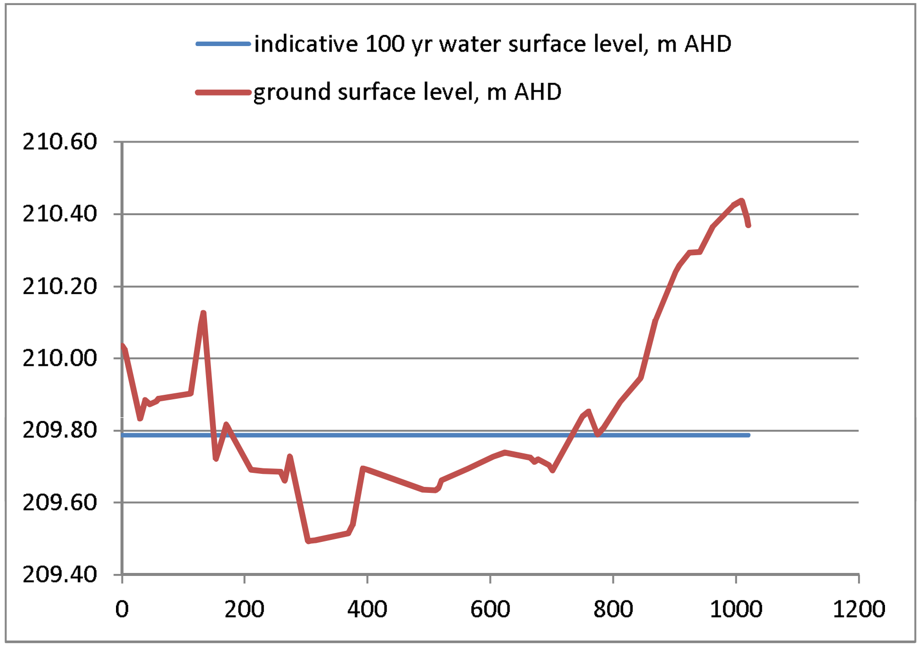
Existing water level calculation - Carmichael Mine Railway

Chainage 101.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	11.7	13.0
slope estimated from LIDAR, m/m	0.0015	0.0015
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	209.78	209.79
min. ground level, m AHD	209.49	209.49
top width, m	562.21	569.57
area, m^2	64.06	68.81
max. depth of water, m	0.29	0.29
avg. depth of water, m	0.11	0.12
avg. velocity, m/s	0.18	0.19

Cross-section



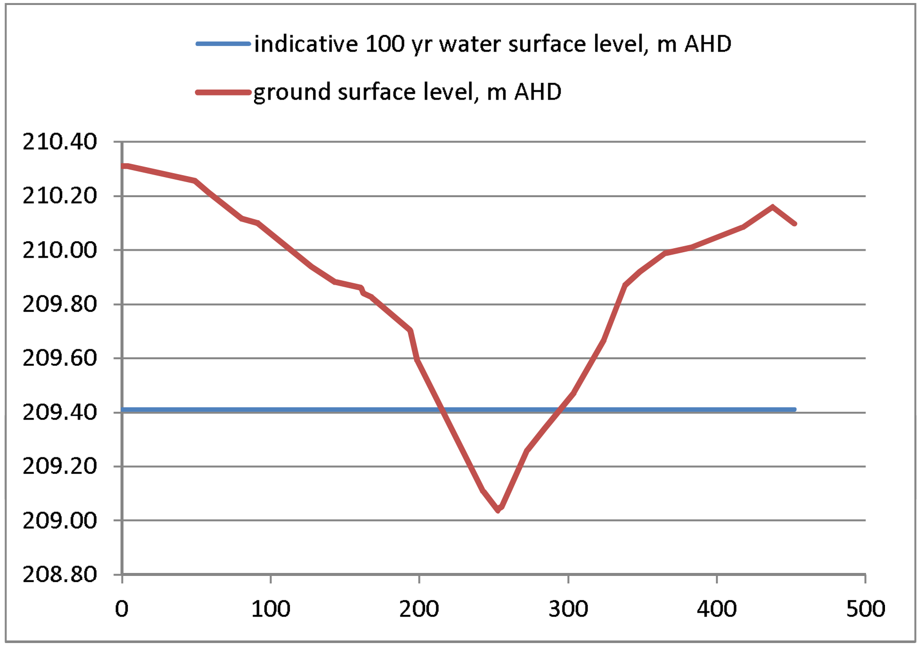
Existing water level calculation - Carmichael Mine Railway

Chainage 102.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	6.5	7.3
slope estimated from LIDAR, m/m	0.006	0.006
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	209.40	209.41
min. ground level, m AHD	209.04	209.04
top width, m	76.33	79.90
area, m^2	13.43	14.59
max. depth of water, m	0.36	0.37
avg. depth of water, m	0.18	0.18
avg. velocity, m/s	0.49	0.50

Cross-section

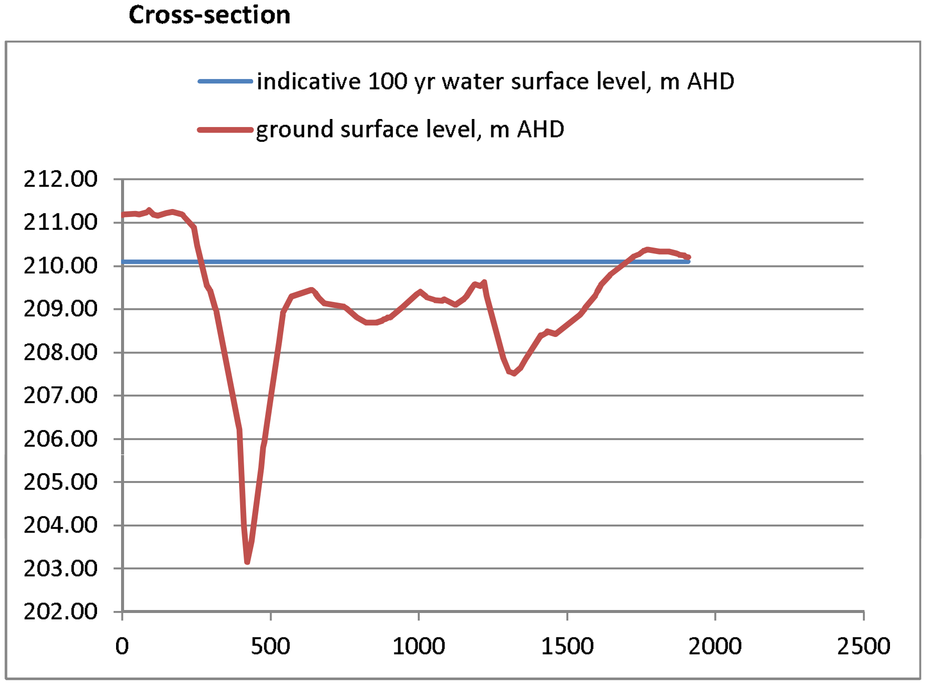


Existing water level calculation - Carmichael Mine Railway

Chainage 102.5

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	1006.3	1301.6
slope estimated from LIDAR, m/m	0.0005	0.0005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	209.86	210.10
min. ground level, m AHD	203.15	203.15
top width, m	1382.10	1437.96
area, m^2	1851.83	2195.54
max. depth of water, m	6.71	6.95
avg. depth of water, m	1.34	1.53
avg. velocity, m/s	0.54	0.59



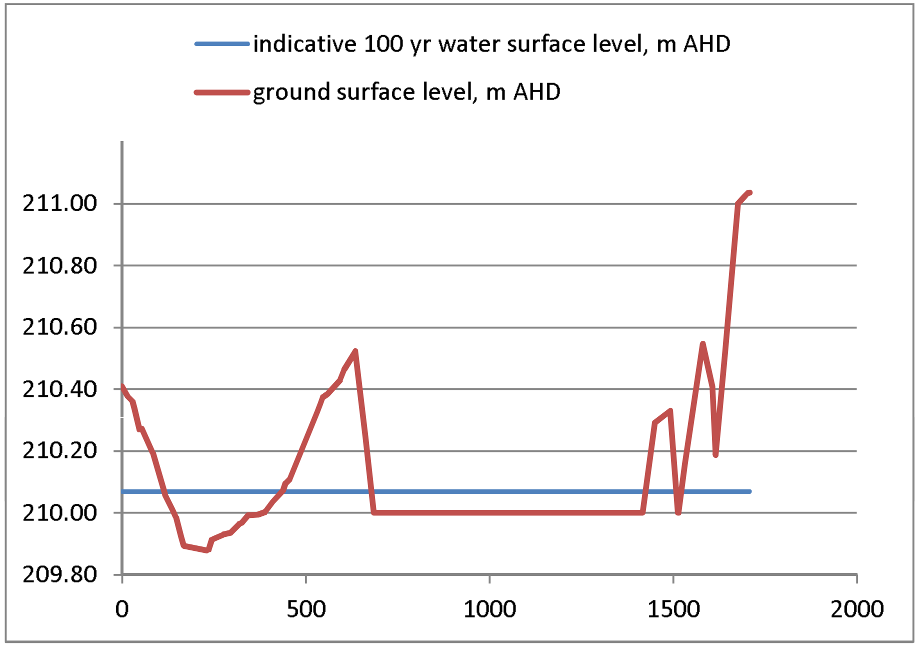
Existing water level calculation - Carmichael Mine Railway

Chainage 104.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	9.4	10.5
slope estimated from LIDAR, m/m	0.001	0.001
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	210.06	210.07
min. ground level, m AHD	209.88	209.88
top width, m	1074.49	1081.98
area, m^2	82.16	87.92
max. depth of water, m	0.19	0.19
avg. depth of water, m	0.08	0.08
avg. velocity, m/s	0.11	0.12

Cross-section



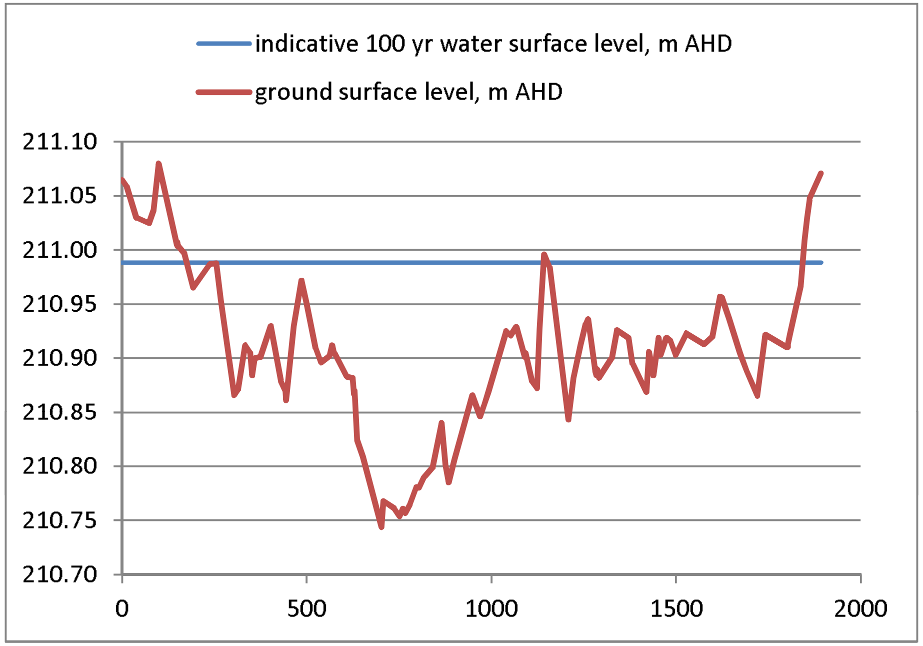
Existing water level calculation - Carmichael Mine Railway

Chainage 107

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	24.6	27.4
slope estimated from LIDAR, m/m	0.0015	0.0015
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	210.98	210.99
min. ground level, m AHD	210.74	210.74
top width, m	1608.91	1656.78
area, m^2	152.43	164.84
max. depth of water, m	0.24	0.24
avg. depth of water, m	0.09	0.10
avg. velocity, m/s	0.16	0.17

Cross-section



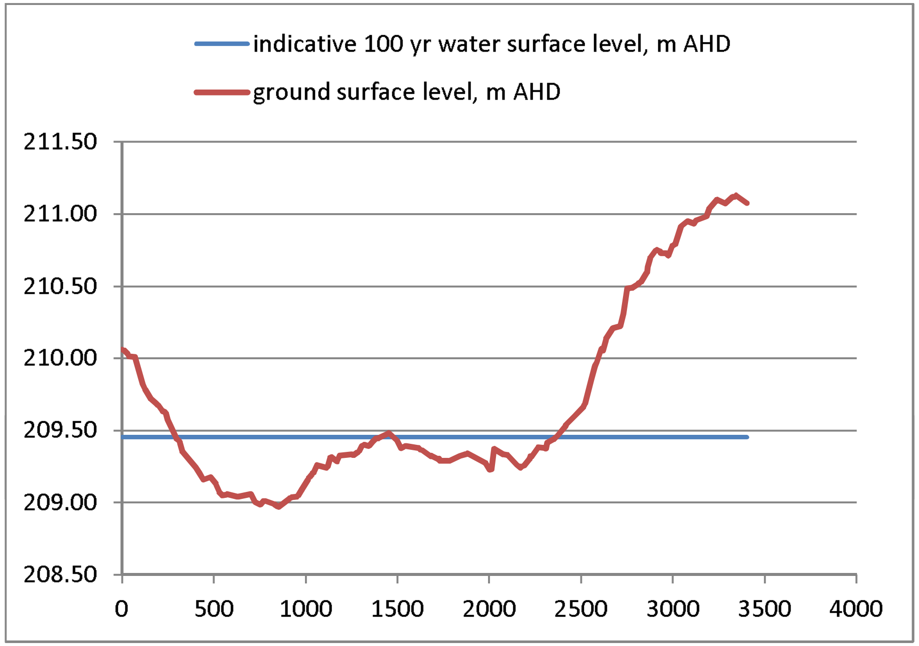
Existing water level calculation - Carmichael Mine Railway

Chainage 110.5

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	80.0	89.8
slope estimated from LIDAR, m/m	0.001	0.001
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	209.44	209.45
min. ground level, m AHD	208.97	208.97
top width, m	1932.31	1999.24
area, m^2	376.59	408.82
max. depth of water, m	0.46	0.48
avg. depth of water, m	0.19	0.20
avg. velocity, m/s	0.21	0.22

Cross-section



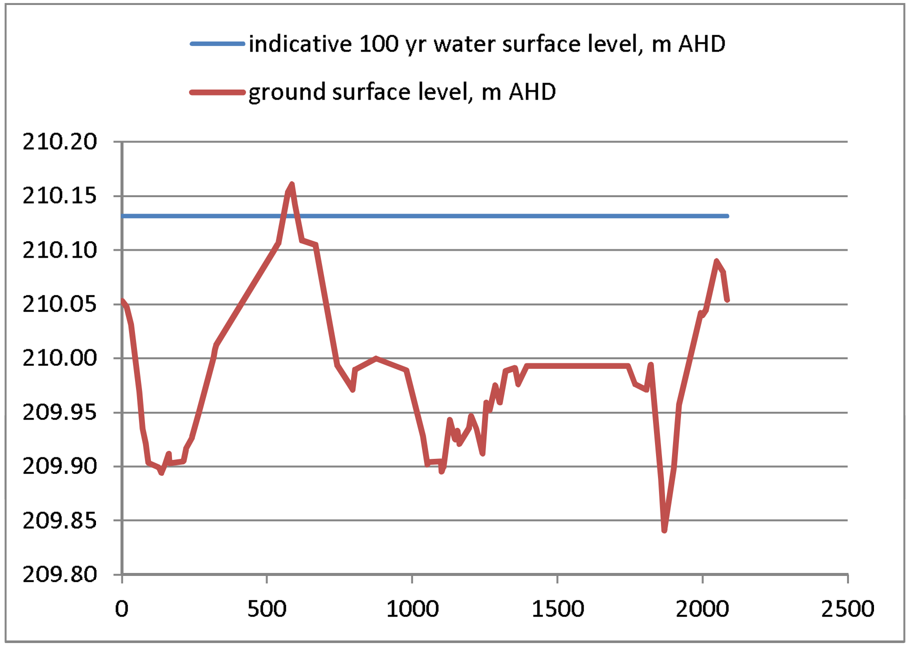
Existing water level calculation - Carmichael Mine Railway

Chainage 112.5

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	45.1	50.5
slope estimated from LIDAR, m/m	0.001	0.001
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	210.12	210.13
min. ground level, m AHD	209.84	209.84
top width, m	2022.90	2036.81
area, m^2	271.75	291.50
max. depth of water, m	0.28	0.29
avg. depth of water, m	0.13	0.14
avg. velocity, m/s	0.17	0.17

Cross-section



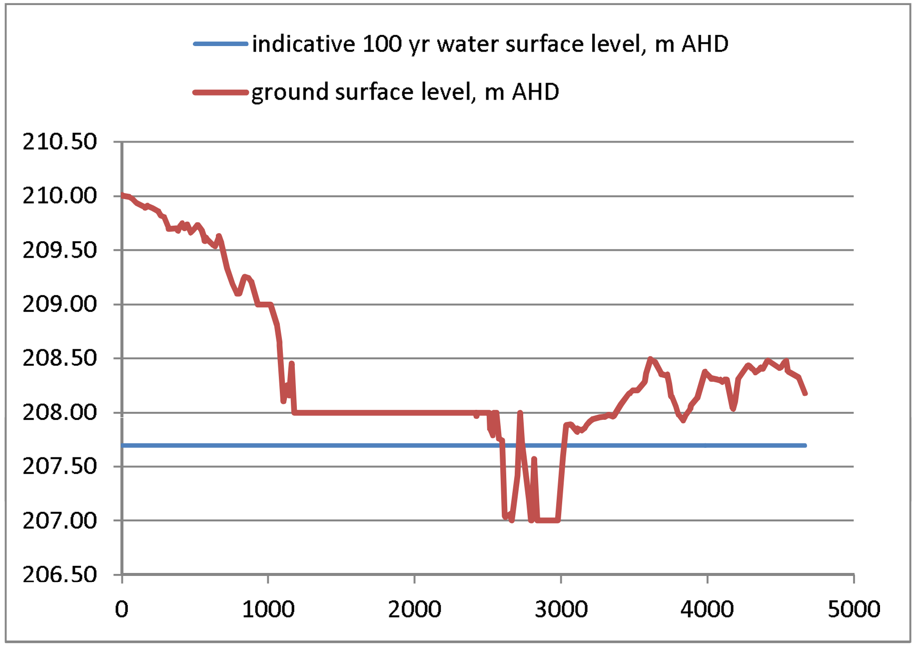
Existing water level calculation - Carmichael Mine Railway

Chainage 115.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	74.6	83.2
slope estimated from LIDAR, m/m	0.001	0.001
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	207.66	207.69
min. ground level, m AHD	207.00	207.00
top width, m	385.40	394.16
area, m^2	189.36	204.00
max. depth of water, m	0.66	0.69
avg. depth of water, m	0.49	0.52
avg. velocity, m/s	0.39	0.41

Cross-section



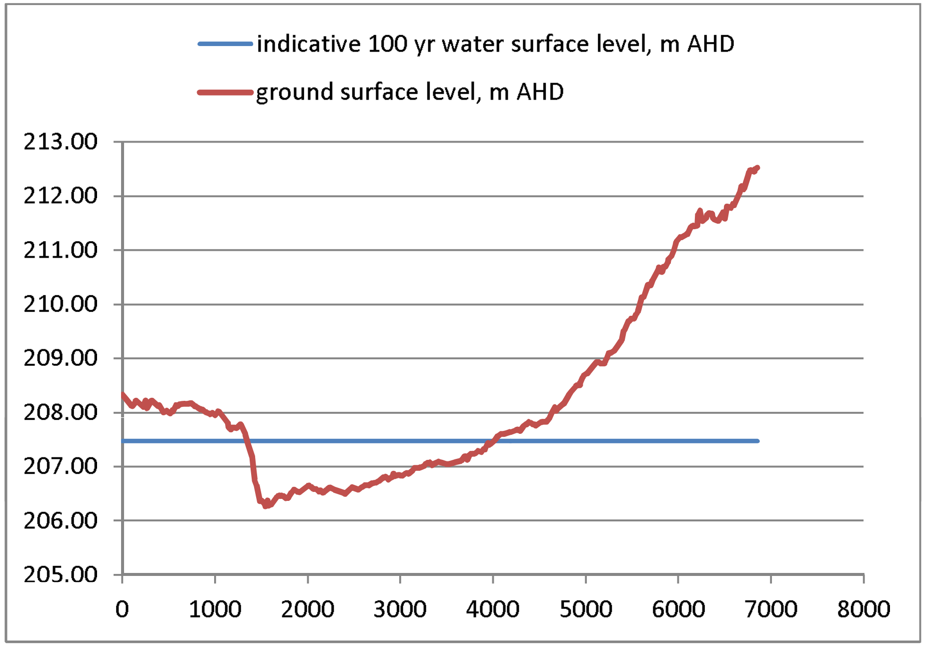
Existing water level calculation - Carmichael Mine Railway

Chainage 119.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	457.5	620.2
slope estimated from LIDAR, m/m	0.0005	0.0005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	207.35	207.47
min. ground level, m AHD	206.26	206.26
top width, m	2552.92	2663.00
area, m^2	1474.80	1800.34
max. depth of water, m	1.09	1.21
avg. depth of water, m	0.58	0.68
avg. velocity, m/s	0.31	0.34

Cross-section



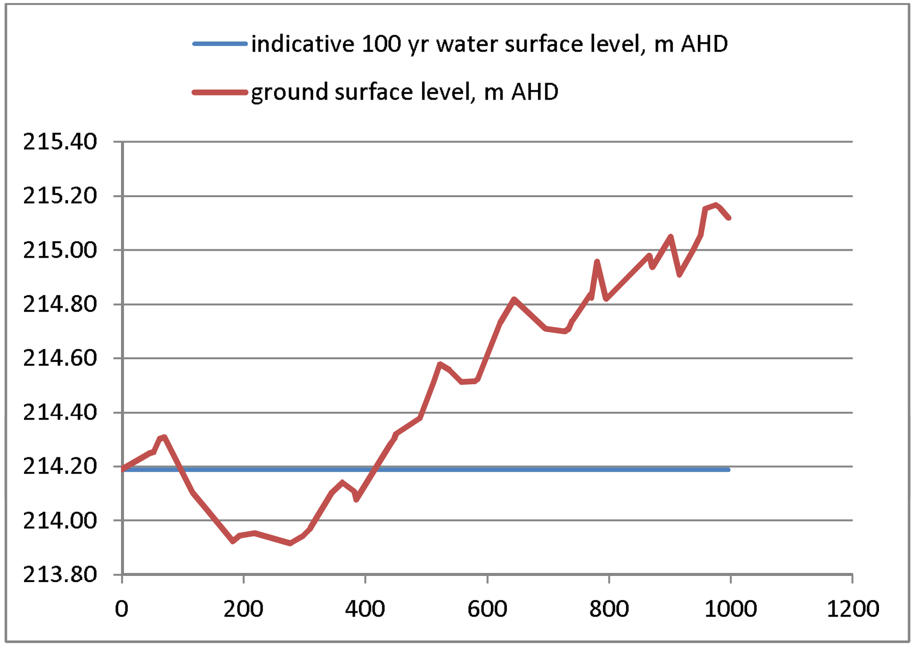
Existing water level calculation - Carmichael Mine Railway

Chainage 125.5

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	13.0	14.5
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	214.18	214.19
min. ground level, m AHD	213.92	213.92
top width, m	311.68	317.58
area, m^2	49.61	53.33
max. depth of water, m	0.26	0.27
avg. depth of water, m	0.16	0.17
avg. velocity, m/s	0.26	0.27

Cross-section



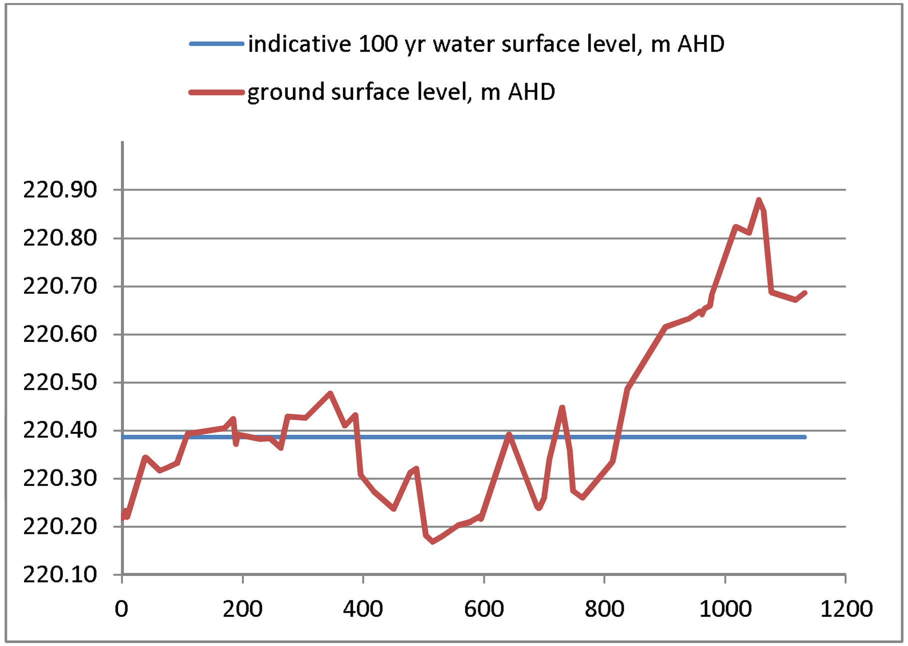
Existing water level calculation - Carmichael Mine Railway

Chainage 129.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	8.0	8.9
slope estimated from LIDAR, m/m	0.0015	0.0015
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	220.38	220.39
min. ground level, m AHD	220.17	220.17
top width, m	511.68	572.49
area, m^2	49.19	54.91
max. depth of water, m	0.21	0.22
avg. depth of water, m	0.10	0.10
avg. velocity, m/s	0.16	0.16

Cross-section



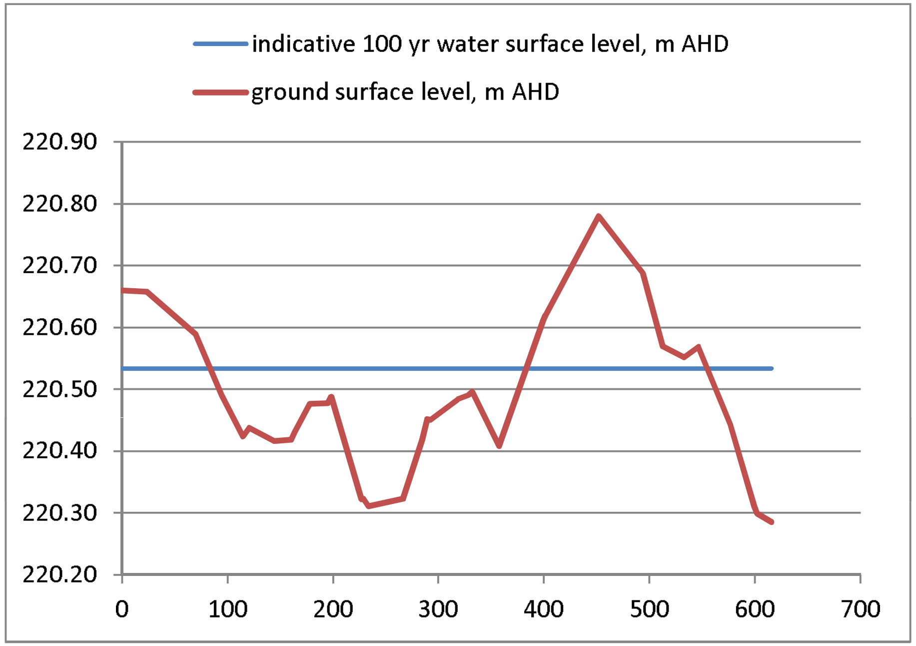
Existing water level calculation - Carmichael Mine Railway

Chainage 130.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	7.3	8.2
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	220.53	220.53
min. ground level, m AHD	220.29	220.29
top width, m	354.64	359.96
area, m^2	37.00	39.73
max. depth of water, m	0.24	0.25
avg. depth of water, m	0.10	0.11
avg. velocity, m/s	0.20	0.21

Cross-section



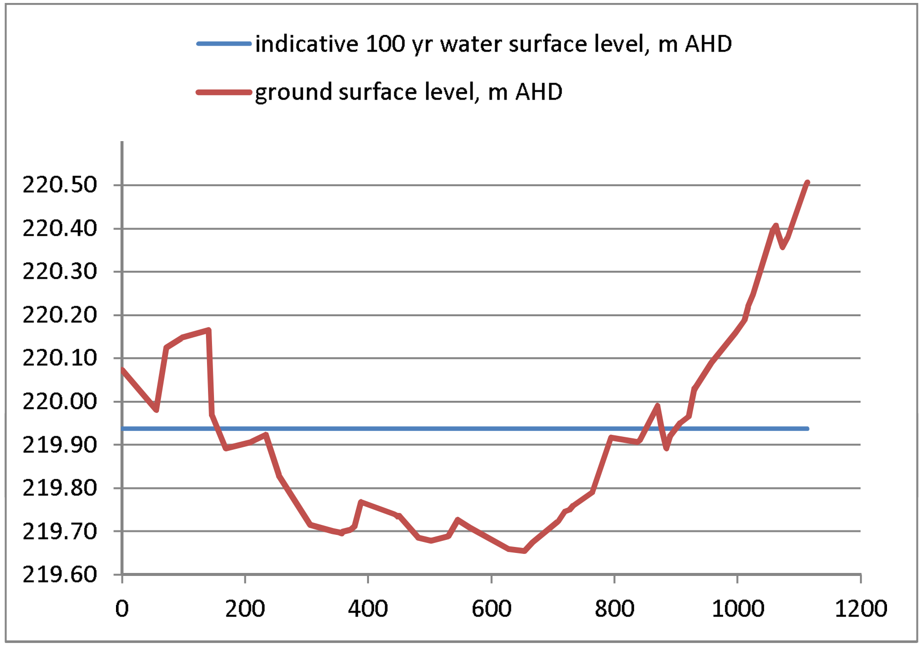
Existing water level calculation - Carmichael Mine Railway

Chainage 131.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	29.3	32.7
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	219.92	219.94
min. ground level, m AHD	219.65	219.65
top width, m	701.56	718.50
area, m^2	111.58	120.25
max. depth of water, m	0.27	0.28
avg. depth of water, m	0.16	0.17
avg. velocity, m/s	0.26	0.27

Cross-section



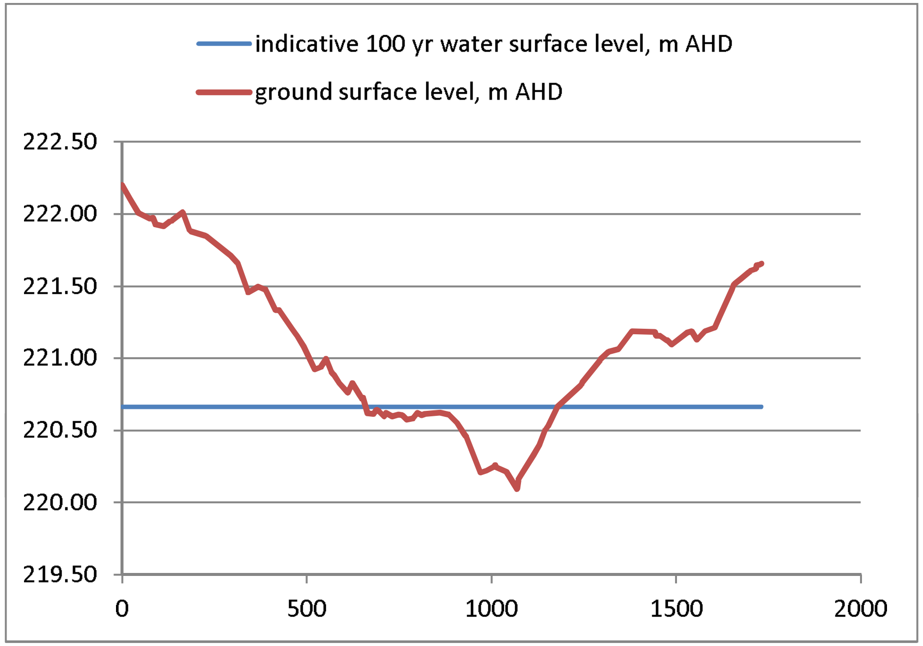
Existing water level calculation - Carmichael Mine Railway

Chainage 133.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	29.5	33.0
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	220.65	220.67
min. ground level, m AHD	220.09	220.09
top width, m	515.61	520.41
area, m^2	99.13	106.34
max. depth of water, m	0.56	0.57
avg. depth of water, m	0.19	0.20
avg. velocity, m/s	0.30	0.31

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 135

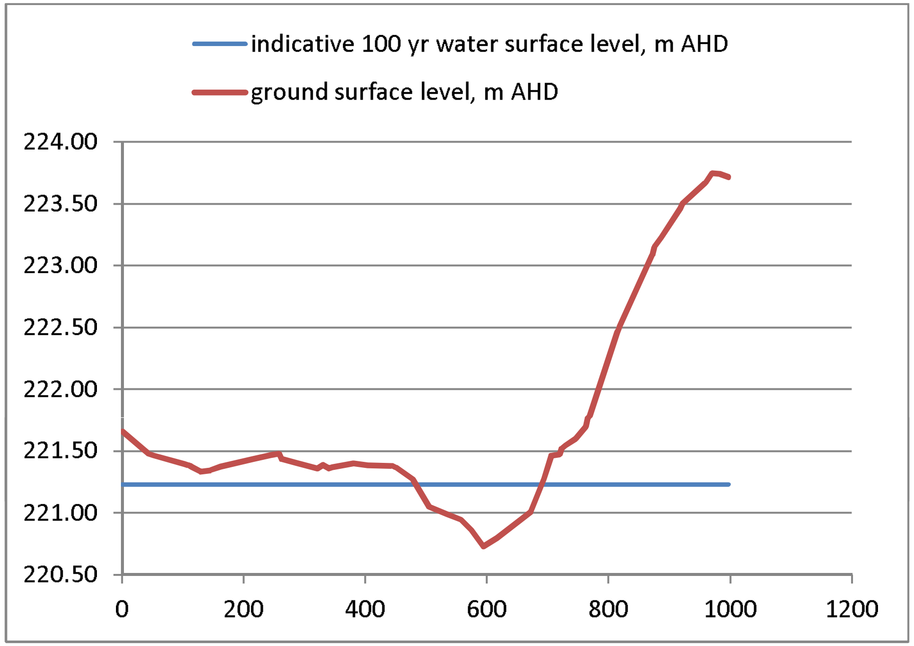
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	20.5	22.9
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	221.21	221.23
min. ground level, m AHD	220.73	220.73
top width, m	203.20	207.33
area, m^2	54.93	59.12
max. depth of water, m	0.48	0.50
avg. depth of water, m	0.27	0.29
avg. velocity, m/s	0.37	0.39

Cross-section



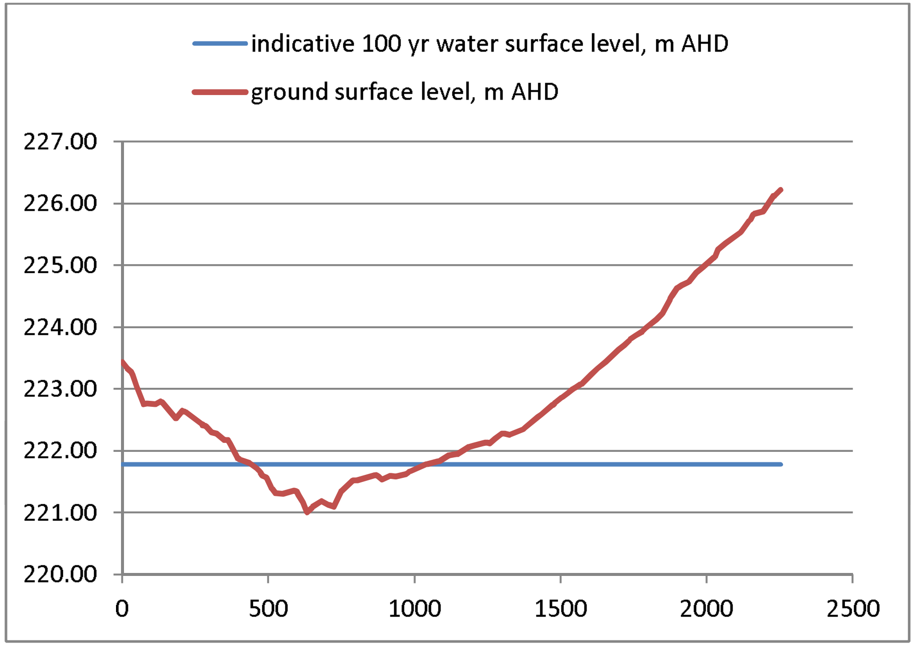
Existing water level calculation - Carmichael Mine Railway

Chainage 136.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	77.5	86.6
slope estimated from LIDAR, m/m	0.002	0.002
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	221.75	221.78
min. ground level, m AHD	221.01	221.01
top width, m	575.69	595.19
area, m^2	184.81	200.22
max. depth of water, m	0.74	0.77
avg. depth of water, m	0.32	0.34
avg. velocity, m/s	0.42	0.43

Cross-section



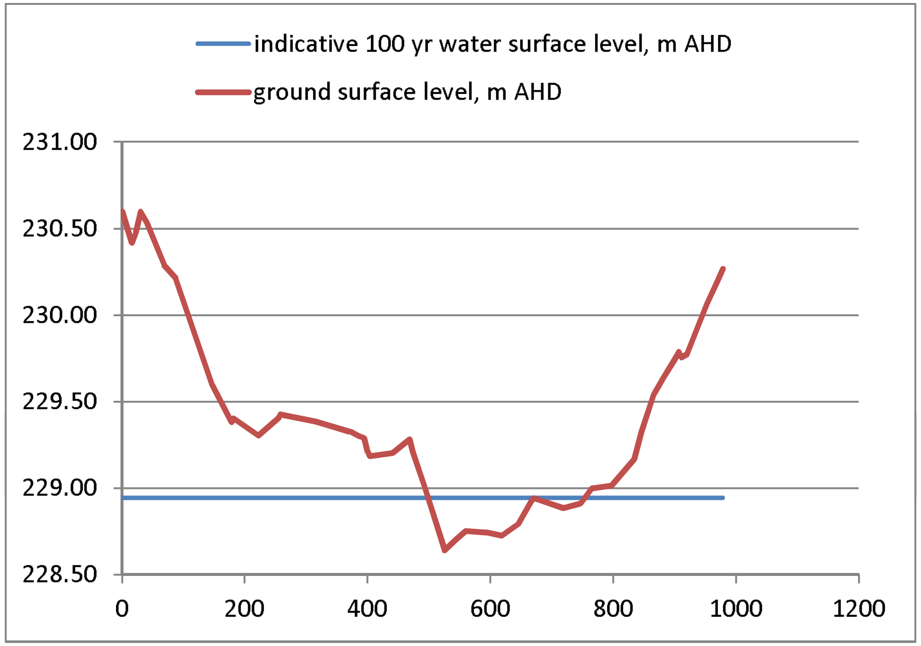
Existing water level calculation - Carmichael Mine Railway

Chainage 138.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	18.7	20.9
slope estimated from LIDAR, m/m	0.013	0.013
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	228.93	228.95
min. ground level, m AHD	228.64	228.64
top width, m	245.09	255.50
area, m^2	31.92	34.71
max. depth of water, m	0.29	0.31
avg. depth of water, m	0.13	0.14
avg. velocity, m/s	0.59	0.60

Cross-section



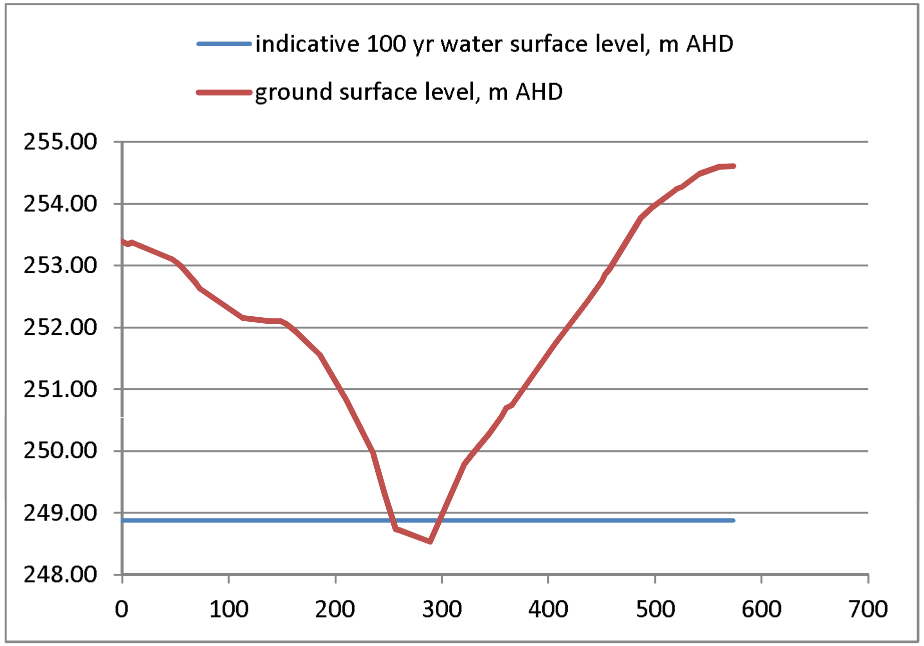
Existing water level calculation - Carmichael Mine Railway

Chainage 139.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	7.3	8.1
slope estimated from LIDAR, m/m	0.014	0.014
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	248.86	248.88
min. ground level, m AHD	248.53	248.53
top width, m	43.01	43.66
area, m^2	8.86	9.50
max. depth of water, m	0.33	0.35
avg. depth of water, m	0.21	0.22
avg. velocity, m/s	0.82	0.86

Cross-section

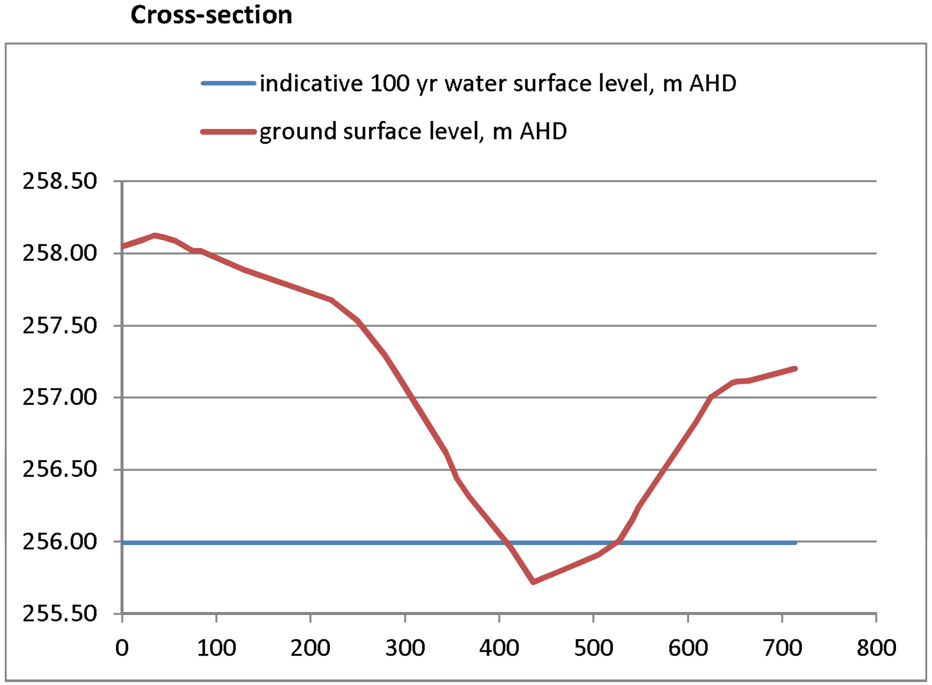


Existing water level calculation - Carmichael Mine Railway

Chainage 140.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	8.7	9.7
slope estimated from LIDAR, m/m	0.011	0.011
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	255.98	255.99
min. ground level, m AHD	255.72	255.72
top width, m	112.21	116.12
area, m^2	15.48	16.74
max. depth of water, m	0.26	0.27
avg. depth of water, m	0.14	0.14
avg. velocity, m/s	0.56	0.58



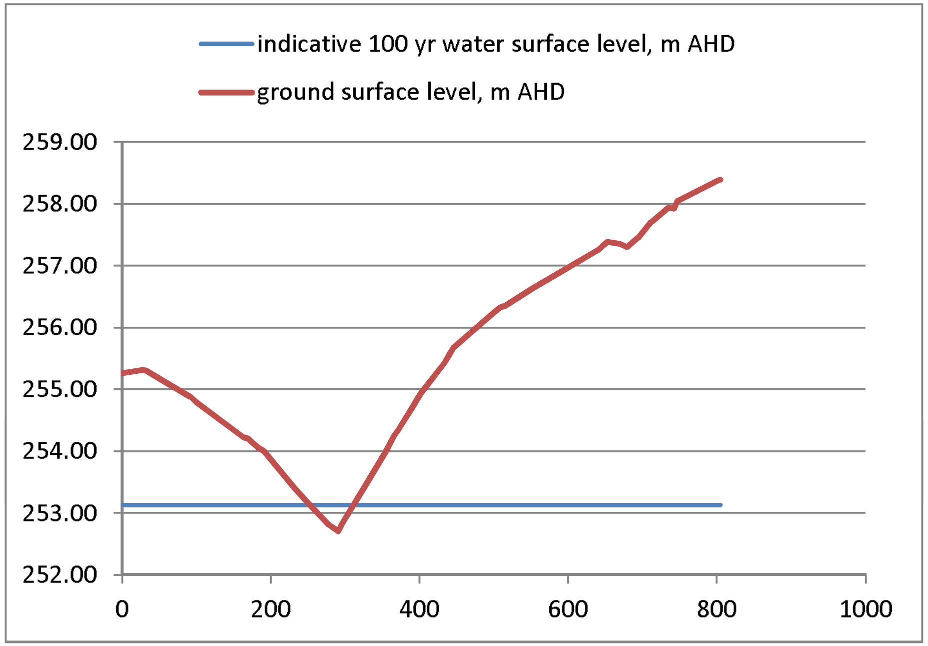
Existing water level calculation - Carmichael Mine Railway

Chainage 141.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	7.7	8.6
slope estimated from LIDAR, m/m	0.008	0.008
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	253.11	253.13
min. ground level, m AHD	252.71	252.71
top width, m	56.01	58.38
area, m^2	12.03	13.09
max. depth of water, m	0.41	0.43
avg. depth of water, m	0.21	0.22
avg. velocity, m/s	0.64	0.66

Cross-section



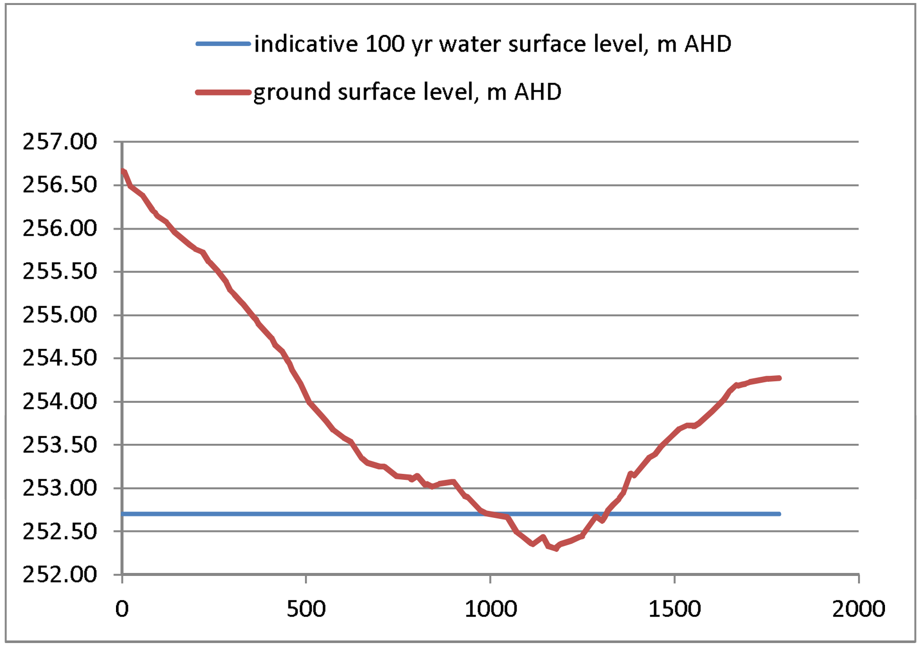
Existing water level calculation - Carmichael Mine Railway

Chainage 142.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

	50 yr	100 yr
ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	31.1	34.6
slope estimated from LIDAR, m/m	0.0055	0.0055
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	252.68	252.70
min. ground level, m AHD	252.30	252.30
top width, m	275.95	309.38
area, m^2	58.73	65.65
max. depth of water, m	0.38	0.40
avg. depth of water, m	0.21	0.21
avg. velocity, m/s	0.53	0.53

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 143.6

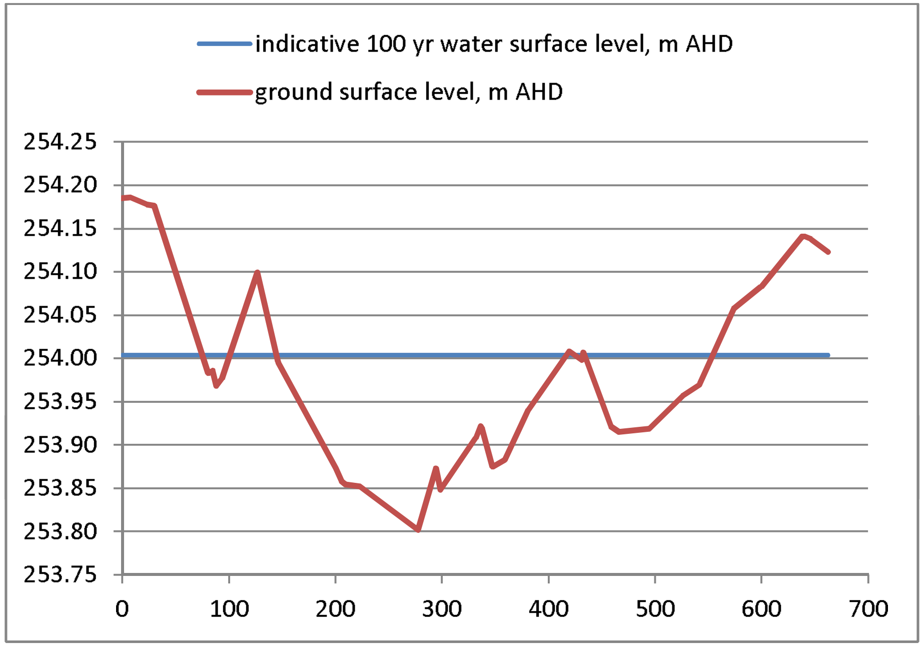
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	9.6	10.7
slope estimated from LIDAR, m/m	0.005	0.005
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	254.00	254.00
min. ground level, m AHD	253.80	253.80
top width, m	403.09	425.46
area, m^2	34.81	37.97
max. depth of water, m	0.19	0.20
avg. depth of water, m	0.09	0.09
avg. velocity, m/s	0.28	0.28

Cross-section



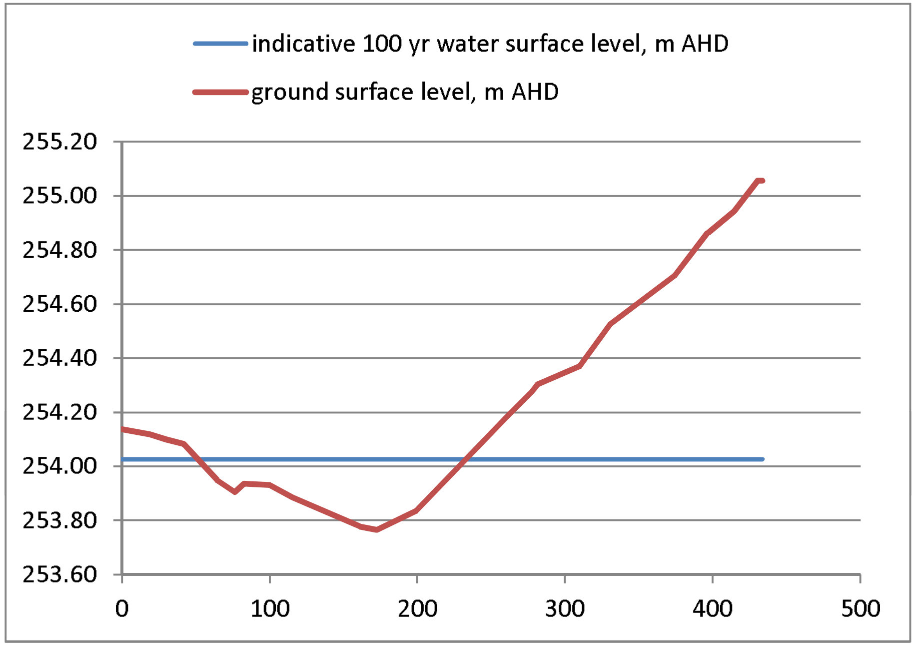
Existing water level calculation - Carmichael Mine Railway

Chainage 144.2

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

	ARI 50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	10.0	11.1
slope estimated from LIDAR, m/m	0.0055	0.0055
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	254.02	254.03
min. ground level, m AHD	253.77	253.77
top width, m	177.81	181.43
area, m^2	24.92	26.80
max. depth of water, m	0.25	0.26
avg. depth of water, m	0.14	0.15
avg. velocity, m/s	0.40	0.41

Cross-section



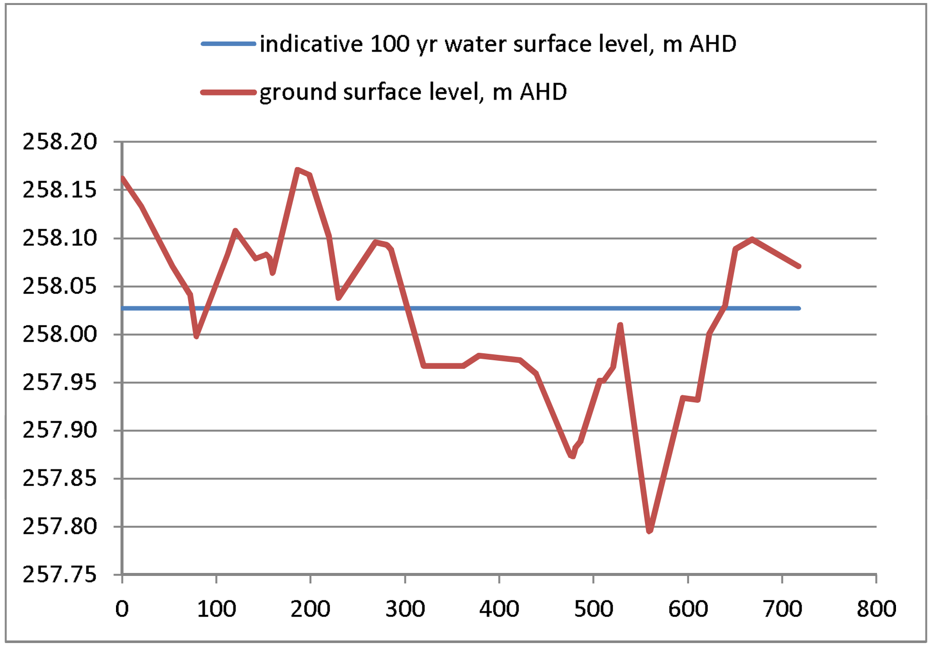
Existing water level calculation - Carmichael Mine Railway

Chainage 146.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	6.1	6.8
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	258.02	258.03
min. ground level, m AHD	257.80	257.80
top width, m	341.89	350.09
area, m^2	26.48	28.53
max. depth of water, m	0.23	0.23
avg. depth of water, m	0.08	0.08
avg. velocity, m/s	0.23	0.24

Cross-section



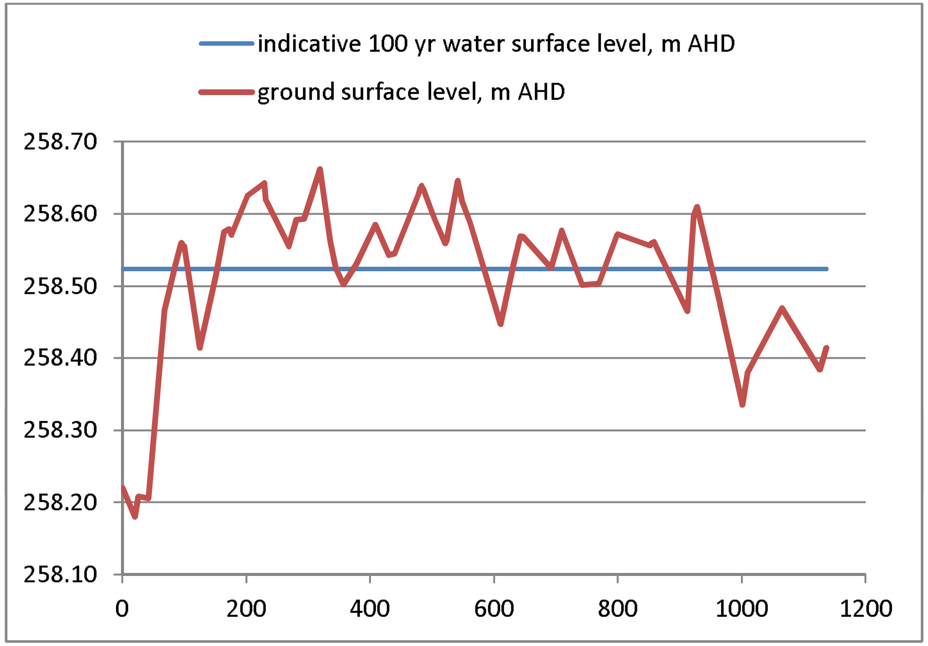
Existing water level calculation - Carmichael Mine Railway

Chainage 147.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	10.4	11.5
slope estimated from LIDAR, m/m	0.004	0.004
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	258.51	258.52
min. ground level, m AHD	258.18	258.18
top width, m	436.18	475.62
area, m^2	40.15	44.33
max. depth of water, m	0.33	0.34
avg. depth of water, m	0.09	0.09
avg. velocity, m/s	0.26	0.26

Cross-section



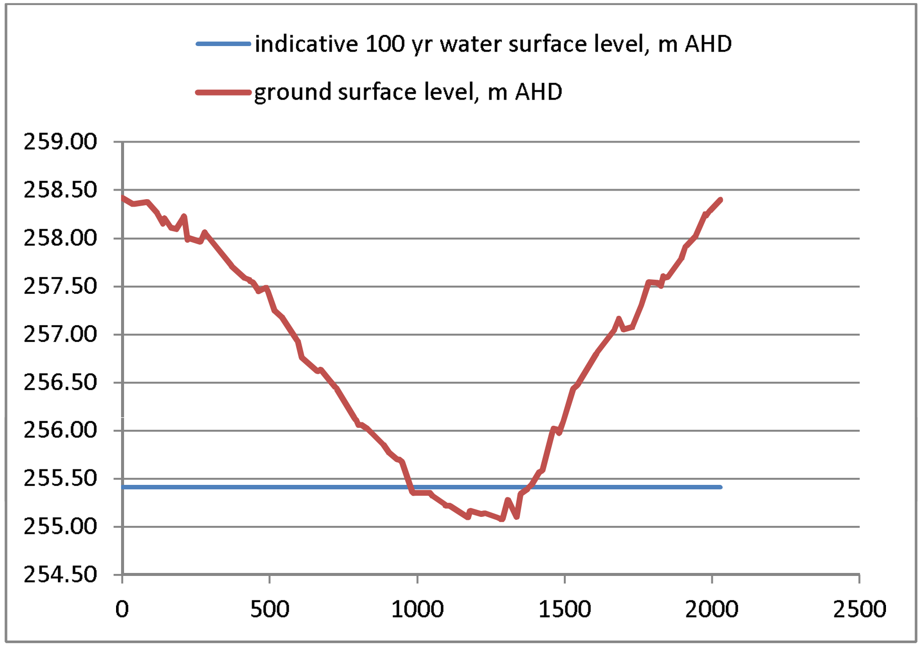
Existing water level calculation - Carmichael Mine Railway

Chainage 149.3

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	30.5	34.0
slope estimated from LIDAR, m/m	0.0045	0.0045
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	255.40	255.41
min. ground level, m AHD	255.08	255.08
top width, m	395.21	401.92
area, m^2	71.22	76.54
max. depth of water, m	0.32	0.33
avg. depth of water, m	0.18	0.19
avg. velocity, m/s	0.43	0.44

Cross-section



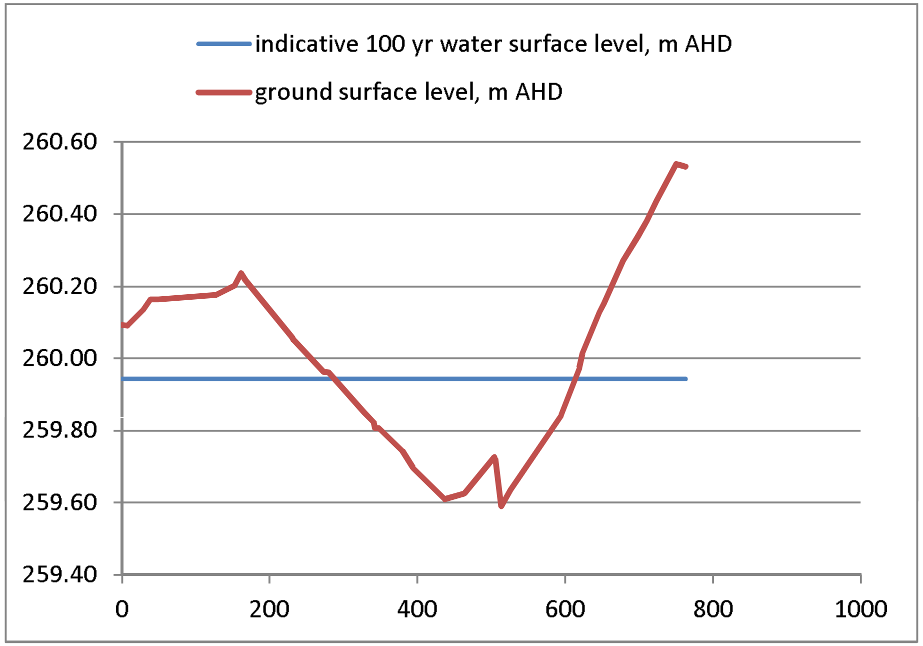
Existing water level calculation - Carmichael Mine Railway

Chainage 150.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

	ARI 50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	24.5	27.3
slope estimated from LIDAR, m/m	0.00353	0.00353
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	259.93	259.94
min. ground level, m AHD	259.59	259.59
top width, m	315.86	325.45
area, m^2	61.40	66.35
max. depth of water, m	0.34	0.35
avg. depth of water, m	0.19	0.20
avg. velocity, m/s	0.40	0.41

Cross-section

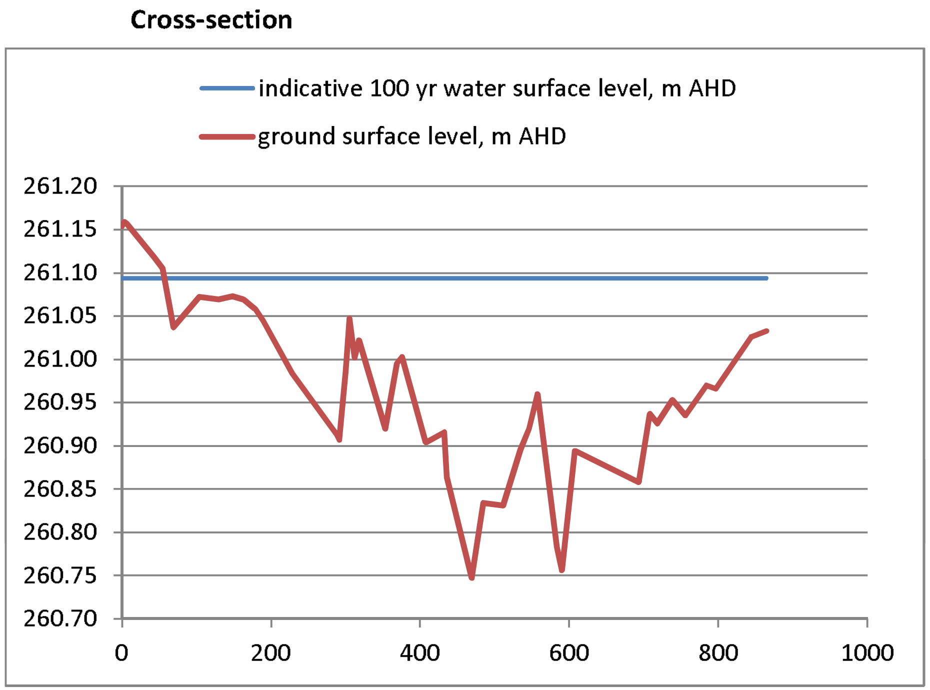


Existing water level calculation - Carmichael Mine Railway

Chainage 154.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	19.0	21.2
slope estimated from LIDAR, m/m	0.001	0.001
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	261.08	261.09
min. ground level, m AHD	260.75	260.75
top width, m	805.53	807.55
area, m^2	112.04	119.73
max. depth of water, m	0.34	0.35
avg. depth of water, m	0.14	0.15
avg. velocity, m/s	0.17	0.18



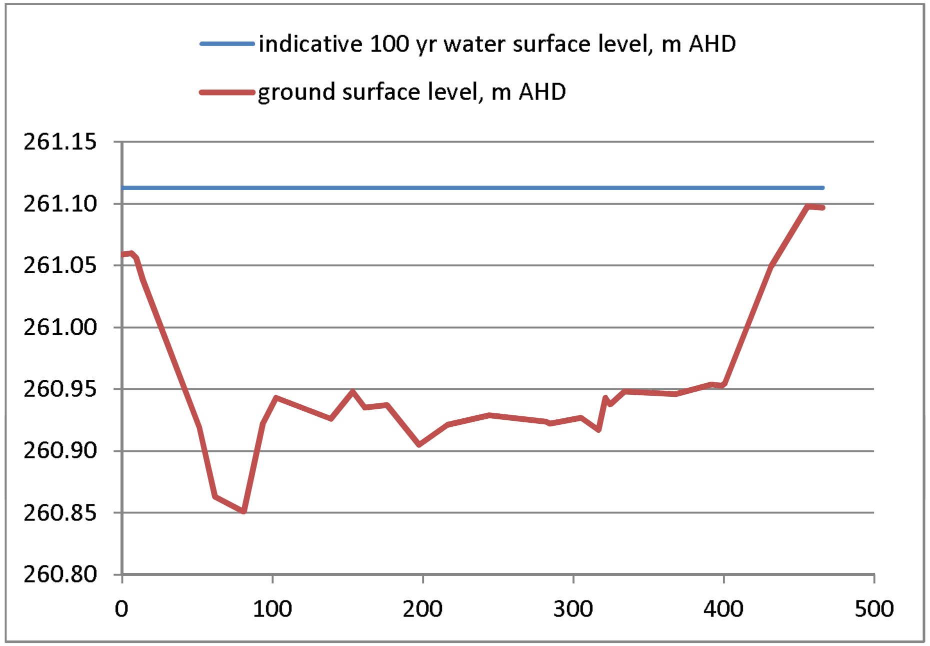
Existing water level calculation - Carmichael Mine Railway

Chainage 155

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	15.7	17.5
slope estimated from LIDAR, m/m	0.0015	0.0015
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	261.10	261.11
min. ground level, m AHD	260.85	260.85
top width, m	465.73	465.73
area, m^2	71.04	75.83
max. depth of water, m	0.25	0.26
avg. depth of water, m	0.15	0.16
avg. velocity, m/s	0.22	0.23

Cross-section



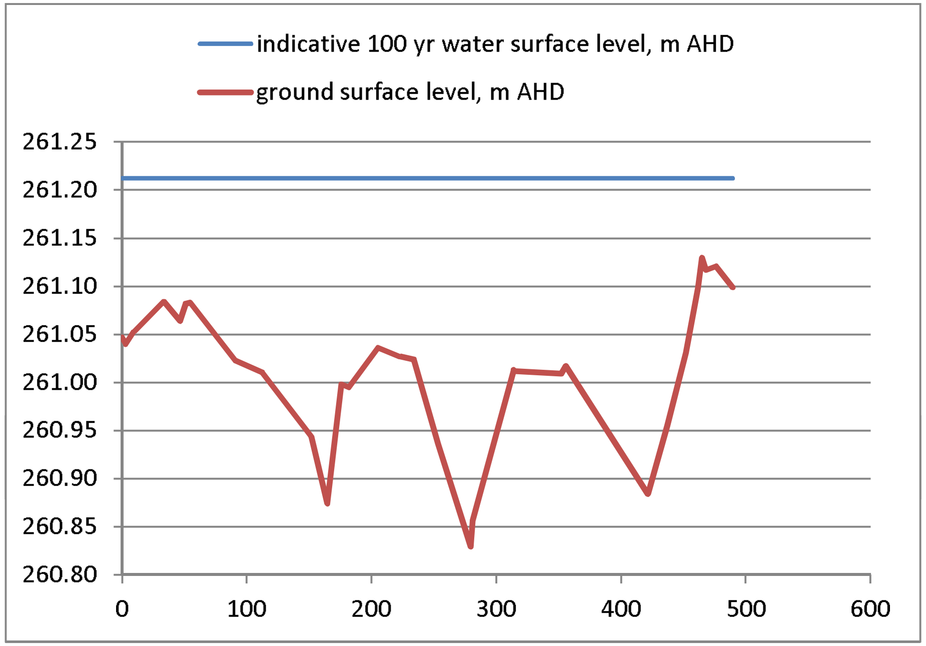
Existing water level calculation - Carmichael Mine Railway

Chainage 157.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	34.2	38.1
slope estimated from LIDAR, m/m	0.0025	0.0025
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	261.20	261.21
min. ground level, m AHD	260.83	260.83
top width, m	489.59	489.59
area, m^2	99.15	105.87
max. depth of water, m	0.37	0.38
avg. depth of water, m	0.20	0.22
avg. velocity, m/s	0.34	0.36

Cross-section



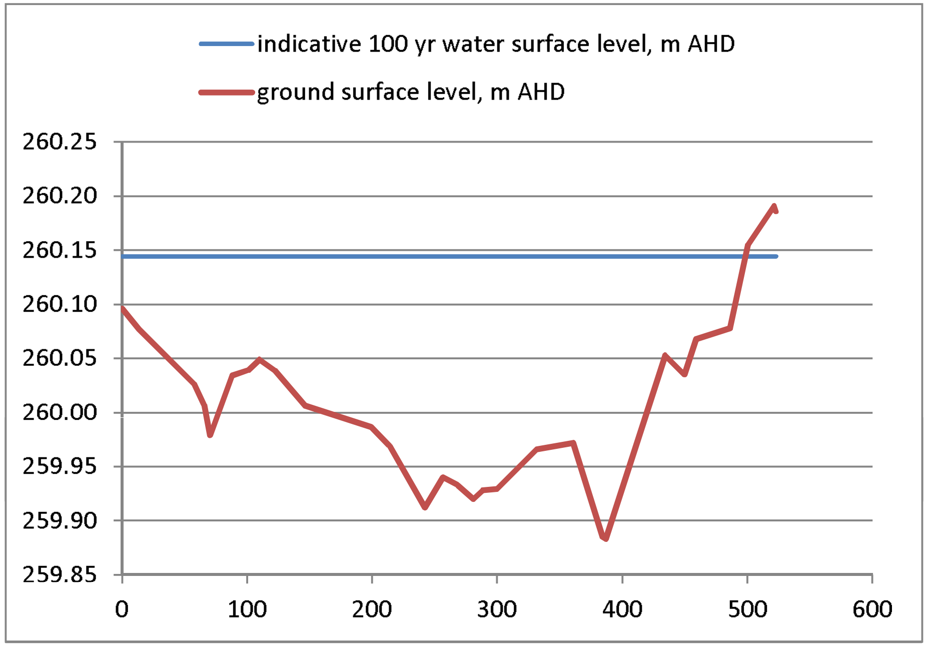
Existing water level calculation - Carmichael Mine Railway

Chainage 158.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	20.5	22.9
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	260.13	260.14
min. ground level, m AHD	259.88	259.88
top width, m	496.66	498.42
area, m^2	69.41	74.25
max. depth of water, m	0.25	0.26
avg. depth of water, m	0.14	0.15
avg. velocity, m/s	0.30	0.31

Cross-section



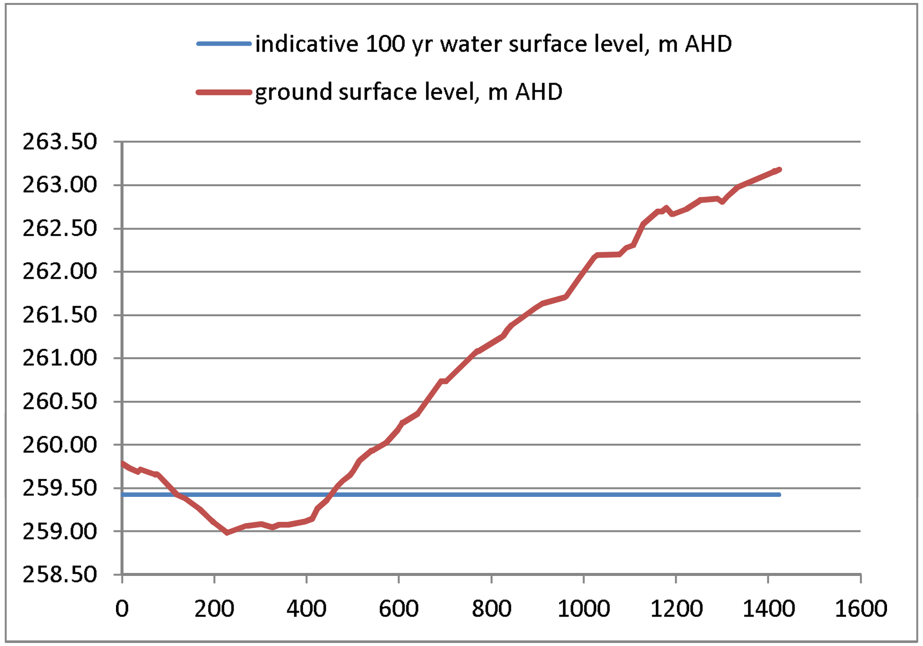
Existing water level calculation - Carmichael Mine Railway

Chainage 159.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	38.1	42.5
slope estimated from LIDAR, m/m	0.003	0.003
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	259.40	259.42
min. ground level, m AHD	258.98	258.98
top width, m	320.57	333.04
area, m^2	84.54	91.66
max. depth of water, m	0.42	0.44
avg. depth of water, m	0.26	0.28
avg. velocity, m/s	0.45	0.46

Cross-section



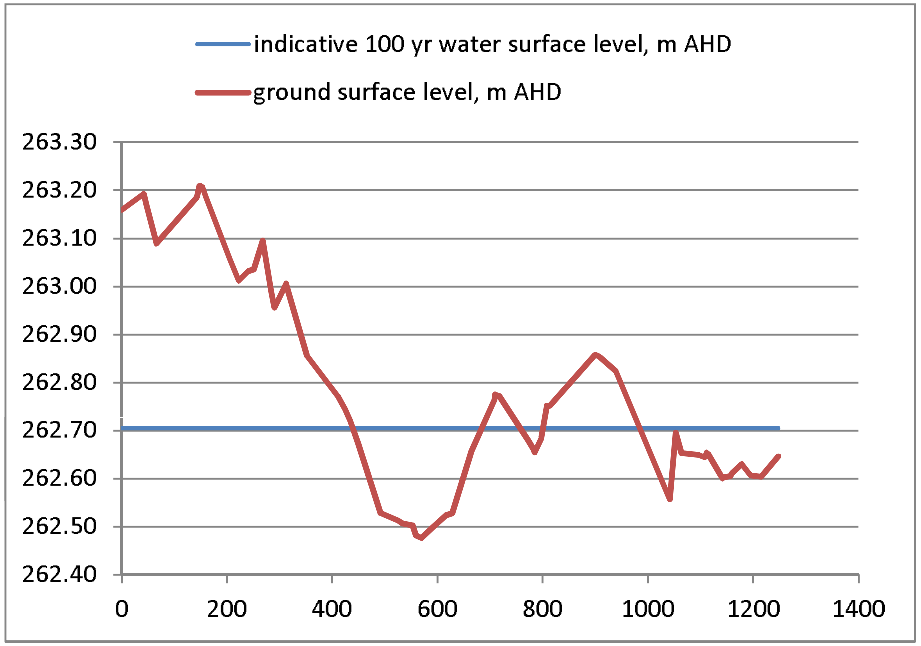
Existing water level calculation - Carmichael Mine Railway

Chainage 160.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	16.0	17.8
slope estimated from LIDAR, m/m	0.005	0.005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	262.70	262.70
min. ground level, m AHD	262.48	262.48
top width, m	538.11	552.33
area, m^2	53.01	57.17
max. depth of water, m	0.22	0.23
avg. depth of water, m	0.10	0.10
avg. velocity, m/s	0.30	0.31

Cross-section



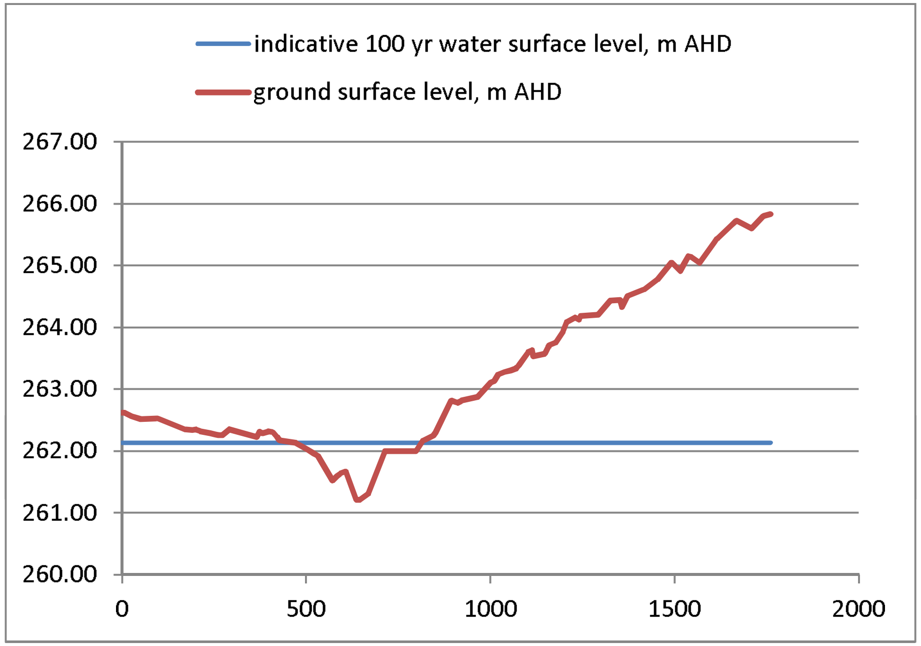
Existing water level calculation - Carmichael Mine Railway

Chainage 162.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	66.6	74.5
slope estimated from LIDAR, m/m	0.0035	0.0035
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	262.11	262.14
min. ground level, m AHD	261.21	261.21
top width, m	329.82	348.02
area, m^2	114.15	124.75
max. depth of water, m	0.89	0.93
avg. depth of water, m	0.35	0.36
avg. velocity, m/s	0.58	0.60

Cross-section



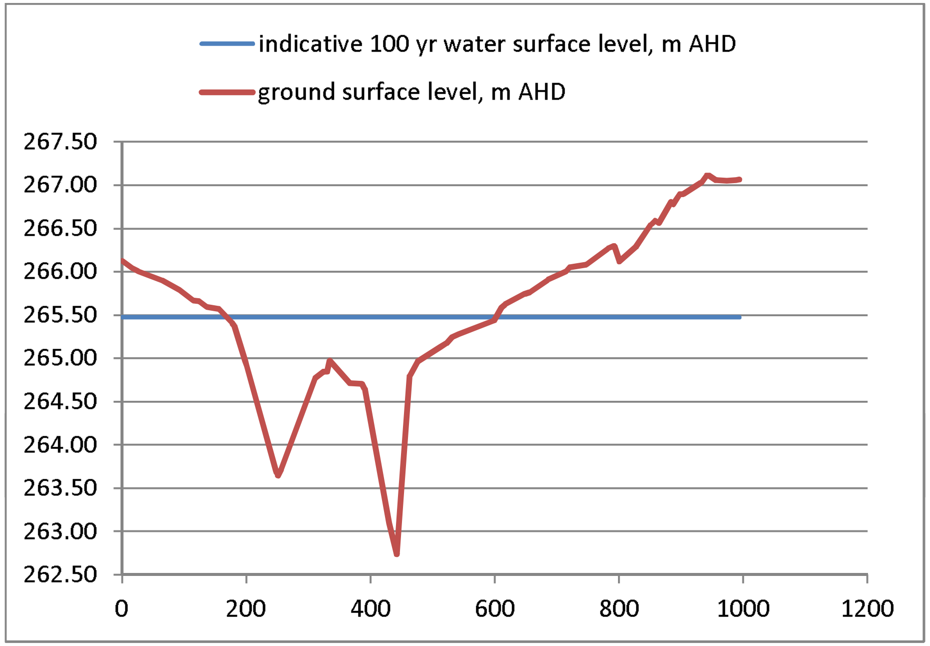
Existing water level calculation - Carmichael Mine Railway

Chainage 163.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	237.9	306.6
slope estimated from LIDAR, m/m	0.0022	0.0022
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	265.29	265.47
min. ground level, m AHD	262.73	262.73
top width, m	362.44	432.99
area, m^2	292.55	365.78
max. depth of water, m	2.56	2.74
avg. depth of water, m	0.81	0.84
avg. velocity, m/s	0.81	0.84

Cross-section



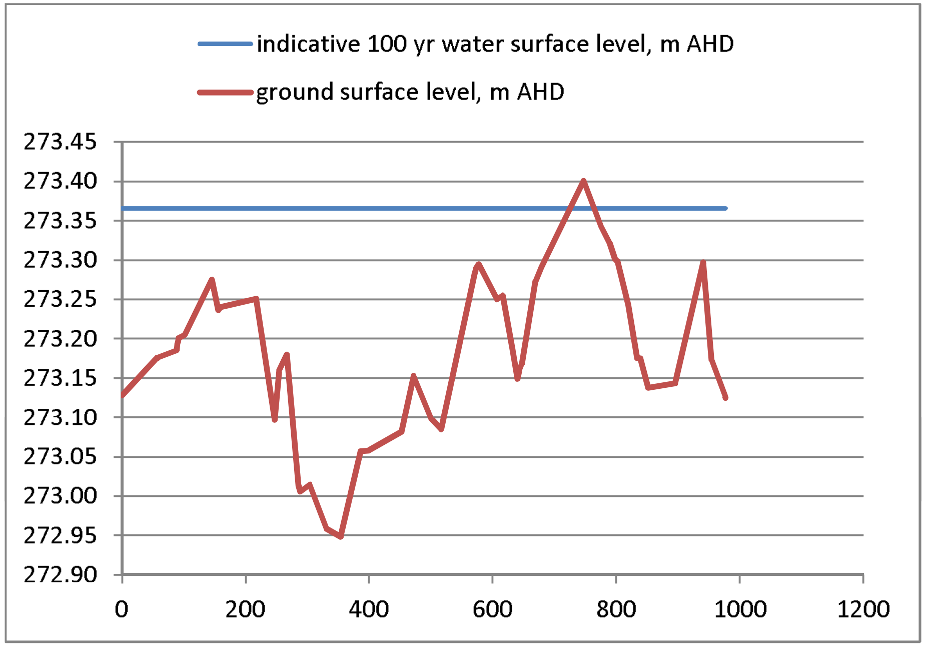
Existing water level calculation - Carmichael Mine Railway

Chainage 165.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	75.9	85.0
slope estimated from LIDAR, m/m	0.005	0.005
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	273.35	273.37
min. ground level, m AHD	272.95	272.95
top width, m	922.48	937.90
area, m^2	167.45	180.40
max. depth of water, m	0.40	0.42
avg. depth of water, m	0.18	0.19
avg. velocity, m/s	0.45	0.47

Cross-section



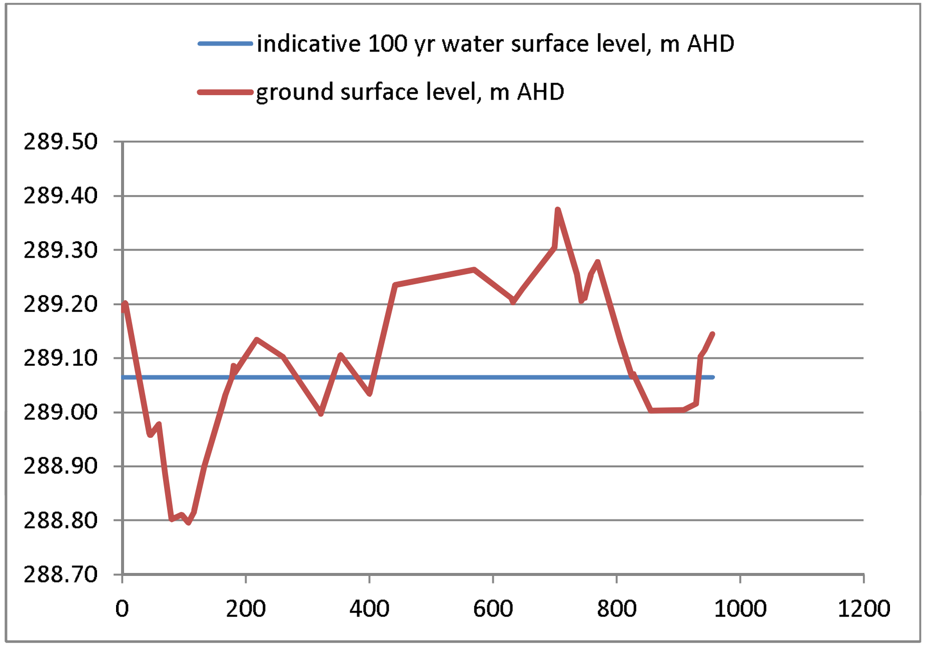
Existing water level calculation - Carmichael Mine Railway

Chainage 168.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	8.3	9.3
slope estimated from LIDAR, m/m	0.006	0.006
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	289.06	289.07
min. ground level, m AHD	288.80	288.80
top width, m	317.16	338.45
area, m^2	27.44	30.06
max. depth of water, m	0.26	0.27
avg. depth of water, m	0.09	0.09
avg. velocity, m/s	0.30	0.31

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 170.6

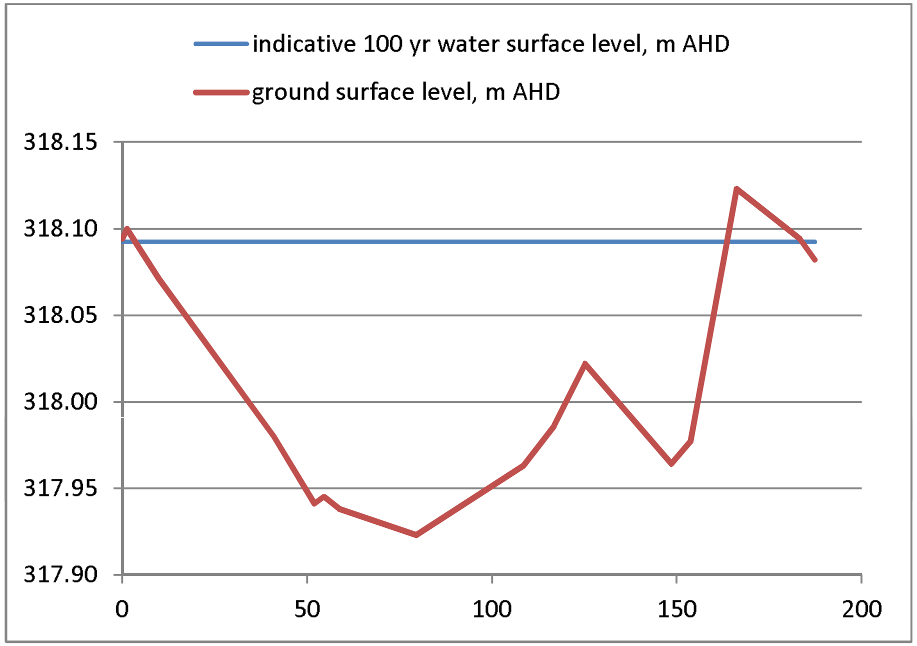
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	8.4	9.4
slope estimated from LIDAR, m/m	0.014	0.014
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	318.08	318.09
min. ground level, m AHD	317.92	317.92
top width, m	157.39	163.36
area, m^2	16.20	17.55
max. depth of water, m	0.16	0.17
avg. depth of water, m	0.10	0.11
avg. velocity, m/s	0.52	0.53

Cross-section



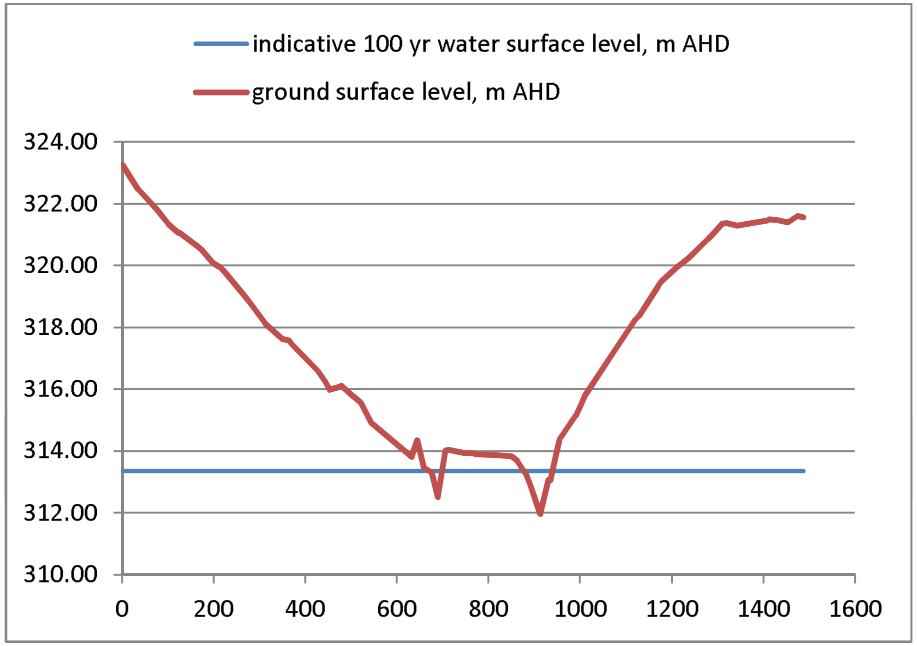
Existing water level calculation - Carmichael Mine Railway

Chainage 172

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	56.1	62.5
slope estimated from LIDAR, m/m	0.009	0.009
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	313.29	313.35
min. ground level, m AHD	311.96	311.96
top width, m	79.75	89.94
area, m^2	44.00	49.24
max. depth of water, m	1.33	1.39
avg. depth of water, m	0.55	0.55
avg. velocity, m/s	1.27	1.27

Cross-section

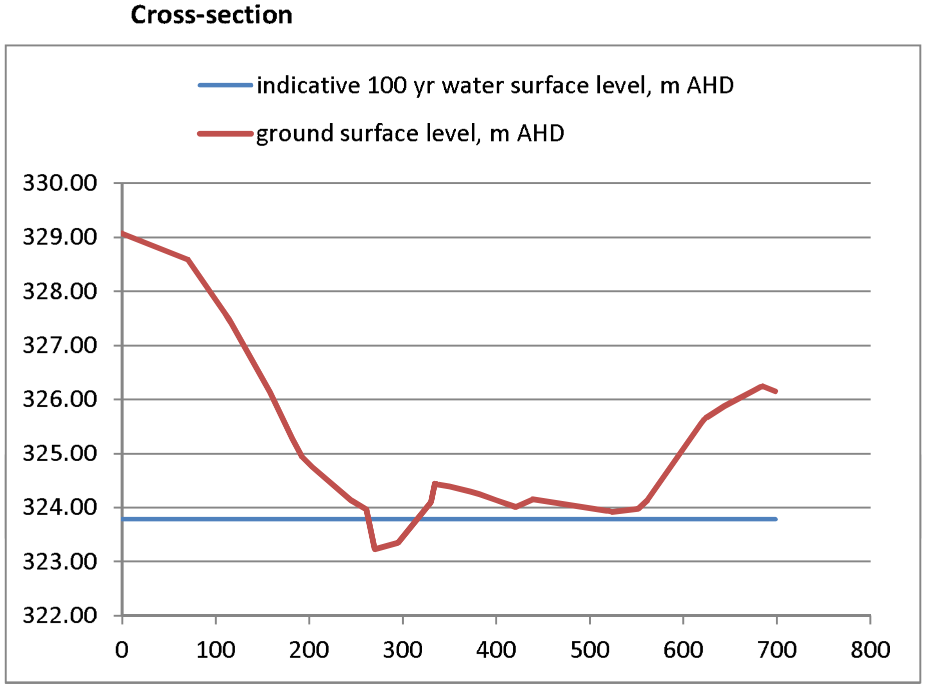


Existing water level calculation - Carmichael Mine Railway

Chainage 173.6

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	24.6	27.4
slope estimated from LIDAR, m/m	0.022	0.022
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	323.75	323.78
min. ground level, m AHD	323.23	323.23
top width, m	50.36	51.94
area, m^2	17.08	18.45
max. depth of water, m	0.52	0.55
avg. depth of water, m	0.34	0.36
avg. velocity, m/s	1.44	1.49



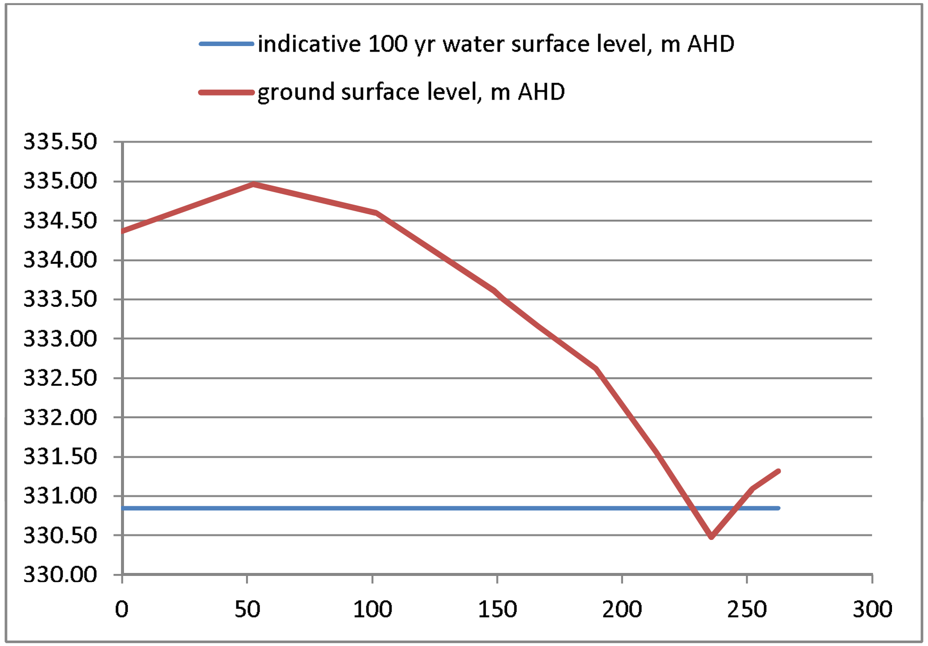
Existing water level calculation - Carmichael Mine Railway

Chainage 174.1

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	6.1	6.8
slope estimated from LIDAR, m/m	0.1	0.1
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	330.83	330.85
min. ground level, m AHD	330.48	330.48
top width, m	16.93	17.65
area, m^2	3.03	3.30
max. depth of water, m	0.36	0.37
avg. depth of water, m	0.18	0.19
avg. velocity, m/s	2.01	2.07

Cross-section



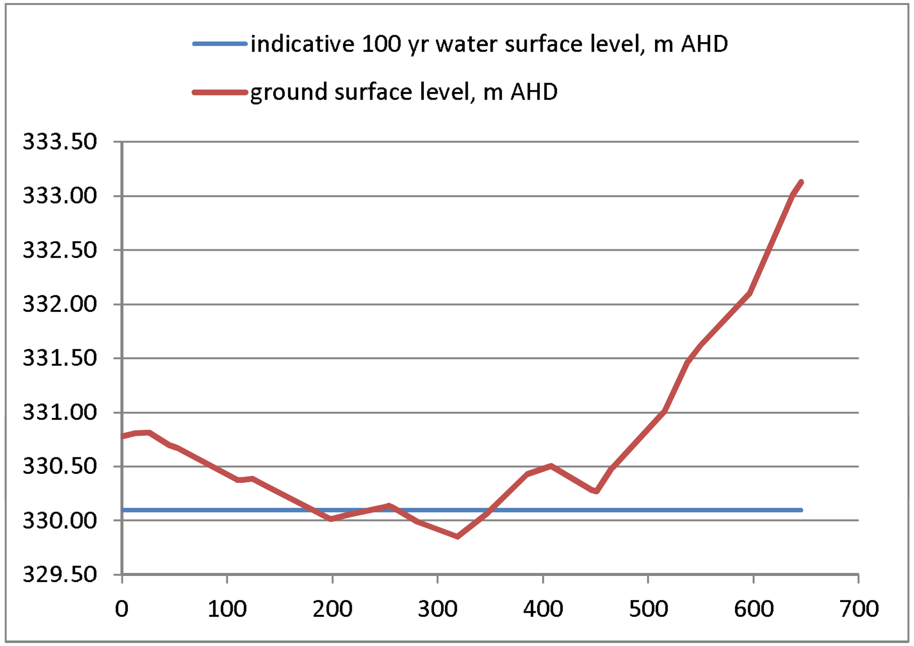
Existing water level calculation - Carmichael Mine Railway

Chainage 174.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	14.4	16.1
slope estimated from LIDAR, m/m	0.075	0.075
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	330.09	330.10
min. ground level, m AHD	329.85	329.85
top width, m	133.89	142.58
area, m^2	12.67	13.89
max. depth of water, m	0.24	0.25
avg. depth of water, m	0.09	0.10
avg. velocity, m/s	1.14	1.16

Cross-section



Existing water level calculation - Carmichael Mine Railway

Chainage 175.3

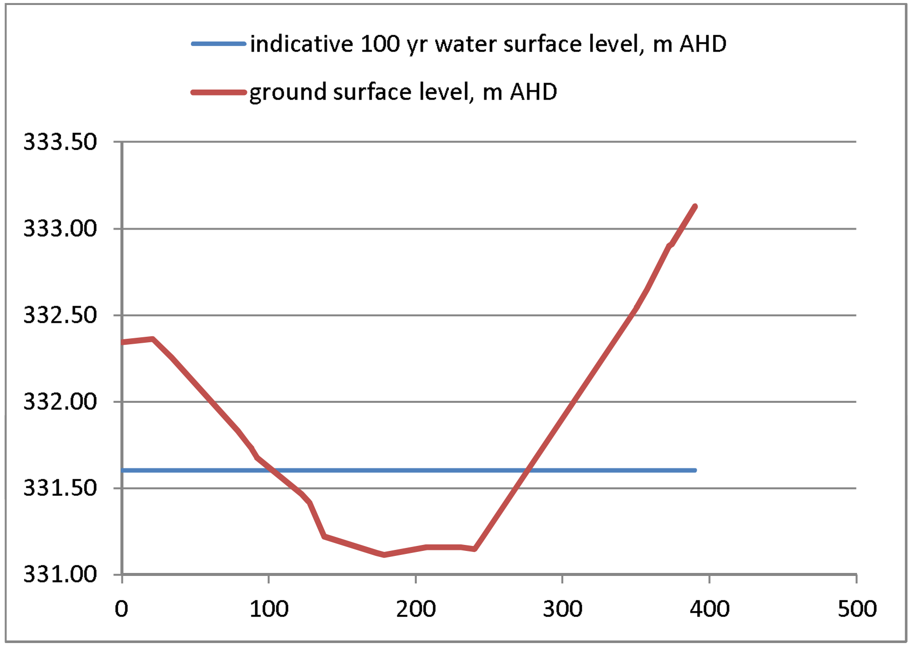
Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	61.7	68.7
slope estimated from LIDAR, m/m	0.014	0.014
n, roughness coeff.	0.05	0.05

Output

water level calc'd based on Manning's Eq., m AHD	331.58	331.60
min. ground level, m AHD	331.11	331.11
top width, m	168.04	173.84
area, m^2	54.93	59.39
max. depth of water, m	0.46	0.49
avg. depth of water, m	0.33	0.34
avg. velocity, m/s	1.12	1.16

Cross-section



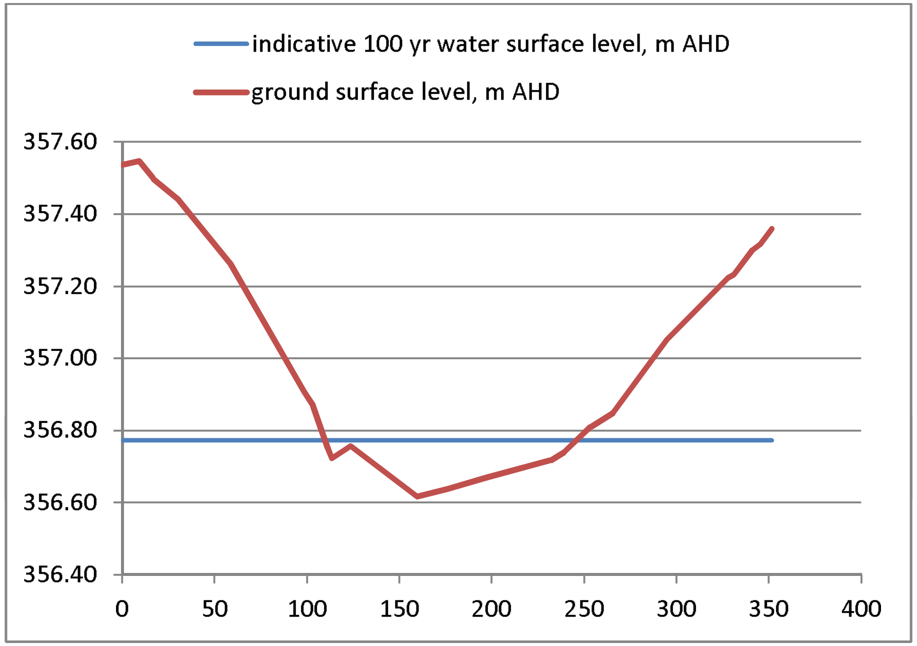
Existing water level calculation - Carmichael Mine Railway

Chainage 176.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	6.5	7.2
slope estimated from LIDAR, m/m	0.026	0.026
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	356.77	356.77
min. ground level, m AHD	356.62	356.62
top width, m	134.38	135.94
area, m^2	10.82	11.59
max. depth of water, m	0.15	0.16
avg. depth of water, m	0.08	0.09
avg. velocity, m/s	0.60	0.63

Cross-section



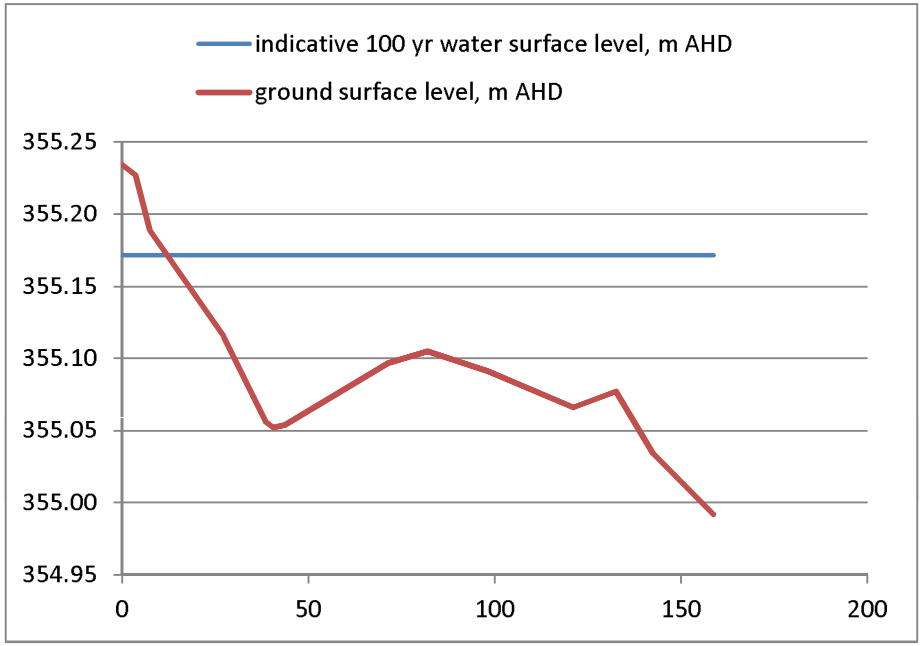
Existing water level calculation - Carmichael Mine Railway

Chainage 177

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	7.1	7.9
slope estimated from LIDAR, m/m	0.02	0.02
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	355.17	355.17
min. ground level, m AHD	354.99	354.99
top width, m	144.82	146.45
area, m^2	12.69	13.58
max. depth of water, m	0.17	0.18
avg. depth of water, m	0.09	0.09
avg. velocity, m/s	0.56	0.58

Cross-section



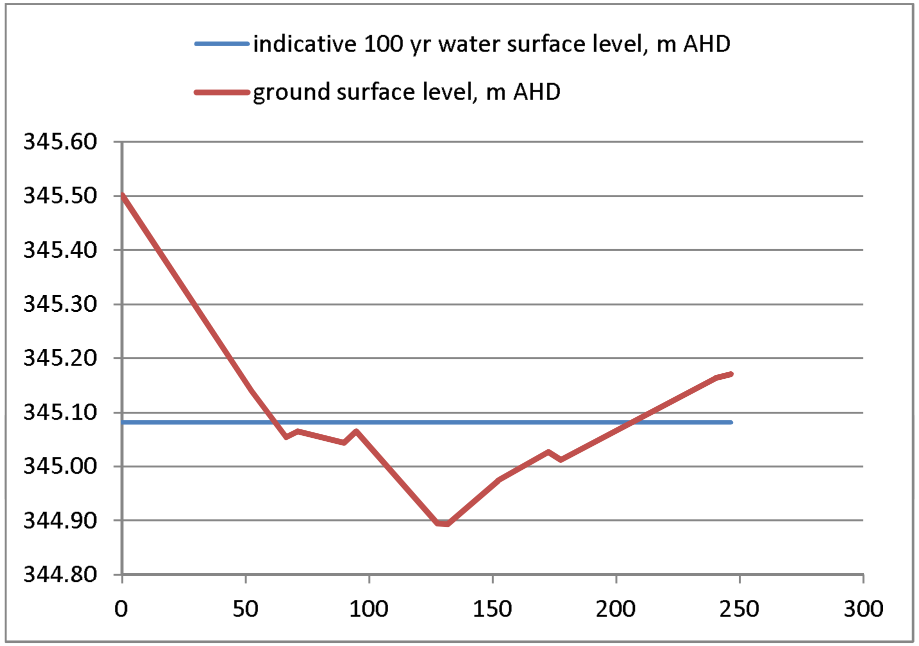
Existing water level calculation - Carmichael Mine Railway

Chainage 177.7

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	5.8	6.4
slope estimated from LIDAR, m/m	0.027	0.027
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	345.08	345.08
min. ground level, m AHD	344.89	344.89
top width, m	141.31	144.50
area, m^2	10.15	10.94
max. depth of water, m	0.18	0.19
avg. depth of water, m	0.07	0.08
avg. velocity, m/s	0.57	0.59

Cross-section



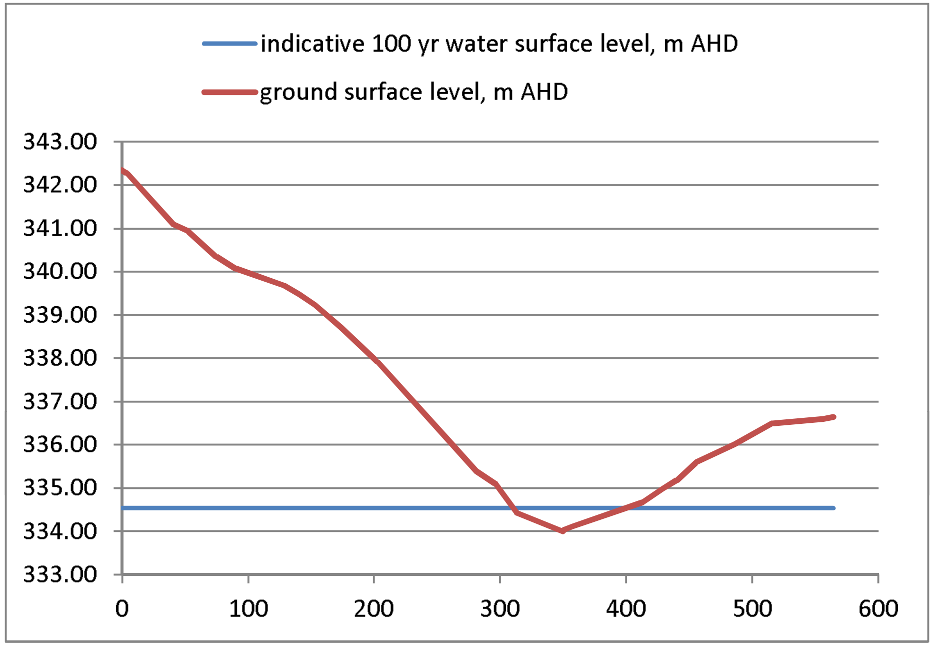
Existing water level calculation - Carmichael Mine Railway

Chainage 178.4

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	21.9	24.4
slope estimated from LIDAR, m/m	0.015	0.015
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	334.51	334.53
min. ground level, m AHD	334.00	334.00
top width, m	86.13	88.67
area, m^2	22.15	23.91
max. depth of water, m	0.51	0.53
avg. depth of water, m	0.26	0.27
avg. velocity, m/s	0.99	1.02

Cross-section



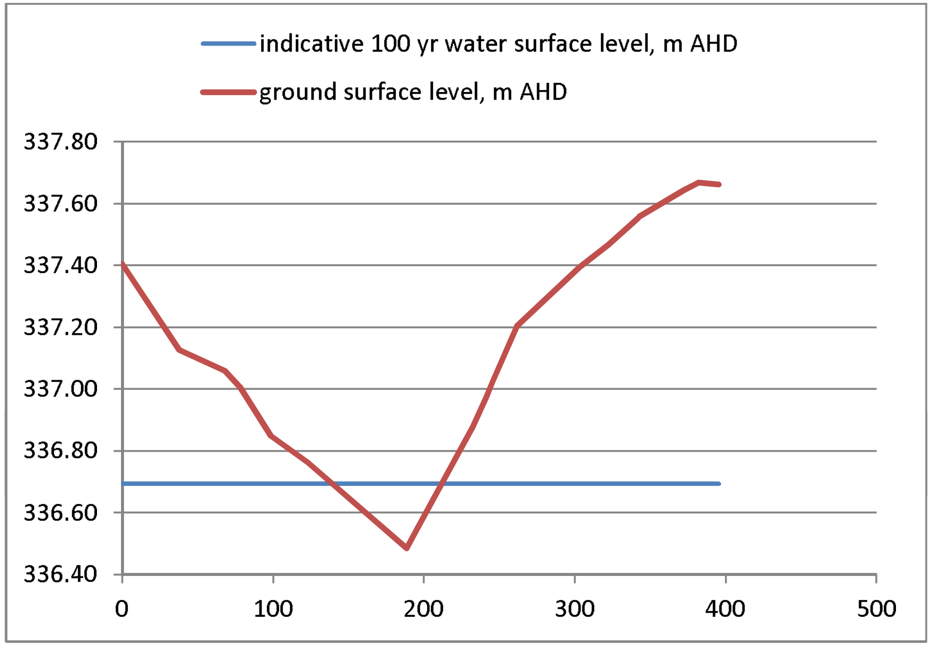
Existing water level calculation - Carmichael Mine Railway

Chainage 178.8

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	4.2	4.7
slope estimated from LIDAR, m/m	0.02	0.02
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	336.68	336.69
min. ground level, m AHD	336.49	336.49
top width, m	69.45	72.36
area, m^2	6.91	7.50
max. depth of water, m	0.20	0.21
avg. depth of water, m	0.10	0.10
avg. velocity, m/s	0.61	0.62

Cross-section



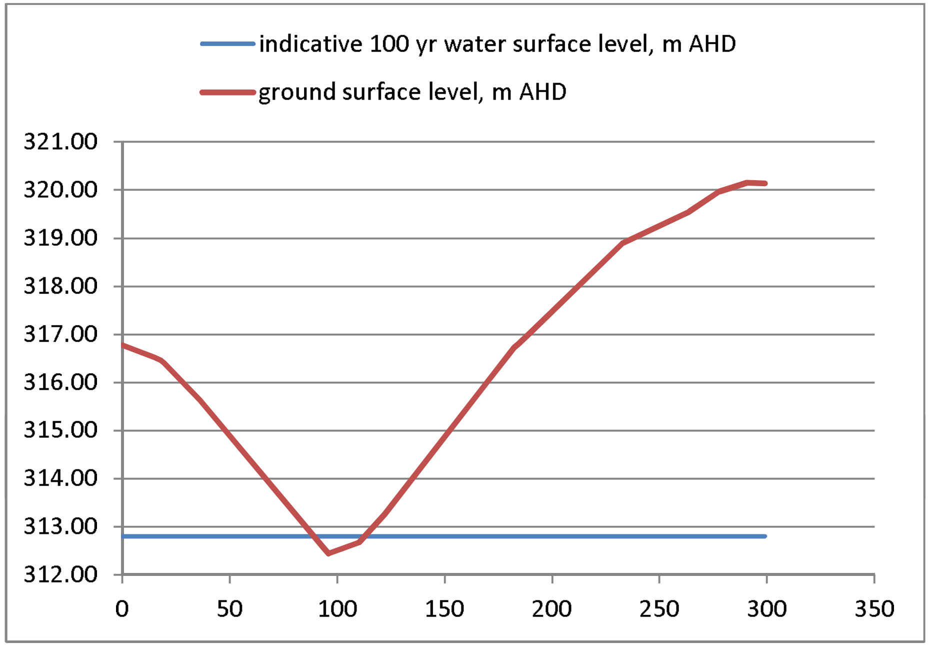
Existing water level calculation - Carmichael Mine Railway

Chainage 180

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is not cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	5.6	6.2
slope estimated from LIDAR, m/m	0.033	0.033
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	312.78	312.80
min. ground level, m AHD	312.44	312.44
top width, m	23.01	23.60
area, m^2	4.53	4.88
max. depth of water, m	0.34	0.36
avg. depth of water, m	0.20	0.21
avg. velocity, m/s	1.23	1.27

Cross-section



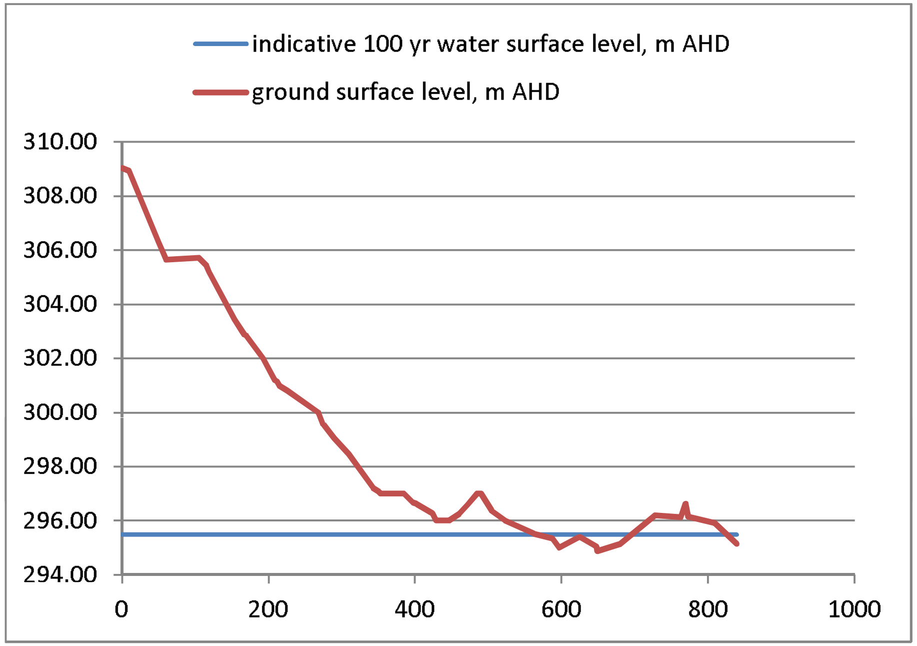
Existing water level calculation - Carmichael Mine Railway

Chainage 181

Results are based on cross sections cut from LIDAR, which are cut approx. perpendicular to the watercourse.
At this location the cross section is cut parallel to the rail alignment.

ARI	50 yr	100 yr
Input		
flow from hydrologic calc's, m3/s	33.4	37.3
slope estimated from LIDAR, m/m	0.014	0.014
n, roughness coeff.	0.05	0.05
Output		
water level calc'd based on Manning's Eq., m AHD	295.46	295.48
min. ground level, m AHD	294.88	294.88
top width, m	134.95	140.05
area, m^2	34.85	37.76
max. depth of water, m	0.58	0.60
avg. depth of water, m	0.26	0.27
avg. velocity, m/s	0.96	0.99

Cross-section



APPENDIX F

Watercourse Crossing Structure Calculations

Preliminary Watercourse Crossing Sizing - 50 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)	D_{min} (m)
2	0.5

total span length for entire railway, m -> 7154

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
1.7		32.1	224.00	224.35	383	81.8	0.35	0.21	0.4	2.0	16.0	0.50	32
4.7	Eight Mile Creek	230.5	218.40	219.40	1015	519.7	1.00	0.51	0.4	2.0	115.3	0.51	225
7.8		49.3	214.91	215.55	353	115.9	0.64	0.33	0.4	2.0	24.6	0.50	49
9.0		17.4	214.56	214.97	277	61.4	0.41	0.22	0.3	2.0	8.7	0.50	17
10.4	North Creek	364.9	214.51	216.25	850	555.6	1.74	0.65	0.7	2.0	182.4	0.65	279
17.1		125.1	207.00	207.20	1835	346.8	0.20	0.19	0.4	2.0	62.6	0.50	125
18.8		21.8	207.61	207.82	352	50.9	0.21	0.14	0.4	2.0	10.9	0.50	22
21.1		45.2	205.96	206.35	531	105.1	0.40	0.20	0.4	2.0	22.6	0.50	45
27.9	Ogenbeena Creek	546.7	197.14	200.06	1428	1300.7	2.92	0.91	0.4	2.0	273.4	0.91	300
30.8	Ogenbeena Creek (lower crossing)	552.3	195.60	198.28	882	1079.3	2.68	1.22	0.5	2.0	276.2	1.22	226
31.4	Belyando River (31.4, 31.9, 34.9)	2572.1	192.31	198.07	5454	5631.5	5.76	1.03	0.5	2.0	1286.1	1.03	1246
41.6	East Tributary of Belyando River	310.5	192.92	193.86	1040	684.1	0.94	0.66	0.5	2.0	155.3	0.66	236
42.1		34.2	193.53	194.33	324	114.1	0.79	0.35	0.3	2.0	17.1	0.50	34
44.1		24.1	198.15	198.55	208	46.3	0.40	0.22	0.5	2.0	12.0	0.50	24
47.3		151.4	193.31	194.25	1457	400.5	0.93	0.27	0.4	2.0	75.7	0.50	151
53.6		97.7	192.77	193.65	292	161.8	0.87	0.55	0.6	2.0	48.8	0.55	88
56.6		27.1	193.20	193.74	153	47.0	0.54	0.31	0.6	2.0	13.6	0.50	27
57.3		19.9	192.40	192.78	128	36.4	0.38	0.28	0.5	2.0	10.0	0.50	20
58.2		28.7	193.54	194.11	159	60.8	0.56	0.38	0.5	2.0	14.3	0.50	29
58.8	Mistake Creek (58.8, 59.4, 60.2, 62.1)	640.0	188.21	190.14	3002	1697.4	1.93	0.57	0.4	2.0	320.0	0.57	566
67.3	Gowrie Creek	346.0	192.02	194.10	1005	645.0	2.09	0.64	0.5	2.0	173.0	0.64	270
70.2		105.6	198.67	200.20	327	177.6	1.53	0.54	0.6	2.0	52.8	0.54	97
74.1		22.5	210.81	211.29	223	50.8	0.48	0.23	0.4	2.0	11.2	0.50	22
75.5		13.4	213.91	214.15	339	42.5	0.24	0.13	0.3	2.0	6.7	0.50	13
76.0		16.7	213.86	214.15	444	58.6	0.29	0.13	0.3	2.0	8.3	0.50	17
76.8		88.0	214.48	215.47	200	115.7	0.99	0.58	0.8	2.0	44.0	0.58	76

Preliminary Watercourse Crossing Sizing - 50 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)
2

D_{min} (m)
0.5

total span length for entire railway, m -> 7154

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
77.7		43.9	218.83	219.48	205	77.0	0.64	0.38	0.6	2.0	22.0	0.50	44
80.4		37.5	221.71	222.59	103	48.8	0.88	0.47	0.8	2.0	18.8	0.50	38
82.3		14.4	221.23	221.42	263	37.4	0.20	0.14	0.4	2.0	7.2	0.50	14
83.3		41.3	220.27	221.25	243	72.9	0.98	0.30	0.6	2.0	20.7	0.50	41
85.4		299.9	210.65	211.74	1057	653.4	1.09	0.62	0.5	2.0	149.9	0.62	242
87.6		16.0	211.27	211.54	293	44.5	0.28	0.15	0.4	2.0	8.0	0.50	16
91.0		35.2	209.95	210.31	734	126.8	0.37	0.17	0.3	2.0	17.6	0.50	35
93.4		241.9	206.57	207.69	912	439.8	1.12	0.48	0.5	2.0	120.9	0.50	242
94.4		134.2	206.67	207.67	425	201.6	1.00	0.47	0.7	2.0	67.1	0.50	134
98.2		13.8	213.14	213.38	493	57.6	0.24	0.12	0.2	2.0	6.9	0.50	14
99.2		21.7	211.63	212.04	389	59.8	0.41	0.15	0.4	2.0	10.9	0.50	22
100.4		43.1	208.90	209.47	463	105.5	0.57	0.23	0.4	2.0	21.6	0.50	43
101.2		11.7	209.49	209.78	562	64.1	0.29	0.11	0.2	2.0	5.8	0.50	12
102.1		6.5	209.04	209.40	76	13.4	0.36	0.18	0.5	2.0	3.3	0.50	7
102.5	Logan Creek (102.5, 103.5)	1006.3	203.15	209.86	1382	1851.8	6.71	1.34	0.5	2.0	503.2	1.34	376
104.2		9.4	209.88	210.06	1074	82.2	0.19	0.08	0.1	2.0	4.7	0.50	9
107.0		24.6	210.74	210.98	1609	152.4	0.24	0.09	0.2	2.0	12.3	0.50	25
110.5		80.0	208.97	209.44	1932	376.6	0.46	0.19	0.2	2.0	40.0	0.50	80
112.5		45.1	209.84	210.12	2023	271.8	0.28	0.13	0.2	2.0	22.5	0.50	45
115.8		74.6	207.00	207.66	385	189.4	0.66	0.49	0.4	2.0	37.3	0.50	75
119.4	Diamond Creek	457.5	206.26	207.35	2553	1474.8	1.09	0.58	0.3	2.0	228.8	0.58	396
125.5		13.0	213.92	214.18	312	49.6	0.26	0.16	0.3	2.0	6.5	0.50	13
129.6		8.0	220.17	220.38	512	49.2	0.21	0.10	0.2	2.0	4.0	0.50	8
130.3		7.3	220.29	220.53	355	37.0	0.24	0.10	0.2	2.0	3.7	0.50	7
131.4		29.3	219.65	219.92	702	111.6	0.27	0.16	0.3	2.0	14.6	0.50	29
133.7		29.5	220.09	220.65	516	99.1	0.56	0.19	0.3	2.0	14.8	0.50	30

Preliminary Watercourse Crossing Sizing - 50 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)	D_{min} (m)
2	0.5

total span length for entire railway, m -> 7154

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
135.0		20.5	220.73	221.21	203	54.9	0.48	0.27	0.4	2.0	10.3	0.50	21
136.4		77.5	221.01	221.75	576	184.8	0.74	0.32	0.4	2.0	38.8	0.50	78
138.2		18.7	228.64	228.93	245	31.9	0.29	0.13	0.6	2.0	9.4	0.50	19
139.4		7.3	248.53	248.86	43	8.9	0.33	0.21	0.8	2.0	3.7	0.50	7
140.7		8.7	255.72	255.98	112	15.5	0.26	0.14	0.6	2.0	4.3	0.50	9
141.2		7.7	252.71	253.11	56	12.0	0.41	0.21	0.6	2.0	3.9	0.50	8
142.6		31.1	252.30	252.68	276	58.7	0.38	0.21	0.5	2.0	15.5	0.50	31
143.6		9.6	253.80	254.00	403	34.8	0.19	0.09	0.3	2.0	4.8	0.50	10
144.2		10.0	253.77	254.02	178	24.9	0.25	0.14	0.4	2.0	5.0	0.50	10
146.6		6.1	257.80	258.02	342	26.5	0.23	0.08	0.2	2.0	3.0	0.50	6
147.6		10.4	258.18	258.51	436	40.2	0.33	0.09	0.3	2.0	5.2	0.50	10
149.3		30.5	255.08	255.40	395	71.2	0.32	0.18	0.4	2.0	15.2	0.50	30
150.7		24.5	259.59	259.93	316	61.4	0.34	0.19	0.4	2.0	12.2	0.50	24
154.6		19.0	260.75	261.08	806	112.0	0.34	0.14	0.2	2.0	9.5	0.50	19
155.0		15.7	260.85	261.10	466	71.0	0.25	0.15	0.2	2.0	7.9	0.50	16
157.1		34.2	260.83	261.20	490	99.1	0.37	0.20	0.3	2.0	17.1	0.50	34
158.6		20.5	259.88	260.13	497	69.4	0.25	0.14	0.3	2.0	10.2	0.50	20
159.1		38.1	258.98	259.40	321	84.5	0.42	0.26	0.5	2.0	19.0	0.50	38
160.8		16.0	262.48	262.70	538	53.0	0.22	0.10	0.3	2.0	8.0	0.50	16
162.1		66.6	261.21	262.11	330	114.1	0.89	0.35	0.6	2.0	33.3	0.50	67
163.7	Grosvenor Creek	237.9	262.73	265.29	362	292.6	2.56	0.81	0.8	2.0	118.9	0.81	147
165.8		75.9	272.95	273.35	922	167.5	0.40	0.18	0.5	2.0	38.0	0.50	76
168.6		8.3	288.80	289.06	317	27.4	0.26	0.09	0.3	2.0	4.2	0.50	8
170.6		8.4	317.92	318.08	157	16.2	0.16	0.10	0.5	2.0	4.2	0.50	8
172.0		56.1	311.96	313.29	80	44.0	1.33	0.55	1.3	2.0	28.0	0.55	51
173.6		24.6	323.23	323.75	50	17.1	0.52	0.34	1.4	2.0	12.3	0.50	25

Preliminary Watercourse Crossing Sizing - 50 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)	D_{min} (m)
2	0.5

total span length for entire railway, m -> 7154

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
174.1		6.1	330.48	330.83	17	3.0	0.36	0.18	2.0	2.0	3.0	0.50	6
174.7		14.4	329.85	330.09	134	12.7	0.24	0.09	1.1	2.0	7.2	0.50	14
175.3		61.7	331.11	331.58	168	54.9	0.46	0.33	1.1	2.0	30.8	0.50	62
176.7		6.5	356.62	356.77	134	10.8	0.15	0.08	0.6	2.0	3.2	0.50	6
177.0		7.1	354.99	355.17	145	12.7	0.17	0.09	0.6	2.0	3.5	0.50	7
177.7		5.8	344.89	345.08	141	10.2	0.18	0.07	0.6	2.0	2.9	0.50	6
178.4		21.9	334.00	334.51	86	22.1	0.51	0.26	1.0	2.0	11.0	0.50	22
178.8		4.2	336.49	336.68	69	6.9	0.20	0.10	0.6	2.0	2.1	0.50	4
180.0		5.6	312.44	312.78	23	4.5	0.34	0.20	1.2	2.0	2.8	0.50	6
181.0		33.4	294.88	295.46	135	34.8	0.58	0.26	1.0	2.0	16.7	0.50	33

Preliminary Watercourse Crossing Sizing - 100 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)
2

D_{min} (m)
0.5

total span length for entire railway, m -> 8179

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
1.7		35.8	224.00	224.37	392	88.3	0.37	0.23	0.4	2.0	17.9	0.50	36
4.7	Eight Mile Creek	306.3	218.40	219.52	1171	652.8	1.12	0.56	0.5	2.0	153.1	0.56	275
7.8		55.2	214.91	215.58	360	125.0	0.67	0.35	0.4	2.0	27.6	0.50	55
9.0		19.4	214.56	214.99	295	67.2	0.43	0.23	0.3	2.0	9.7	0.50	19
10.4	North Creek	467.7	214.51	216.35	850	644.9	1.84	0.76	0.7	2.0	233.9	0.76	308
17.1		140.1	207.00	207.22	1853	372.8	0.22	0.20	0.4	2.0	70.1	0.50	140
18.8		24.3	207.61	207.83	360	54.9	0.22	0.15	0.4	2.0	12.1	0.50	24
21.1		50.4	205.96	206.37	554	114.2	0.41	0.21	0.4	2.0	25.2	0.50	50
27.9	Ogenbeena Creek	710.8	197.14	200.22	1439	1527.5	3.08	1.06	0.5	2.0	355.4	1.06	335
30.8	Ogenbeena Creek (lower crossing)	718.2	195.60	198.70	1541	1579.7	3.10	1.03	0.5	2.0	359.1	1.03	350
31.4	Belyando River (31.4, 31.9, 34.9)	3336.0	192.31	198.27	5815	6753.1	5.96	1.16	0.5	2.0	1668.0	1.16	1436
41.6	East Tributary of Belyando River	397.6	192.92	193.97	1067	801.7	1.05	0.75	0.5	2.0	198.8	0.75	265
42.1		38.1	193.53	194.36	356	126.5	0.83	0.36	0.3	2.0	19.1	0.50	38
44.1		26.8	198.15	198.57	214	50.0	0.42	0.23	0.5	2.0	13.4	0.50	27
47.3		169.8	193.31	194.27	1462	429.7	0.95	0.29	0.4	2.0	84.9	0.50	170
53.6		109.4	192.77	193.69	298	174.6	0.92	0.59	0.6	2.0	54.7	0.59	93
56.6		30.2	193.20	193.77	158	50.8	0.57	0.32	0.6	2.0	15.1	0.50	30
57.3		22.2	192.40	192.80	130	39.2	0.40	0.30	0.6	2.0	11.1	0.50	22
58.2		31.9	193.54	194.14	166	66.0	0.59	0.40	0.5	2.0	16.0	0.50	32
58.8	Mistake Creek (58.8, 59.4, 60.2, 62.1)	697.0	188.21	190.19	3209	1834.9	1.97	0.57	0.4	2.0	348.5	0.57	609
67.3	Gowrie Creek	435.2	192.02	194.20	1029	747.2	2.19	0.73	0.6	2.0	217.6	0.73	300
70.2		118.1	198.67	200.24	332	191.0	1.57	0.57	0.6	2.0	59.0	0.57	103
74.1		25.1	210.81	211.31	241	56.0	0.50	0.23	0.4	2.0	12.5	0.50	25
75.5		15.0	213.91	214.16	345	45.6	0.25	0.13	0.3	2.0	7.5	0.50	15
76.0		18.6	213.86	214.16	455	63.3	0.30	0.14	0.3	2.0	9.3	0.50	19
76.8		98.3	214.48	215.52	209	126.0	1.04	0.60	0.8	2.0	49.2	0.60	82

Preliminary Watercourse Crossing Sizing - 100 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)	D_{min} (m)
2	0.5

total span length for entire railway, m -> 8179

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
77.7		49.0	218.83	219.51	216	84.0	0.68	0.39	0.6	2.0	24.5	0.50	49
80.4		41.9	221.71	222.63	107	53.0	0.92	0.49	0.8	2.0	20.9	0.50	42
82.3		16.1	221.23	221.44	268	40.2	0.21	0.15	0.4	2.0	8.0	0.50	16
83.3		46.2	220.27	221.28	257	79.8	1.01	0.31	0.6	2.0	23.1	0.50	46
85.4		336.3	210.65	211.79	1101	711.6	1.15	0.65	0.5	2.0	168.2	0.65	260
87.6		17.9	211.27	211.56	313	48.8	0.29	0.16	0.4	2.0	8.9	0.50	18
91.0		39.3	209.95	210.33	754	136.9	0.38	0.18	0.3	2.0	19.6	0.50	39
93.4		271.4	206.57	207.73	945	477.9	1.16	0.51	0.6	2.0	135.7	0.51	268
94.4		150.4	206.67	207.70	434	217.5	1.04	0.50	0.7	2.0	75.2	0.50	150
98.2		15.4	213.14	213.39	499	61.8	0.25	0.12	0.2	2.0	7.7	0.50	15
99.2		24.2	211.63	212.06	418	65.7	0.43	0.16	0.4	2.0	12.1	0.50	24
100.4		48.2	208.90	209.49	480	114.5	0.59	0.24	0.4	2.0	24.1	0.50	48
101.2		13.0	209.49	209.79	570	68.8	0.29	0.12	0.2	2.0	6.5	0.50	13
102.1		7.3	209.04	209.41	80	14.6	0.37	0.18	0.5	2.0	3.6	0.50	7
102.5	Logan Creek (102.5, 103.5)	1301.6	203.15	210.10	1438	2195.5	6.95	1.53	0.6	2.0	650.8	1.53	426
104.2		10.5	209.88	210.07	1082	87.9	0.19	0.08	0.1	2.0	5.2	0.50	10
107.0		27.4	210.74	210.99	1657	164.8	0.24	0.10	0.2	2.0	13.7	0.50	27
110.5		89.8	208.97	209.45	1999	408.8	0.48	0.20	0.2	2.0	44.9	0.50	90
112.5		50.5	209.84	210.13	2037	291.5	0.29	0.14	0.2	2.0	25.2	0.50	50
115.8		83.2	207.00	207.69	394	204.0	0.69	0.52	0.4	2.0	41.6	0.52	80
119.4	Diamond Creek	620.2	206.26	207.47	2663	1800.3	1.21	0.68	0.3	2.0	310.1	0.68	459
125.5		14.5	213.92	214.19	318	53.3	0.27	0.17	0.3	2.0	7.3	0.50	15
129.6		8.9	220.17	220.39	572	54.9	0.22	0.10	0.2	2.0	4.5	0.50	9
130.3		8.2	220.29	220.53	360	39.7	0.25	0.11	0.2	2.0	4.1	0.50	8
131.4		32.7	219.65	219.94	718	120.3	0.28	0.17	0.3	2.0	16.3	0.50	33
133.7		33.0	220.09	220.67	520	106.3	0.57	0.20	0.3	2.0	16.5	0.50	33

Preliminary Watercourse Crossing Sizing - 100 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)	D_{min} (m)
2	0.5

total span length for entire railway, m -> 8179

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
135.0		22.9	220.73	221.23	207	59.1	0.50	0.29	0.4	2.0	11.5	0.50	23
136.4		86.6	221.01	221.78	595	200.2	0.77	0.34	0.4	2.0	43.3	0.50	87
138.2		20.9	228.64	228.95	255	34.7	0.31	0.14	0.6	2.0	10.5	0.50	21
139.4		8.1	248.53	248.88	44	9.5	0.35	0.22	0.9	2.0	4.1	0.50	8
140.7		9.7	255.72	255.99	116	16.7	0.27	0.14	0.6	2.0	4.8	0.50	10
141.2		8.6	252.71	253.13	58	13.1	0.43	0.22	0.7	2.0	4.3	0.50	9
142.6		34.6	252.30	252.70	309	65.6	0.40	0.21	0.5	2.0	17.3	0.50	35
143.6		10.7	253.80	254.00	425	38.0	0.20	0.09	0.3	2.0	5.4	0.50	11
144.2		11.1	253.77	254.03	181	26.8	0.26	0.15	0.4	2.0	5.6	0.50	11
146.6		6.8	257.80	258.03	350	28.5	0.23	0.08	0.2	2.0	3.4	0.50	7
147.6		11.5	258.18	258.52	476	44.3	0.34	0.09	0.3	2.0	5.8	0.50	12
149.3		34.0	255.08	255.41	402	76.5	0.33	0.19	0.4	2.0	17.0	0.50	34
150.7		27.3	259.59	259.94	325	66.4	0.35	0.20	0.4	2.0	13.7	0.50	27
154.6		21.2	260.75	261.09	808	119.7	0.35	0.15	0.2	2.0	10.6	0.50	21
155.0		17.5	260.85	261.11	466	75.8	0.26	0.16	0.2	2.0	8.8	0.50	18
157.1		38.1	260.83	261.21	490	105.9	0.38	0.22	0.4	2.0	19.1	0.50	38
158.6		22.9	259.88	260.14	498	74.2	0.26	0.15	0.3	2.0	11.4	0.50	23
159.1		42.5	258.98	259.42	333	91.7	0.44	0.28	0.5	2.0	21.2	0.50	42
160.8		17.8	262.48	262.70	552	57.2	0.23	0.10	0.3	2.0	8.9	0.50	18
162.1		74.5	261.21	262.14	348	124.8	0.93	0.36	0.6	2.0	37.2	0.50	74
163.7	Grosvenor Creek	306.6	262.73	265.47	433	365.8	2.74	0.84	0.8	2.0	153.3	0.84	181
165.8		85.0	272.95	273.37	938	180.4	0.42	0.19	0.5	2.0	42.5	0.50	85
168.6		9.3	288.80	289.07	338	30.1	0.27	0.09	0.3	2.0	4.6	0.50	9
170.6		9.4	317.92	318.09	163	17.5	0.17	0.11	0.5	2.0	4.7	0.50	9
172.0		62.5	311.96	313.35	90	49.2	1.39	0.55	1.3	2.0	31.2	0.55	57
173.6		27.4	323.23	323.78	52	18.4	0.55	0.36	1.5	2.0	13.7	0.50	27

Preliminary Watercourse Crossing Sizing - 100 year ARI

Carmichael Mine - Railway

method: estimate crossing span length based on velocity criteria.

V_{des} (m/s)	D_{min} (m)
2	0.5

total span length for entire railway, m -> 8179

			Existing channel section (see normal depth calc's)							Proposed Crossing Structure			
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	Q, design flow, m3/s	invert ground level, m	water level, m	W_n, top width, m	A_n, flow area, m2	D_{max}, maximum depth, m	D_n, average depth, m	V_n, average velocity, m/s	V_c, velocity through crossing = max of V_{des} or V_{nat}, m/s	A_c, flow area at crossing = Q / V_c, m2	D_c, depth of water at through crossing = max of D_n and D_{min}, m^2	estimated crossing span = A_c / D_c, m
174.1		6.8	330.48	330.85	18	3.3	0.37	0.19	2.1	2.1	3.3	0.50	7
174.7		16.1	329.85	330.10	143	13.9	0.25	0.10	1.2	2.0	8.1	0.50	16
175.3		68.7	331.11	331.60	174	59.4	0.49	0.34	1.2	2.0	34.3	0.50	69
176.7		7.2	356.62	356.77	136	11.6	0.16	0.09	0.6	2.0	3.6	0.50	7
177.0		7.9	354.99	355.17	146	13.6	0.18	0.09	0.6	2.0	3.9	0.50	8
177.7		6.4	344.89	345.08	144	10.9	0.19	0.08	0.6	2.0	3.2	0.50	6
178.4		24.4	334.00	334.53	89	23.9	0.53	0.27	1.0	2.0	12.2	0.50	24
178.8		4.7	336.49	336.69	72	7.5	0.21	0.10	0.6	2.0	2.3	0.50	5
180.0		6.2	312.44	312.80	24	4.9	0.36	0.21	1.3	2.0	3.1	0.50	6
181.0		37.3	294.88	295.48	140	37.8	0.60	0.27	1.0	2.0	18.6	0.50	37

APPENDIX G

Comparison of Updates in Hydrology

Comparison of Updated Hydrologic Results

Carmichael Mine - Railway

			50 year ARI					
			Peak Flow		Max Depth		Span Length	
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	catchment area, km²	Draft Hydrology, m3/s	Updated Hydrology, m3/s	Draft Hydrology, m	Updated Hydrology, m	Based on Max Depth, m	Based on Avg Depth, m
1.7		4.1	56.1	32.1	0.45	0.35	28	32
4.7	Eight Mile Creek	180.0	248.0	230.5	1.03	1.00	124	225
7.8		12.5	86.3	49.3	0.79	0.64	43	49
9.0		2.2	30.5	17.4	0.53	0.41	15	17
10.4	North Creek	300.0	395.0	364.9	1.77	1.74	99	279
17.1		36.5	219.0	125.1	0.28	0.20	109	125
18.8		2.7	38.1	21.8	0.27	0.21	19	22
21.1		4.2	64.6	45.2	0.46	0.40	32	45
27.9	Ogenbeena Creek	850.0	591.0	546.7	2.97	2.92	99	300
30.8	Ogenbeena Creek (lower crossing)	870.0	597.0	552.3	2.90	2.68	100	226
31.4	Belyando River (31.4, 31.9, 34.9)	22000.0	2785.0	2572.1	5.82	5.76	232	1246
41.6	East Tributary of Belyando River	210.0	336.0	310.5	0.98	0.94	168	236
42.1		5.0	59.8	34.2	0.99	0.79	30	34
44.1		1.1	24.1	24.1	0.40	0.40	12	24
47.3		59.7	264.9	151.4	1.05	0.93	132	151
53.6		27.9	170.9	97.7	1.13	0.87	85	88
56.6		1.3	27.1	27.1	0.54	0.54	14	27
57.3		1.0	19.9	19.9	0.38	0.38	10	20
58.2		1.5	28.7	28.7	0.56	0.56	14	29
58.8	Mistake Creek (58.8, 59.4, 60.2, 62.1)	7900.0	2372.0	640.0	2.65	1.93	395	566
67.3	Gowrie Creek	210.0	376.0	346.0	2.12	2.09	94	270
70.2		21.9	184.8	105.6	1.76	1.53	46	97
74.1		3.3	39.3	22.5	0.60	0.48	20	22
75.5		0.8	14.3	13.4	0.24	0.24	7	13
76.0		0.9	17.7	16.7	0.30	0.29	9	17
76.8		17.7	154.0	88.0	1.29	0.99	77	76
77.7		6.6	76.8	43.9	0.82	0.64	38	44
80.4		5.6	65.7	37.5	1.10	0.88	33	38
82.3		1.4	20.6	14.4	0.24	0.20	10	14
83.3		8.5	72.4	41.3	1.12	0.98	36	41
85.4		109.7	524.8	299.9	1.36	1.09	262	242
87.6		2.1	28.1	16.0	0.35	0.28	14	16
91.0		6.7	61.5	35.2	0.44	0.37	31	35
93.4		99.4	423.3	241.9	1.35	1.12	212	242
94.4		42.8	234.9	134.2	1.21	1.00	117	134
98.2		0.6	13.8	13.8	0.24	0.24	7	14
99.2		1.1	21.7	21.7	0.41	0.41	11	22
100.4		10.8	75.4	43.1	0.69	0.57	38	43
101.2		1.7	20.4	11.7	0.34	0.29	10	12
102.1		0.4	6.9	6.5	0.37	0.36	3	7
102.5	Logan Creek (102.5, 103.5)	2900.0	1089.0	1006.3	6.78	6.71	78	376
104.2		1.7	16.4	9.4	0.22	0.19	8	9
107.0		3.9	43.0	24.6	0.28	0.24	21	25
110.5		30.1	140.1	80.0	0.55	0.46	70	80
112.5		12.5	78.9	45.1	0.34	0.28	39	45
115.8		9.9	130.5	74.6	1.07	0.66	65	75
119.4	Diamond Creek	1000.0	490.0	457.5	1.11	1.09	245	396
125.5		1.2	18.6	13.0	0.31	0.26	9	13
129.6		0.3	8.0	8.0	0.21	0.21	4	8
130.3		0.4	7.8	7.3	0.24	0.24	4	7
131.4		3.9	51.3	29.3	0.34	0.27	26	29
133.7		5.4	51.7	29.5	0.64	0.56	26	30
135.0		2.0	29.3	20.5	0.55	0.48	15	21

Comparison of Updated Hydrologic Results

Carmichael Mine - Railway

Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	catchment area, km²	50 year ARI Peak Flow Draft Hydrology, m3/s	Peak Flow Updated Hydrology, m3/s	Max Depth Draft Hydrology, m	Max Depth Updated Hydrology, m	Span Length Based on Max Depth, m	Span Length Based on Avg Depth, m
136.4		14.4	135.6	77.5	0.89	0.74	68	78
138.2		0.6	18.7	18.7	0.29	0.29	9	19
139.4		0.3	7.3	7.3	0.33	0.33	4	7
140.7		0.4	8.7	8.7	0.26	0.26	4	9
141.2		0.2	7.7	7.7	0.41	0.41	4	8
142.6		1.1	31.1	31.1	0.38	0.38	16	31
143.6		0.4	9.6	9.6	0.19	0.19	5	10
144.2		0.4	10.0	10.0	0.19	0.25	5	10
146.6		0.3	6.1	6.1	0.23	0.23	3	6
147.6		0.4	10.4	10.4	0.33	0.33	5	10
149.3		4.4	53.3	30.5	0.40	0.32	27	30
150.7		1.5	26.0	24.5	0.35	0.34	13	24
154.6		2.9	33.3	19.0	0.40	0.34	17	19
155.0		2.0	27.5	15.7	0.31	0.25	14	16
157.1		3.3	48.9	34.2	0.42	0.37	24	34
158.6		2.8	35.9	20.5	0.31	0.25	18	20
159.1		6.0	66.6	38.1	0.53	0.42	33	38
160.8		0.8	16.0	16.0	0.22	0.22	8	16
162.1		16.5	116.5	66.6	1.11	0.89	58	67
163.7	Grosvenor Creek	128.4	257.2	237.9	2.62	2.56	43	147
165.8		20.5	132.8	75.9	0.48	0.40	66	76
168.6		0.6	10.0	8.3	0.28	0.26	5	8
170.6		0.3	8.4	8.4	0.16	0.16	4	8
172.0		2.1	56.1	56.1	1.33	1.33	28	51
173.6		0.9	24.6	24.6	0.52	0.52	12	25
174.1		0.2	6.1	6.1	0.36	0.36	3	6
174.7		0.4	14.4	14.4	0.24	0.24	7	14
175.3		2.5	61.7	61.7	0.46	0.46	31	62
176.7		0.2	6.5	6.5	0.15	0.15	3	6
177.0		0.2	7.1	7.1	0.31	0.17	4	7
177.7		0.2	5.8	5.8	0.18	0.18	3	6
178.4		1.0	21.9	21.9	0.51	0.51	11	22
178.8		0.1	4.2	4.2	0.20	0.20	2	4
180.0		0.3	5.6	5.6	0.34	0.34	3	6
181.0		3.3	47.8	33.4	0.65	0.58	24	33

Comparison of Updated Hydrologic Results

Carmichael Mine - Railway

			100 year ARI					
			Peak Flow		Max Depth		Span Length	
Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	catchment area, km²	Draft Hydrology, m3/s	Updated Hydrology, m3/s	Draft Hydrology, m	Updated Hydrology, m	Based on Max Depth, m	Based on Avg Depth, m
1.7		4.1	62.6	35.8	0.47	0.37	31	36
4.7	Eight Mile Creek	180.0	338.0	306.3	1.16	1.12	169	275
7.8		12.5	96.5	55.2	0.82	0.67	48	55
9.0		2.2	34.0	19.4	0.55	0.43	17	19
10.4	North Creek	300.0	522.0	467.7	1.89	1.84	131	308
17.1		36.5	245.2	140.1	0.30	0.22	123	140
18.8		2.7	42.5	24.3	0.29	0.22	21	24
21.1		4.2	72.0	50.4	0.48	0.41	36	50
27.9	Ogenbeena Creek	850.0	791.0	710.8	3.15	3.08	132	335
30.8	Ogenbeena Creek (lower crossing)	870.0	799.0	718.2	3.20	3.10	133	350
31.4	Belyando River (31.4, 31.9, 34.9)	22000.0	3727.0	3336.0	6.06	5.96	311	1436
41.6	East Tributary of Belyando River	210.0	443.0	397.6	1.11	1.05	222	265
42.1		5.0	66.7	38.1	1.02	0.83	33	38
44.1		1.1	26.8	26.8	0.42	0.42	13	27
47.3		59.7	297.2	169.8	1.07	0.95	149	170
53.6		27.9	191.4	109.4	1.19	0.92	96	93
56.6		1.3	30.2	30.2	0.57	0.57	15	30
57.3		1.0	22.2	22.2	0.40	0.40	11	22
58.2		1.5	31.9	31.9	0.59	0.59	16	32
58.8	Mistake Creek (58.8, 59.4, 60.2, 62.1)	7900.0	3022.0	697.0	2.84	1.97	504	609
67.3	Gowrie Creek	210.0	488.0	435.2	2.24	2.19	122	300
70.2		21.9	206.6	118.1	1.81	1.57	52	103
74.1		3.3	43.8	25.1	0.61	0.50	22	25
75.5		0.8	15.9	15.0	0.25	0.25	8	15
76.0		0.9	19.7	18.6	0.31	0.30	10	19
76.8		17.7	172.1	98.3	1.34	1.04	86	82
77.7		6.6	85.8	49.0	0.86	0.68	43	49
80.4		5.6	73.3	41.9	1.15	0.92	37	42
82.3		1.4	22.9	16.1	0.25	0.21	11	16
83.3		8.5	80.9	46.2	1.15	1.01	40	46
85.4		109.7	588.5	336.3	1.42	1.15	294	260
87.6		2.1	31.3	17.9	0.36	0.29	16	18
91.0		6.7	68.7	39.3	0.46	0.38	34	39
93.4		99.4	474.9	271.4	1.41	1.16	237	268
94.4		42.8	263.2	150.4	1.27	1.04	132	150
98.2		0.6	15.4	15.4	0.25	0.25	8	15
99.2		1.1	24.2	24.2	0.43	0.43	12	24
100.4		10.8	84.4	48.2	0.71	0.59	42	48
101.2		1.7	22.8	13.0	0.35	0.29	11	13
102.1		0.4	7.7	7.3	0.38	0.37	4	7
102.5	Logan Creek (102.5, 103.5)	2900.0	1452.0	1301.6	7.07	6.95	104	426
104.2		1.7	18.3	10.5	0.22	0.19	9	10
107.0		3.9	48.0	27.4	0.29	0.24	24	27
110.5		30.1	157.1	89.8	0.57	0.48	79	90
112.5		12.5	88.3	50.5	0.35	0.29	44	50
115.8		9.9	145.6	83.2	1.09	0.69	73	80
119.4	Diamond Creek	1000.0	682.0	620.2	1.26	1.21	341	459
125.5		1.2	20.7	14.5	0.32	0.27	10	15
129.6		0.3	8.9	8.9	0.22	0.22	4	9
130.3		0.4	8.7	8.2	0.25	0.25	4	8
131.4		3.9	57.2	32.7	0.36	0.28	29	33
133.7		5.4	57.7	33.0	0.66	0.57	29	33
135.0		2.0	32.7	22.9	0.58	0.50	16	23

Comparison of Updated Hydrologic Results

Carmichael Mine - Railway

Crossing ID (based on chainage)	Name (including chainages of multiple crossings)	catchment area, km²	100 year ARI					
			Peak Flow		Max Depth		Span Length	
			Draft Hydrology, m3/s	Updated Hydrology, m3/s	Draft Hydrology, m	Updated Hydrology, m	Based on Max Depth, m	Based on Avg Depth, m
136.4		14.4	151.5	86.6	0.92	0.77	76	87
138.2		0.6	20.9	20.9	0.31	0.31	10	21
139.4		0.3	8.1	8.1	0.35	0.35	4	8
140.7		0.4	9.7	9.7	0.27	0.27	5	10
141.2		0.2	8.6	8.6	0.43	0.43	4	9
142.6		1.1	34.6	34.6	0.40	0.40	17	35
143.6		0.4	10.7	10.7	0.20	0.20	5	11
144.2		0.4	11.1	11.1	0.26	0.26	6	11
146.6		0.3	6.8	6.8	0.23	0.23	3	7
147.6		0.4	11.5	11.5	0.34	0.34	6	12
149.3		4.4	59.5	34.0	0.41	0.33	30	34
150.7		1.5	29.0	27.3	0.36	0.35	14	27
154.6		2.9	37.1	21.2	0.41	0.35	19	21
155.0		2.0	30.7	17.5	0.33	0.26	15	18
157.1		3.3	54.5	38.1	0.43	0.38	27	38
158.6		2.8	40.0	22.9	0.32	0.26	20	23
159.1		6.0	74.4	42.5	0.56	0.44	37	42
160.8		0.8	17.8	17.8	0.23	0.23	9	18
162.1		16.5	130.4	74.5	1.14	0.93	65	74
163.7	Grosvenor Creek	128.4	341.1	306.6	2.81	2.74	57	181
165.8		20.5	148.7	85.0	0.50	0.42	74	85
168.6		0.6	11.2	9.3	0.28	0.27	6	9
170.6		0.3	9.4	9.4	0.17	0.17	5	9
172.0		2.1	62.5	62.5	1.39	1.39	31	57
173.6		0.9	27.4	27.4	0.55	0.55	14	27
174.1		0.2	6.8	6.8	0.37	0.37	3	7
174.7		0.4	16.1	16.1	0.25	0.25	8	16
175.3		2.5	68.7	68.7	0.49	0.49	34	69
176.7		0.2	7.2	7.2	0.16	0.16	4	7
177.0		0.2	7.9	7.9	0.18	0.18	4	8
177.7		0.2	6.4	6.4	0.19	0.19	3	6
178.4		1.0	24.4	24.4	0.53	0.53	12	24
178.8		0.1	4.7	4.7	0.21	0.21	2	5
180.0		0.3	6.2	6.2	0.36	0.36	3	6
181.0		3.3	53.3	37.3	0.67	0.60	27	37

APPENDIX H

Limitations

LIMITATIONS

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ADANI MINING PTY LTD

Carmichael Coal Rail Line - Hydraulic Modelling of Major Watercourses

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REPORT

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TABLES

APPENDICES

1.0 INTRODUCTION

1.1 Scope

Hydraulic modelling of Belyando River and Mistake Creek was previously completed and presented in the *Preliminary Railway Hydrological Investigation*[1], which was submitted to Adani Mining Pty Ltd on 19 October 2011. This study provides similar preliminary hydraulic modelling for the remaining major watercourse crossings of the proposed Carmichael rail line for the 100 year ARI flood event.

The information provided in this study is intended for preliminary assessments as input to the environmental impact statement (EIS) and conceptual railway design.

1.2 Background

Ten major watercourses were identified in the *Preliminary Railway Hydrological Investigation*, but more recently 12 watercourses were identified in the *Carmichael Rail Line Concept Design*[2]. The two new watercourse crossings include a previously identified minor watercourse between Logan and Gowrie Creeks and the lower crossing of Ogenbeena Creek that was grouped with the Ogenbeena Creek crossing.

Additionally, the rail line alignment has been updated to Option 9 Revision 2. This alignment significantly deviates from that for which LIDAR data was obtained between Chainages 63 km and 101 km (chainage is east to west as per the *Carmichael Rail Line Concept Design*), which contains Logan Creek and the unidentified crossing at Chainage 93.1 km. No LIDAR data therefore exists for these crossings with the best available digital topographical data in this region being a global digital elevation model (GDEM). The quality of the GDEM data was reassessed at these crossings, but found to be not sufficiently accurate for meaningful hydraulic modelling.

Therefore, hydraulic modelling for a further five watercourse crossings are presented in this report. Hydraulic impacts at Logan Creek crossing and the unidentified crossing at Chainage 93.1 km are summarised based on qualitative comparisons of the other crossings. Results from the previous models of Belyando River and Mistake Creek have also been included in this report with additional details. Table 1 summarises each of the 12 major watercourse crossings.

Table 1: Carmichael Rail Line Major Watercourse Crossings

Name	Chainage (km)	Status
Grosvenor Creek	18.5	Hydraulic model
Diamond Creek	62.6	Hydraulic model
Logan Creek	76.6	Qualitative assessment (outside of LIDAR survey)
Unidentified watercourse at Chainage 93.1 km	93.1	Qualitative assessment (outside of LIDAR survey)
Gowrie Creek	113.4	Hydraulic model
Mistake Creek	112.0	Hydraulic model previously completed (results included in this report)
East Tributary of Belyando River	139.1	Hydraulic model previously completed (results included in this report). All watercourses backwater together and are part of Belyando River model
Belyando River	145.8	
Ogenbeena Creek (lower crossing)	150.6	
Ogenbeena Creek	152.8	
North Creek	170.4	Hydraulic model
Eight Mile Creek	176.1	Hydraulic model

[1] Golder Associates. 19 October 2011. *Preliminary Railway Hydrological Investigation* (Report 117632041-009-R-Rev1). Submitted to Adani.

[2] Aarvee Associates. 17 November 2011. *Carmichael Rail Line Concept Design.* Submitted to Adani.

2.0 HYDRAULIC MODELLING

Hydraulic modelling has been undertaken at the watercourses referenced in Table 1 over a range of proposed span sizes (scenarios) to provide an indication of the potential hydraulic impacts from the proposed crossings.

2.1 Methodology

A two dimensional (2D) XPSWMM/TUFLOW model was used due to the complexity of multiple channels and broad floodplains of each of the crossings.

The hydraulic model for each of the watercourses was run for existing conditions and three proposed scenarios for a range of span lengths as presented in Table 2. The span lengths for Scenario 1 were selected based on sizes reported in the *Carmichael Rail Line Concept Design* (except for Mistake Creek and Belyando River because they were previously modelled). The span lengths for Scenarios 2 and 3 were initially set at double and half of the span length of Scenario 1. However, where Scenario 1 resulted in significant floodwater bypassing the opening, then the span length for Scenarios 2 and 3 were set at double and four times the span length of Scenario 1.

Table 2: Hydraulic Model Setup

Name	Proposed Total Span Length (m)			100 year ARI Peak Discharge (m^3/s)*	Time Step (sec)	Grid Size (m x m)
	Scenario 1	Scenario 2	Scenario 3			
Grosvenor Creek	60	240	120	310	7	17 x 17
Diamond Creek	340	200	680	620	10	25 x 25
Gowrie Creek	125	250	65	440	5	20 x 20
Mistake Creek	4000	1500	800	700	10	35 x 35
Belyando River (including Ogenbeena Creek and E. Tributary)	6000	2000	800	3400	10	50 x 50
North Creek	130	260	520	470	5	20 x 20
Eight Mile Creek	170	340	85	310	10	16 x 16

*Discharge from Preliminary Railway Hydrologic Investigation

It should be noted that in the absence of more detailed information, span lengths modelled represent the clear opening width provided by either a bridge structure or a combination of bridge and culvert type openings under free surface (non-pressure) flow conditions without taking into account the effects of pier, multiple culvert or pressure flow losses. For final design, it will be necessary to model the specifics of piers, abutments and culvert configurations.

Furthermore, Grosvenor Creek, Mistake Creek, Belyando River, and North Creek all contain multiple channels during flood condition. Multiple spans for these crossings have been modelled.

The following considerations were taken into account in the development of each of the hydraulic models:

- Topography data was provided from a LIDAR survey by Vekta in August, 2011. The LIDAR survey was provided in a 1 m x 1 m horizontal grid with a vertical accuracy of +/- 10 cm [RMSE 1 sigma].
- Model Extents – The extents of the models was positioned as far downstream and upstream as possible within the limit of the available LIDAR data. The extents included several kilometres in both directions.

- Downstream Boundary Condition – The downstream boundary was set as a constant water level less than critical depth, which forces the model to pass through critical depth. It has been assumed that normal depth is established within the lower extent of the model, well downstream of the railway. The downstream boundary condition is the same for all scenarios.
- Manning's Roughness The Manning's value can be expected to change throughout the study reaches; however, a fixed value of 0.05 was used for simplicity as was done in the *Preliminary Railway Hydrological Investigation*.
- Flow – The models upstream boundaries were flow boundaries based on the estimated 100 year ARI peak flow presented in Table 2.
- Time step and grid size – A time step and grid size for the models were set to provide an acceptable resolution for results while allowing the model to run efficiently for the preliminary analysis. Table 2 presents the time step and grid size for each of the models.

Results of the each of the hydraulic models reported hereafter include:

- Peak water level, velocity and afflux at each of the bridge openings
- Afflux at differing distances upstream of the bridge opening in the main channel
- Increase in flood inundated area with respect to existing conditions

2.2 Grosvenor Creek

The water depths and flood inundation mapping for Grosvenor Creek are presented in Figures 1 through 4 in APPENDIX A.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 3. It shows that the average afflux in the main channel increases with decrease in total span lengths.

Table 3: Grosvenor Creek Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Location	Peak Water Level (m)	Peak Velocity (m/s)	Peak Afflux (m)
Existing	West channel	265.26	1.04	NA
	Main channel	265.45	1.58	NA
	East channel	265.63	0.52	NA
Scenario 1 (60 m)	West channel	NA	NA	NA
	Main channel (60 m)	266.45	3.96	1.00
	East channel	NA	NA	NA
Scenario 2 (240 m)	West channel (60 m)	265.53	1.79	0.27
	Main channel (120 m)	265.81	1.86	0.36
	East channel (60 m)	266.71	0.95	1.08
Scenario 3 (120 m)	West channel (50 m)	265.79	1.87	0.53
	Main channel (70 m)	265.88	2.27	0.43
	East channel	NA	NA	NA

The afflux at 0.2 km, 0.5 km and 1 km upstream of the main channel is presented in Table 4. It shows that the afflux decreases with the distance upstream of the main channel for a specified scenario. It also shows a decrease in afflux with an increase in span length for specified distance upstream of the main channel.

Table 4: Grosvenor Creek Upstream Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.2 km Upstream	0.5 km Upstream	1 km Upstream
Scenario 1 (60 m)	0.54	0.03	<0.01
Scenario 2 (240 m)	0.04	<0.01	<0.01
Scenario 3 (120 m)	0.11	<0.01	<0.01

The 100 year ARI flood inundated areas for different scenarios were estimated from the model run, and were compared to the flood inundated area under existing conditions. The results are reported in Table 5. The general tendency is that smaller bridge opening leads to higher inundated area with respect to existing condition. If the total span length of 60 m (Scenario 1) is increased to 120 m (Scenario 2), the inundated area is halved, and inundated area is reduced significantly when the total span length is four fold.

Table 5: Grosvenor Creek Upstream Inundation Area

Scenario	Area Inundated (ha)	Approximate Increase in Inundated Area above Existing Conditions	
		ha	%
Existing	220	NA	NA
Scenario 1 (60 m)	235	15	7%
Scenario 2 (240 m)	221	1	<1%
Scenario 1 (120 m)	228	8	4%

2.3 Diamond Creek

The water depths and flood inundation mapping for Diamond Creek are presented in Figures 5 through 8 in APPENDIX A.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 6. The afflux in the main channel increases with decrease in total span lengths.

Table 6: Diamond Creek Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Peak Water Level (m)	Peak Velocity (m/s)	Peak Afflux (m)
Existing	207.44	0.44	NA
Scenario 1 (340 m)	207.88	1.87	0.44
Scenario 2 (200 m)	208.04	2.64	0.60
Scenario 3 (680 m)	207.67	1.56	0.23

The afflux upstream of the rail alignment is shown in Table 7. The afflux is inversely related to span length and distance upstream of the rail alignment.

Table 7: Diamond Creek Upstream Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.2 km Upstream	0.5 km Upstream	1 km Upstream
Scenario 1 (340 m)	0.50	0.47	0.34
Scenario 2 (200 m)	0.79	0.70	0.52
Scenario 3 (680 m)	0.23	0.26	0.19

The 100 year ARI flood inundated areas for different scenarios were estimated from the model run, and were compared to the flood inundated area under existing conditions. The results are reported in Table 8. The results reveal a that smaller span increases the inundated area significantly.

Table 8: Diamond Creek Upstream Inundation Area

Scenario	Area Inundated (ha)	Approximate Increase in Inundated Area above Existing Conditions	
		ha	%
Existing	660	NA	NA
Scenario 1 (340 m)	738	78	12%
Scenario 2 (200 m)	830	170	26%
Scenario 3 (680 m)	677	17	2.6%

2.4 Gowrie Creek

The water depths and flood inundation mapping for Gowrie Creek are presented in Figures 9 through 12 in APPENDIX A.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 9. The afflux in the main channel increases with decrease in total span lengths.

Table 9: Gowrie Creek Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Peak Water Level (m)	Peak Velocity (m/s)	Peak Afflux (m)
Existing	194.13	0.88	NA
Scenario 1 (125 m)	194.47	2.16	0.34
Scenario 2 (250 m)	194.27	1.67	0.14
Scenario 3 (65 m)	194.78	3.82	0.65

The afflux for each Scenario at 0.2 km, 0.5 km and 1 km upstream of the rail alignment is shown in Table 10. The afflux increases with a decrease in span length and a decrease in distance upstream of the rail alignment.

Table 10: Gowrie Creek Upstream Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.2 km Upstream	0.5 km Upstream	1 km Upstream
Scenario 1 (125 m)	0.31	0.34	0.20
Scenario 2 (250 m)	0.22	0.30	0.18
Scenario 3 (65 m)	0.56	0.48	0.25

The 100 year ARI flood inundated areas for different scenarios were estimated from the model run, and were compared to flood inundated area under existing conditions. The results are reported in Table 11. The results reveal that smaller span length increases the inundated area.

Table 11: Gowrie Creek Upstream Inundation Area

Scenario	Area Inundated (ha)	Approximate Increase in Inundated Area above Existing Conditions	
		ha	%
Existing	180	NA	NA
Scenario 1 (125 m)	224	44	24%
Scenario 2 (250 m)	218	38	21%
Scenario 3 (65 m)	232	52	29%

2.5 Mistake Creek

The water depths and flood inundation mapping for Mistake Creek are presented in Figures 13 through 16 in APPENDIX A.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 12. The afflux in the central and west channels increases with a decrease in total span length. However, the peak afflux in the east channel is the highest for greatest span length, which is counterintuitive. This is caused by localised effects and differing number of bridge openings in each scenario.

Table 12: Mistake Creek Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Location	Peak Water Level (m)	Peak Velocity (m/s)	Peak Afflux (m)
Existing	West channel	190.11	0.88	NA
	Central channel	190.16	0.98	NA
	East channel	190.83	0.33	NA
Scenario 1 (4000 m)	West channel (2000 m)	190.20	1.10	0.09
	Central channel	NA	NA	NA
	East channel (2000 m)	190.96	0.35	0.14
Scenario 2 (1500 m)	West channel (1000 m)	190.26	1.07	0.15
	Central channel	NA	NA	NA
	East channel (500 m)	190.82	0.71	<0.01
Scenario 3 (800 m)	West channel (200 m)	190.34	1.25	0.23
	Central channel (200 m)	190.44	1.67	0.28
	East channel (400 m)	190.89	0.56	0.06

The afflux for each Scenario at 0.5 km, 1 km and 2 km upstream of the rail alignment is shown in Table 13. The afflux is inversely proportional to distance upstream of the rail alignment and also inversely related to span length.

Table 13: Mistake Creek Upstream Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.5 km Upstream	1 km Upstream	2 km Upstream
Scenario 1 (4000 m)	0.04	0.03	0.02
Scenario 2 (1500 m)	0.07	0.05	0.04
Scenario 3 (800 m)	0.20	0.13	0.09

The 100 year ARI flood inundated areas for different scenarios were estimated from the model run, and were compared to flood inundated area under existing conditions. The results are reported in Table 14. Both afflux and inundated area increase with the decrease in span length; however, the increase in inundation is not as significant because of relatively large model extents.

Table 14: Mistake Creek Upstream Inundation Area

Scenario	Area Inundated (ha)	Approximate Increase in Inundated Area above Existing Conditions	
		ha	%
Existing	1900	NA	NA
Scenario 1 (4000 m)	1900	0	0.0%
Scenario 2 (1500 m)	1926	26	1.4%
Scenario 3 (800 m)	1955	55	2.9%

2.6 Belyando River (East Tributary of Belyando River and Ogenbeena Creek included)

The water depths and flood inundation mapping for Belyando River are presented in Figures 17 through 20 in APPENDIX A.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 15. The afflux in the main channel increases with a decrease in total span length. The afflux increases significantly when total span length is 800 m as contrast to span length of 6000 m.

Table 15: Belyando River Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Location	Peak water level (m)	Peak velocity (m/s)	Peak Afflux (m)
Average Existing	West channel 1	200.16	0.65	NA
	West channel 2	198.67	0.55	NA
	Central channel	198.24	0.76	NA
	East channel	194.70	0.64	NA
Scenario 1 (6000 m)	West channel 1 (600 m)	200.39	0.82	0.23
	West channel 2 (1800 m)	198.86	0.57	0.19
	Central channel (1600 m)	198.37	0.92	0.13
	East channel (2000 m)	194.67	0.65	<0.01
Scenario 2 (2000 m)	West channel 1 (400 m)	200.40	0.85	0.24
	West channel 2 (500 m)	198.79	0.84	0.12
	Central channel (500 m)	198.57	1.75	0.33
	East channel (600 m)	195.07	1.52	0.37
Scenario 3 (800 m)	West channel 1 (150 m)	200.51	1.98	0.35
	West channel 2 (200 m)	199.18	2.27	0.51
	Central channel (200 m)	198.97	2.67	0.73
	East channel (250 m)	196.65	3.50	1.95

The water level was measured for each scenario at 0.5 km, 1 km and 2 km upstream of the rail alignment. This data was used to calculate the afflux predicted by the model for Scenarios 1, 2 and 3. The afflux for each scenario at 0.5 km, 1 km and 2 km upstream of the rail alignment is shown in Table 16. The afflux is significantly higher in the case of Scenario 3 where the total span length is only 800 m as opposed to other two scenarios having relatively high span length.

Table 16: Belyando River Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.5 km Upstream	1 km Upstream	2 km Upstream
Scenario 1 (6000 m)	0.12	0.10	0.03
Scenario 2 (2000 m)	0.35	0.29	0.12
Scenario 3 (800 m)	0.71	0.61	0.33

The 100 year ARI flood inundated areas for different scenarios were estimated from the model run, and were compared to flood inundated area under existing conditions. The results are reported in Table 17. Both afflux and inundated area increase with the decrease in span length.

Table 17: Belyando River Upstream Inundation Area

Scenario	Area Inundated (ha)	Approximate Increase in Inundated Area above Existing Conditions	
		ha	%
Existing	5300	NA	NA
Scenario 1 (6000 m)	5465	165	3.1%
Scenario 2 (2000 m)	5777	477	9.0%
Scenario 3 (800 m)	5947	647	12.2%

2.7 North Creek

The water depths and flood inundation mapping for North Creek are presented in Figures 21 through 24 in APPENDIX A. It can be seen that the flooding extends to the left and right boundaries of the model. This may be an indication that the estimated peak discharge has been over-estimated. It is recommended that this be further investigated during detail rail design.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 18. The afflux in the main channel increases with decrease in total span lengths.

Table 18: North Creek Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Location	Peak Water Level (m)	Peak Velocity (m/s)	Peak Afflux (m)
Average Existing	West channel	215.24	0.74	NA
	Main channel	214.98	1.24	NA
	East channel	213.80	0.50	NA
Scenario 1 (130 m)	West channel	NA	NA	NA
	Main channel (130 m)	215.45	1.68	0.47
	East channel	NA	NA	NA
Scenario 2 (260 m)	West channel (130 m)	215.75	2.17	0.51
	Main channel (130 m)	215.14	1.33	0.16
	East channel	NA	NA	NA
Scenario 3 (520 m)	West channel (200 m)	215.47	2.06	0.23
	Main channel (250 m)	215.09	1.58	0.11
	East channel (70 m)	213.99	1.38	0.19

The afflux for each Scenario at 0.2 km, 0.5 km and 1 km upstream of the rail alignment is shown in Table 19. The afflux increases with smaller span lengths and shorter distance upstream of the rail alignment.

Table 19: North Creek Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.2 km Upstream	0.5 km Upstream	1 km Upstream
Scenario 1 (130 m)	0.42	0.23	<0.01
Scenario 2 (260 m)	0.10	0.01	<0.01
Scenario 3 (520 m)	0.08	0.01	<0.01

The majority of flood inundation area extended to the model boundaries, so no increase in flood area was estimated.

2.8 Eight Mile Creek

The water depths and flood inundation mapping for North Creek are presented in Figures 25 through 28 in APPENDIX A.

The peak water level, velocity and afflux within the bridge openings under different scenarios are shown in Table 20. The afflux in the main channel increases with a decrease in total span length.

Table 20: Eight Mile Creek Peak Water Level, Velocity and Afflux at the Bridge Openings

Scenario	Peak Water Level (m)	Peak Velocity (m/s)	Peak Afflux (m)
Average Existing	218.93	0.89	NA
Scenario 1 (170 m)	219.03	1.34	0.10
Scenario 2 (340 m)	218.98	1.03	0.05
Scenario 3 (85 m)	219.10	1.81	0.17

The afflux for each scenario at 0.2 km, 0.5 km and 1 km upstream of the rail alignment is shown in Table 21. The afflux increases with a decrease in span length. Afflux also increases with a decrease in distance upstream of the rail alignment.

Table 21: Eight Mile Creek Afflux Results from XPSWMM

Scenario	Afflux (m)		
	0.2 km Upstream	0.5 km Upstream	1 km Upstream
Scenario 1 (170 m)	0.21	0.13	<0.01
Scenario 2 (340 m)	0.14	0.10	<0.01
Scenario 3 (85 m)	0.31	0.18	<0.01

The increase in 100 year ARI flood inundated area compared to existing conditions for the scenarios with different span lengths are also shown in Table 22. The inundated area increases with the decrease in span length.

Table 22: Eight Mile Creek Upstream Inundation Area

Scenario	Area Inundated (ha)	Approximate Increase in Inundated Area above Existing Conditions	
		ha	%
Existing	250	NA	NA
Scenario 1 (170 m)	275	25	9.3%
Scenario 2 (340 m)	270	20	7.4%
Scenario 3 (85 m)	280	30	11.1%

3.0 DISSCUSSION OF POTENTIAL FLOOD IMPACTS AT LOGAN CREEK AND UNIDENTIFIED CROSSING AT CHAINAGE 93.1

As stated previously, hydraulic modelling could not be completed for Logan Creek or the unidentified watercourse at Chainage 93.1 km because these crossings were outside the LIDAR survey and sufficient topography was not available. However, potential flood impacts at these crossings will be similar to the other major watercourse crossings of the rail line.

The estimated 100 year ARI peak discharge for Logan Creek and the unidentified crossing at Chainage 93.1 km are 1300 and 336 m^3/s, respectively. These discharges fall within the range for the other crossings which can therefore be used to provide a preliminary qualitative indication of potential impacts for Logan Creek and the unidentified crossing.

Logan Creek is most similar to Diamond Creek in that is closest in proximity and both have an average slope of 0.05% at the rail line. However, the catchment area of Logan Creek is 3 times that of Diamond Creek. The 100 year ARI peak flow of Logan Creek is more than 2.5 times the peak flow of Diamond Creek. The hydraulic modelling on Diamond Creek shows that the peak afflux within the bridge openings under different scenarios vary from 0.23 m to 0.60 m. Considering an increased total span length is proportionally related to the increased discharge, the afflux could be maintained within the same range.

The unidentified crossing at Chainage 93.1 km is most similar to Gowrie Creek in that is closest in proximity and both have an average slope of 0.1% at the rail line. However, the catchment area of the unnamed watercourse is approximately half that of times that of Gowrie Creek. The 100 year ARI peak flow of unnamed watercourse is approximately 70% of Gowrie Creek. The hydraulic modelling on Gowrie Creek shows that the peak afflux within the bridge openings under different scenarios vary from 0.14 m to 0.65 m. Considering a decreased total span length is proportionally related to the decreased discharge, the afflux could be maintained within the same range.

4.0 FLOOD DURATION

To provide preliminary estimates of average flood duration for the major watercourses, daily data from the closest and most representative gauging stations (Mistake Creek and Belyando River) were analysed. It was found that during significant events (> 2 year ARI), continuous flood levels remained elevated between approximately 3 and 15 days. The average was approximately 6 days for Belyando River and 4 days for Mistake Creek. These long flood durations are a result of a number of factors including: flat terrain, large amount of floodplain storage, slow moving water and multiple-day rainfall events.

Average flood durations were then estimated at each of the crossings based on a direct relationship between time of concentration and observed flood duration. Time of concentration was estimated using the Bransby-Williams formula. Table 23 summarises the estimated time of concentration and the resulting typical flood duration for each of the major watercourses.

Table 23: Estimated Typical Flood Duration for Existing Conditions

Name	Catchment area (sq km)	Catchment Length (km)	Catchment Slope (%)	Estimated Time of concentration (day)	Estimated Average Flood Duration (days)
Grosvenor Creek	130	23	1.7	0.13	0.9
Diamond Creek	1000	57	1.1	0.29	2
Logan Creek	2900	120	1.5	0.51	3
Unidentified watercourse at Chainage 93.1	110	12	0.2	0.11	0.7
Gowrie Creek	210	19	1.6	0.10	0.7
Mistake Creek	7900	170	1.9	0.63	4
Belyando River	22000	310	2.4	0.98	6
Ogenbeena Creek	870	54	1.5	0.26	1.7
North Creek	300	36	2.0	0.18	1.2
Eight Mile Creek	180	28	1.3	0.16	1.1

While outside the scope of this report, impacts on flood duration from the proposed railway crossings can be directly modelled using an unsteady model with the input of a design storm hydrograph. However, the resulting flood duration can be quite variable dependent upon proposed span length and the shape of the design storm which is further dependent upon the rainfall patterns and the storage within the catchment. For the purposes of this preliminary analysis, flood duration has not been modelled.

The increase in flood duration is directly related to afflux and increase in flood inundation area. It is expected that if the amount of afflux at each of the watercourse crossings is minimised through a balance of environmental, social and economic impacts, then the increase in flood duration is not likely to be significant.

5.0 LIMITATIONS

Your attention is drawn to the document - “Limitations”, which is included in APPENDIX B of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the services provided for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

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SD/SS

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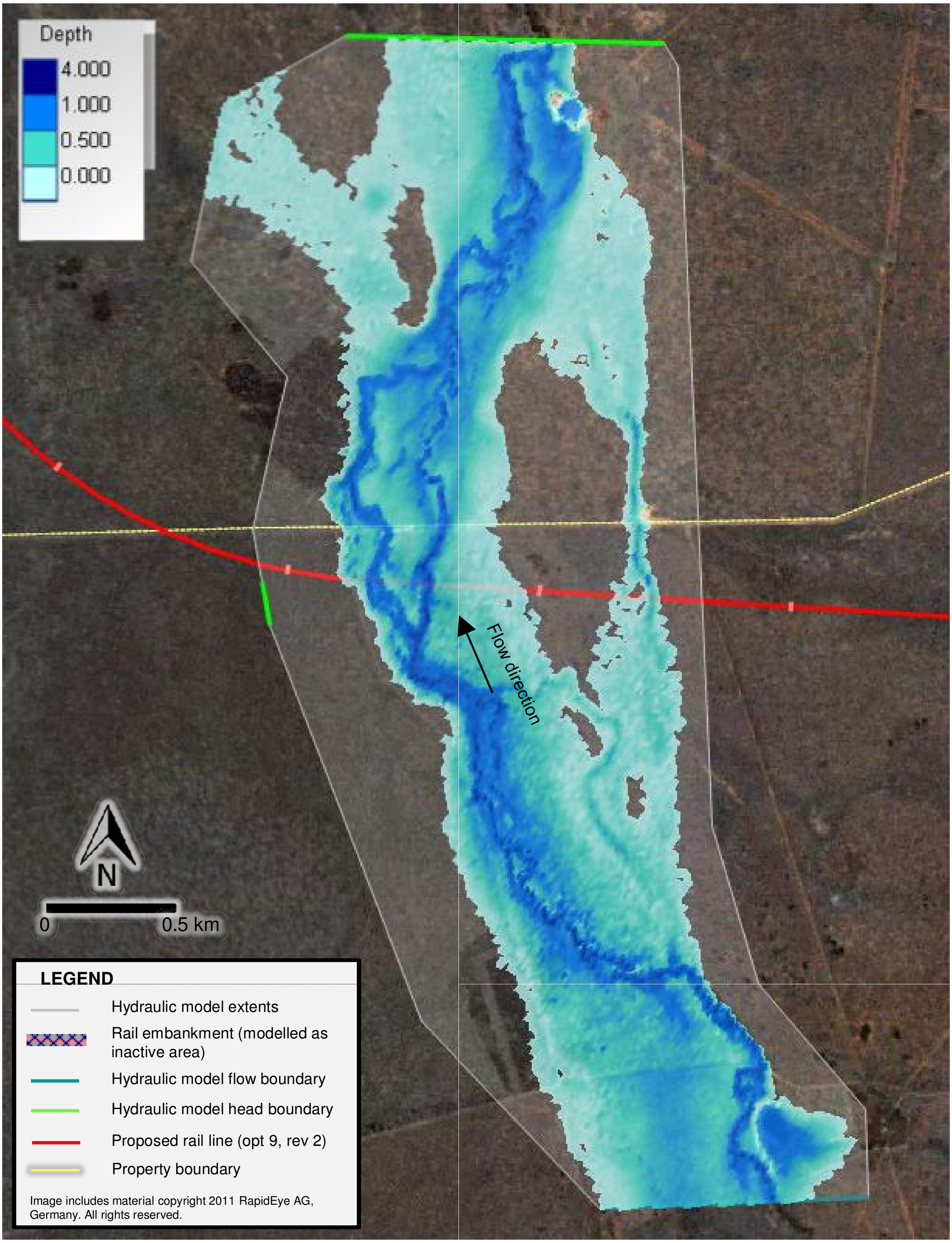
APPENDIX A

100 year ARI Flood Inundation Maps



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	DRAWN AL	DATE 16 Dec 11		TITLE Grosvenor Creek 100 year ARI Flood Map Existing Conditions	
	CHECKED SS	DATE 16 Dec 11			
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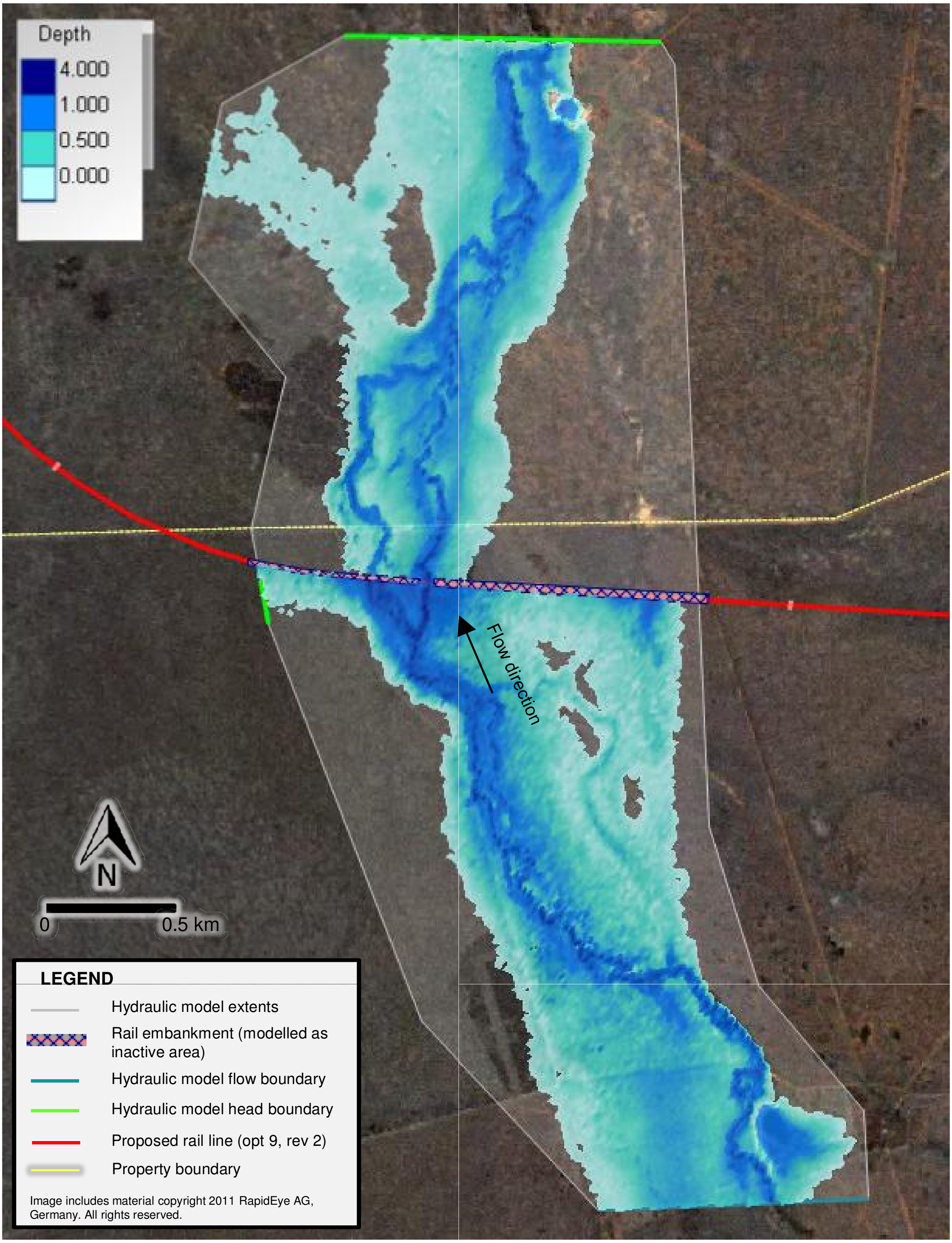

Golder Associates	CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings		
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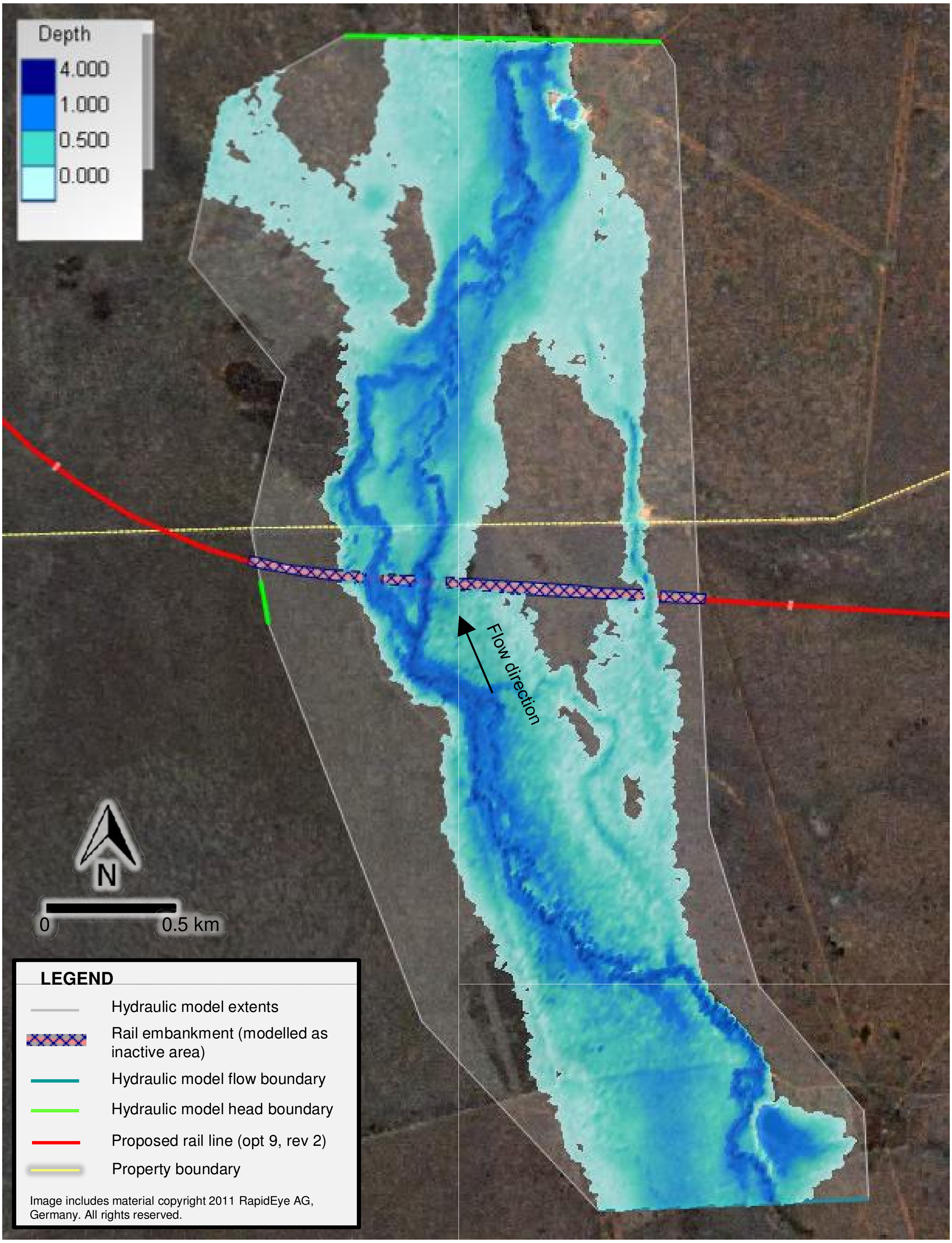

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CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings	
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		FIGURE No FIGURE 3	

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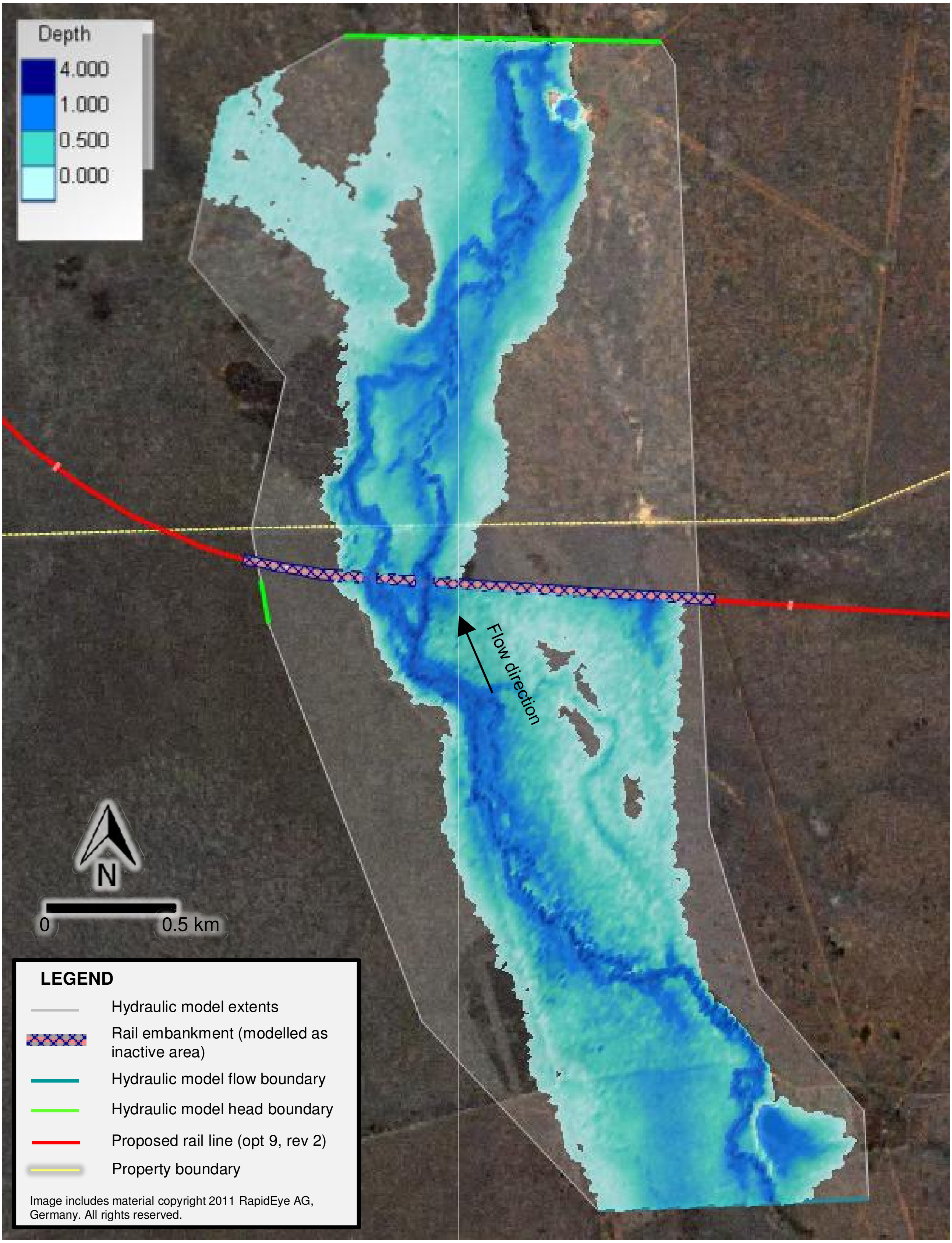

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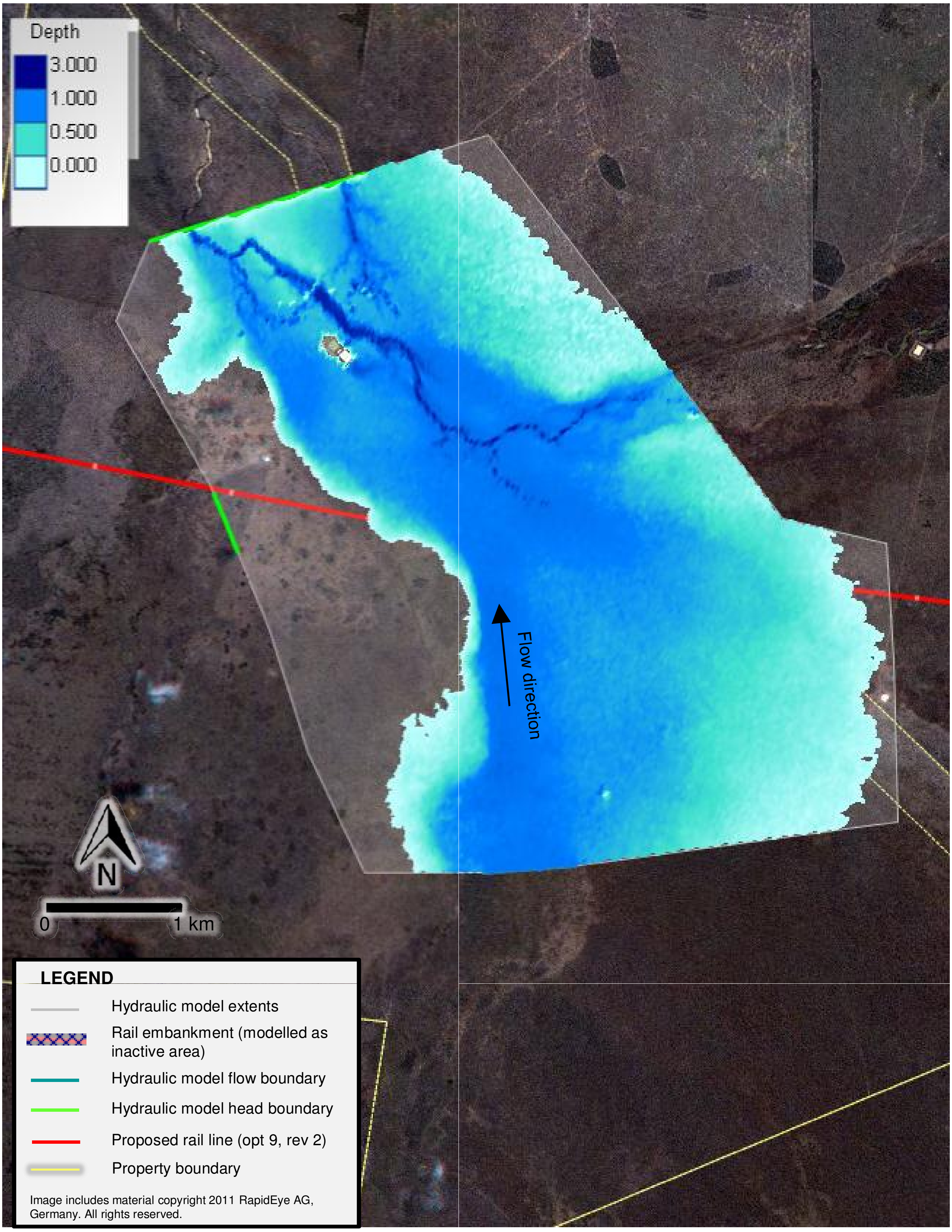

Golder Associates

CLIENT	Adani Mining Pty Ltd	PROJECT	Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings
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CHECKED SS	DATE 16 Dec 11		
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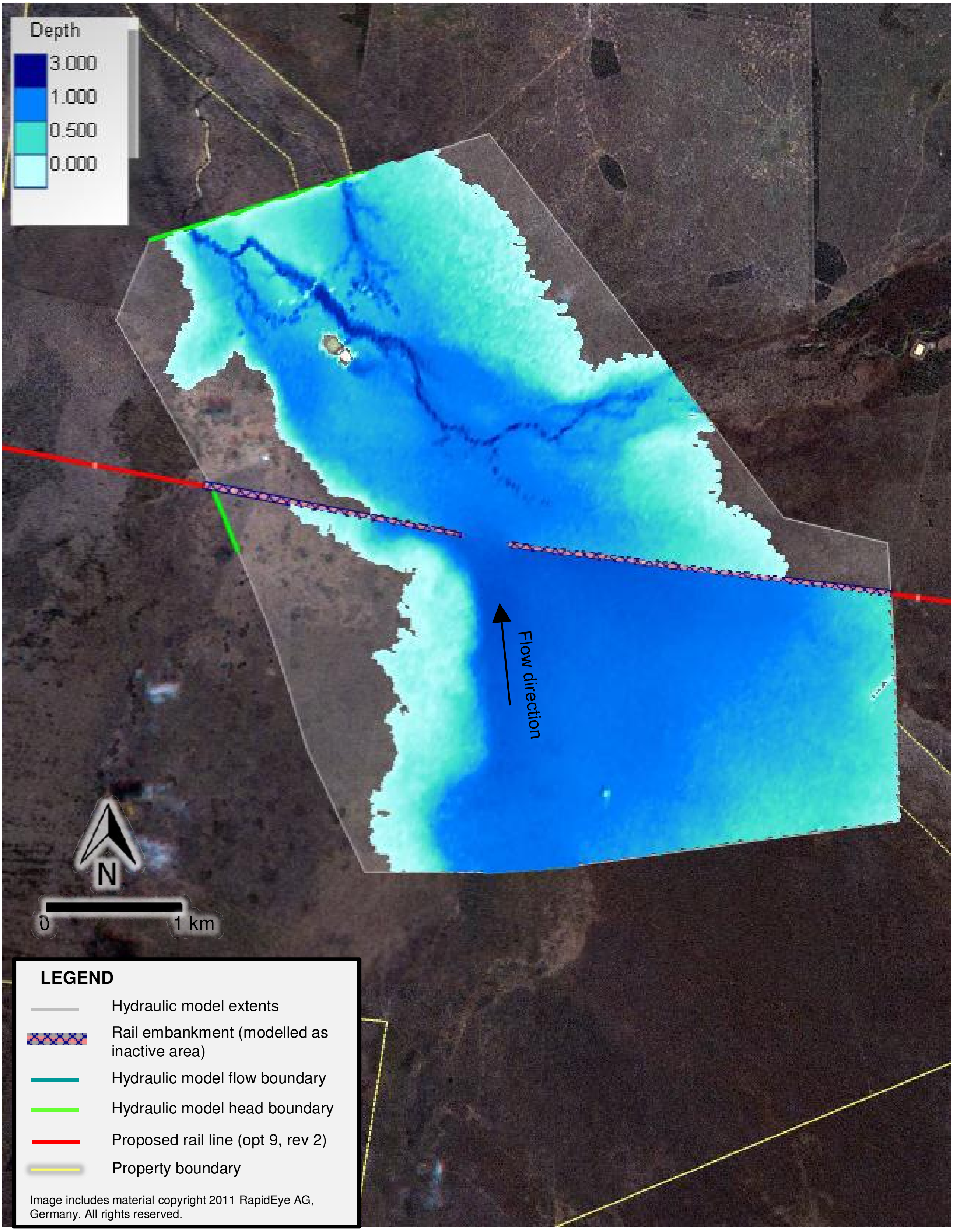

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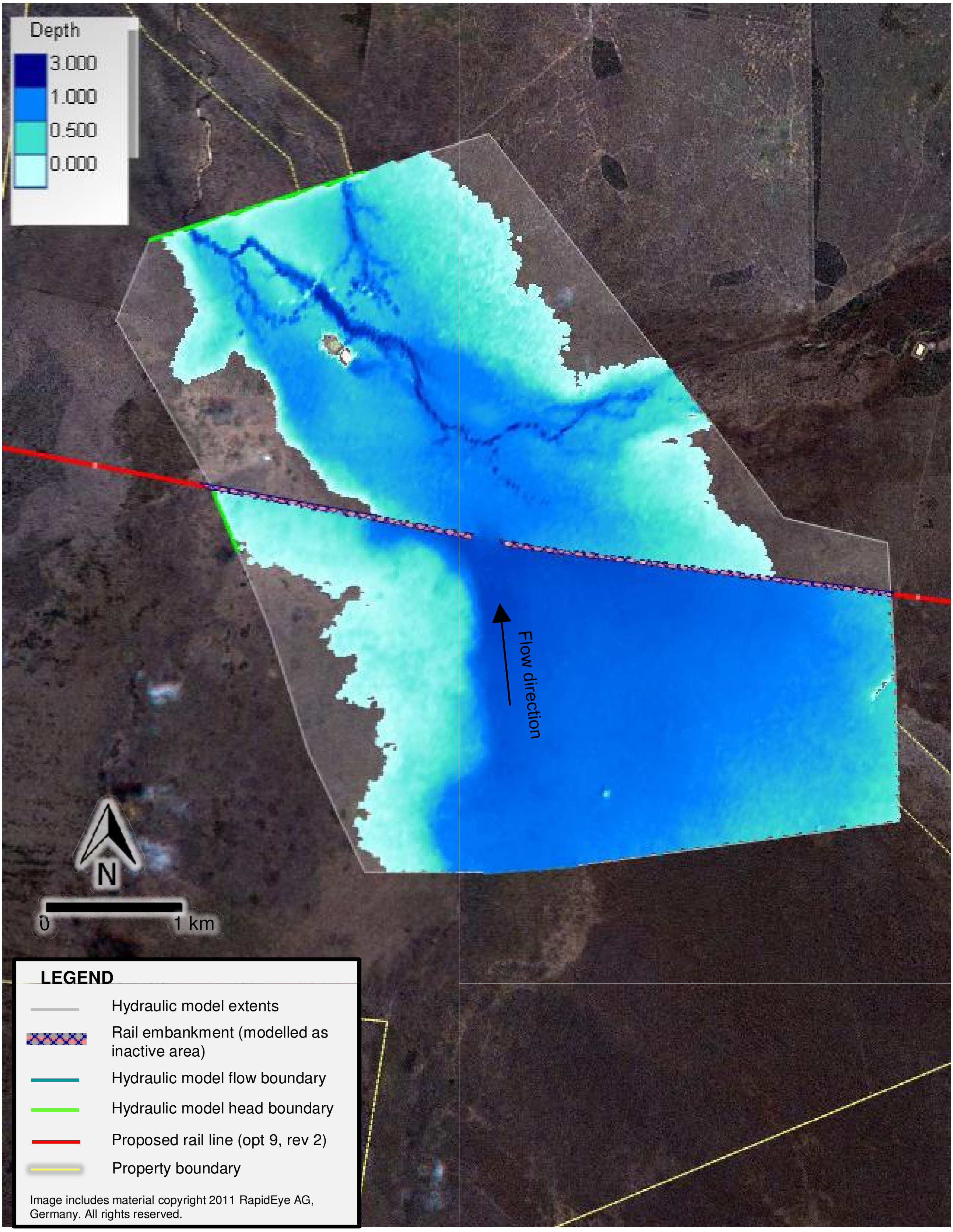

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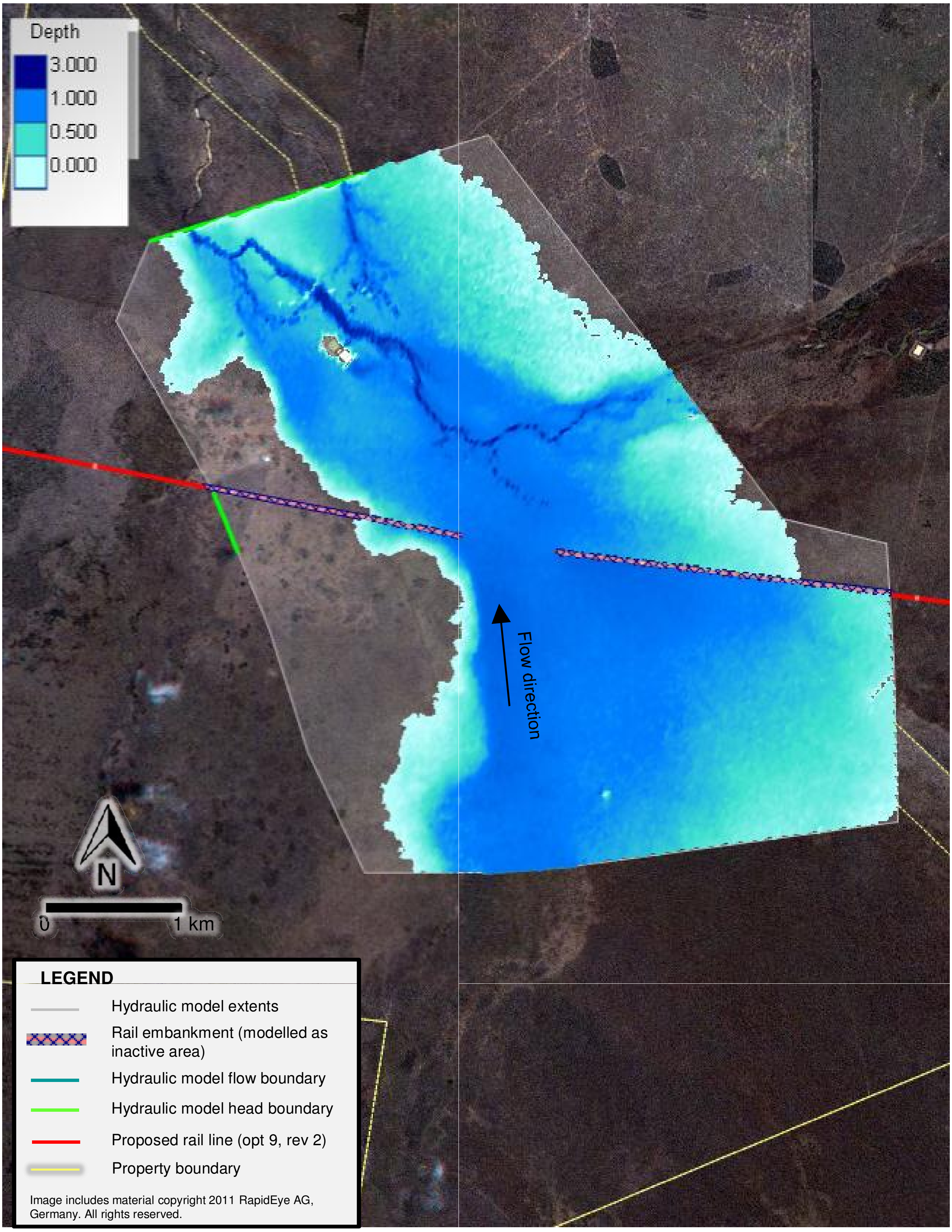

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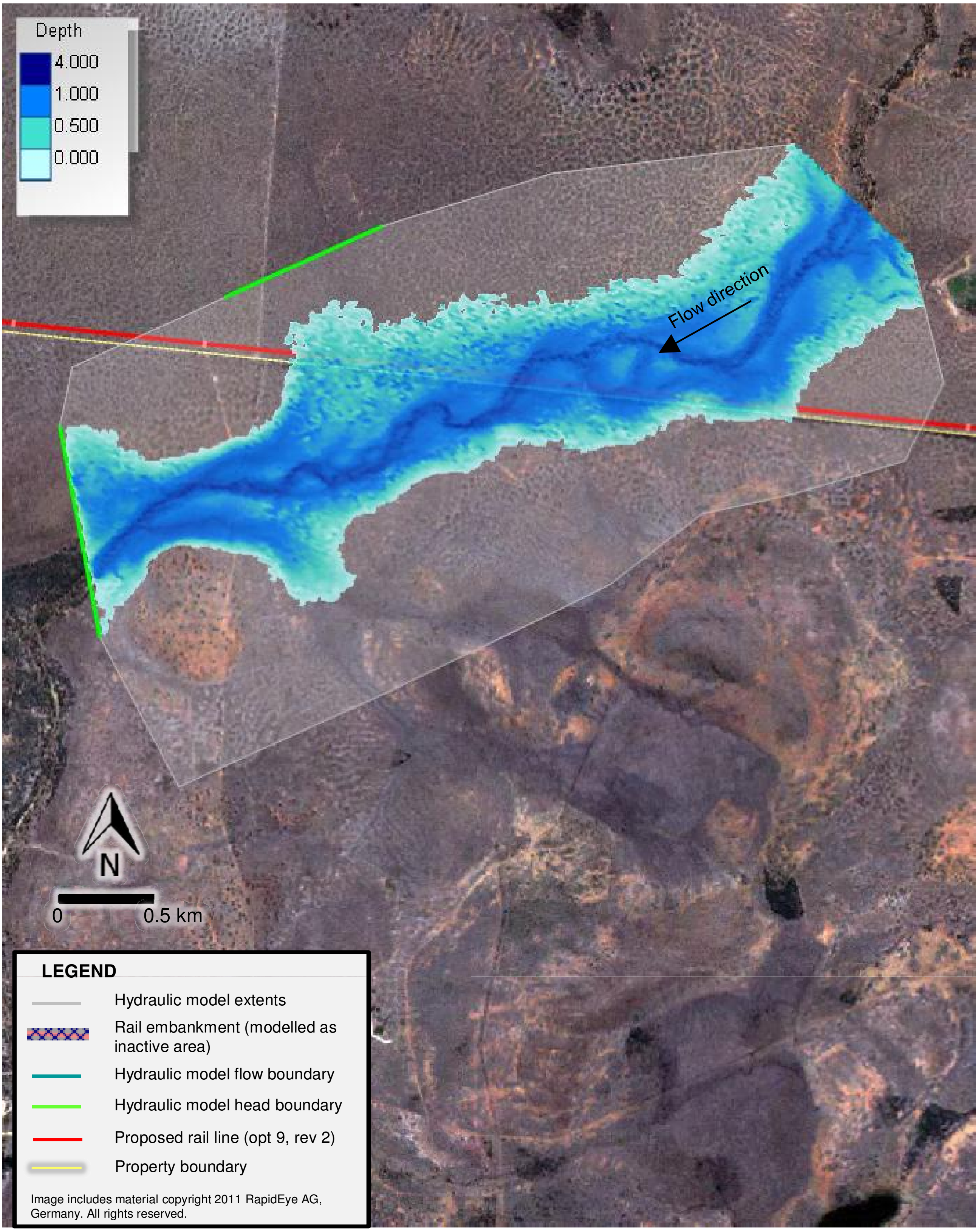

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CLIENT: Adani Mining Pty Ltd		PROJECT: Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings	
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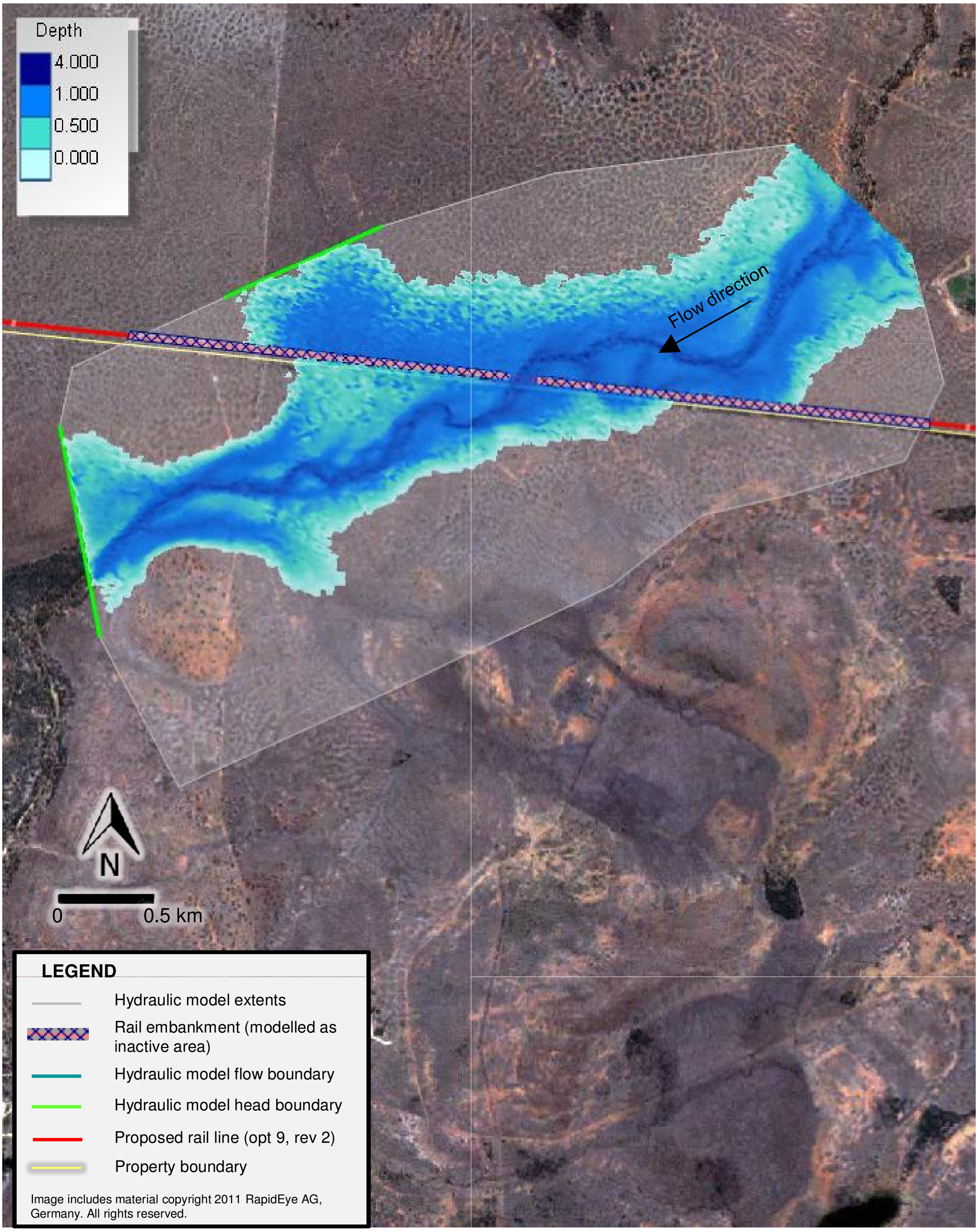

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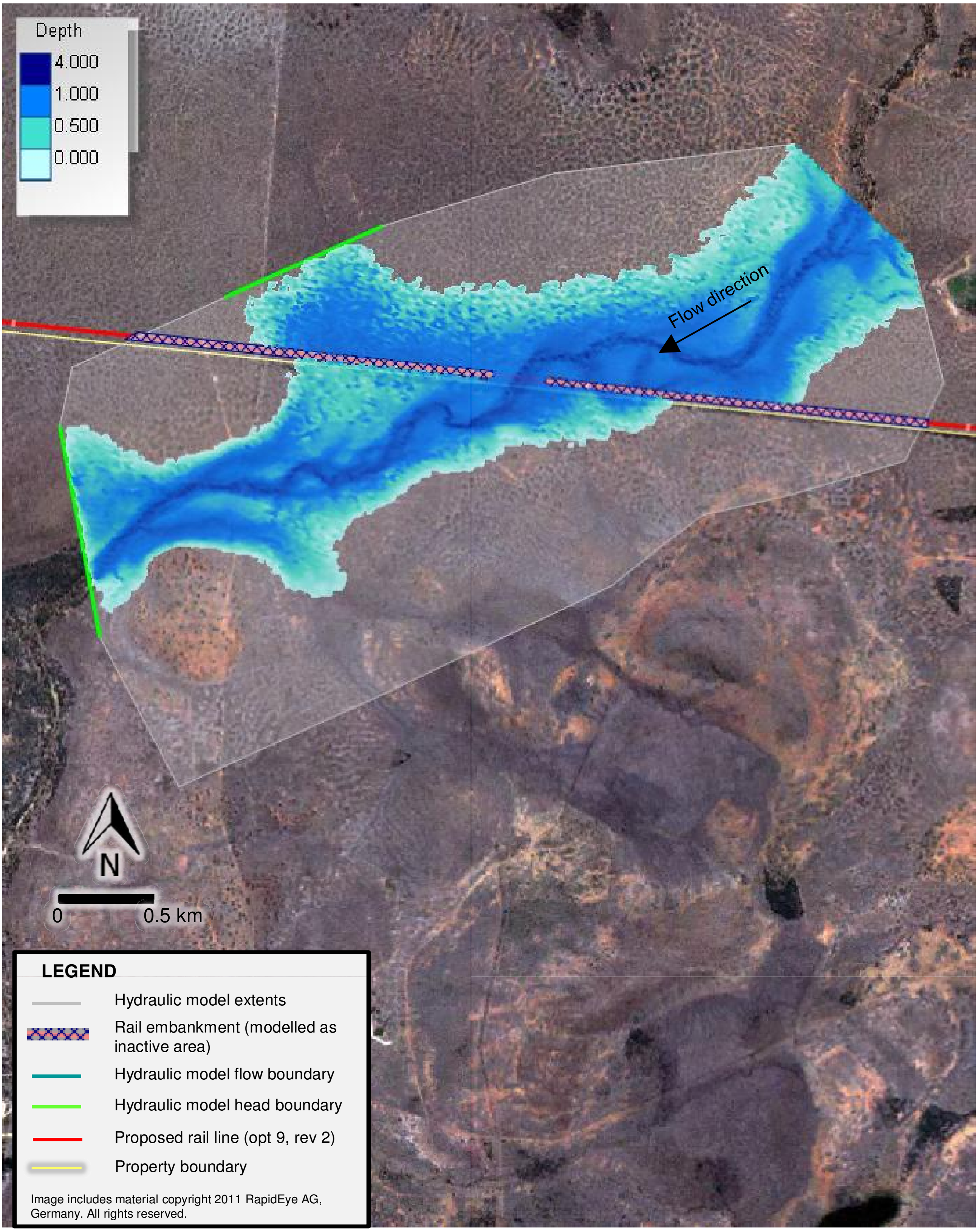

Golder Associates

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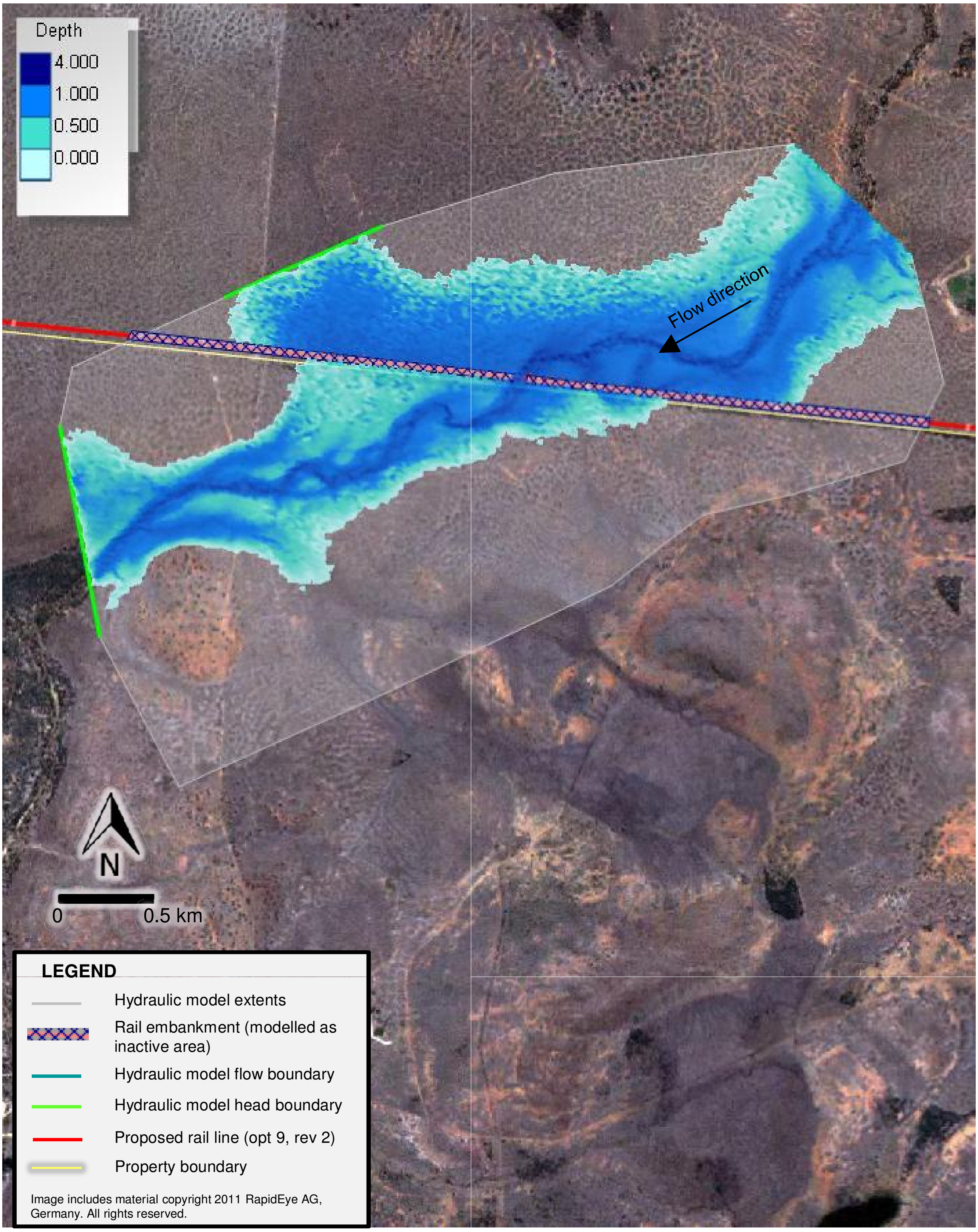

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CLIENT: Adani Mining Pty Ltd		PROJECT: Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings	
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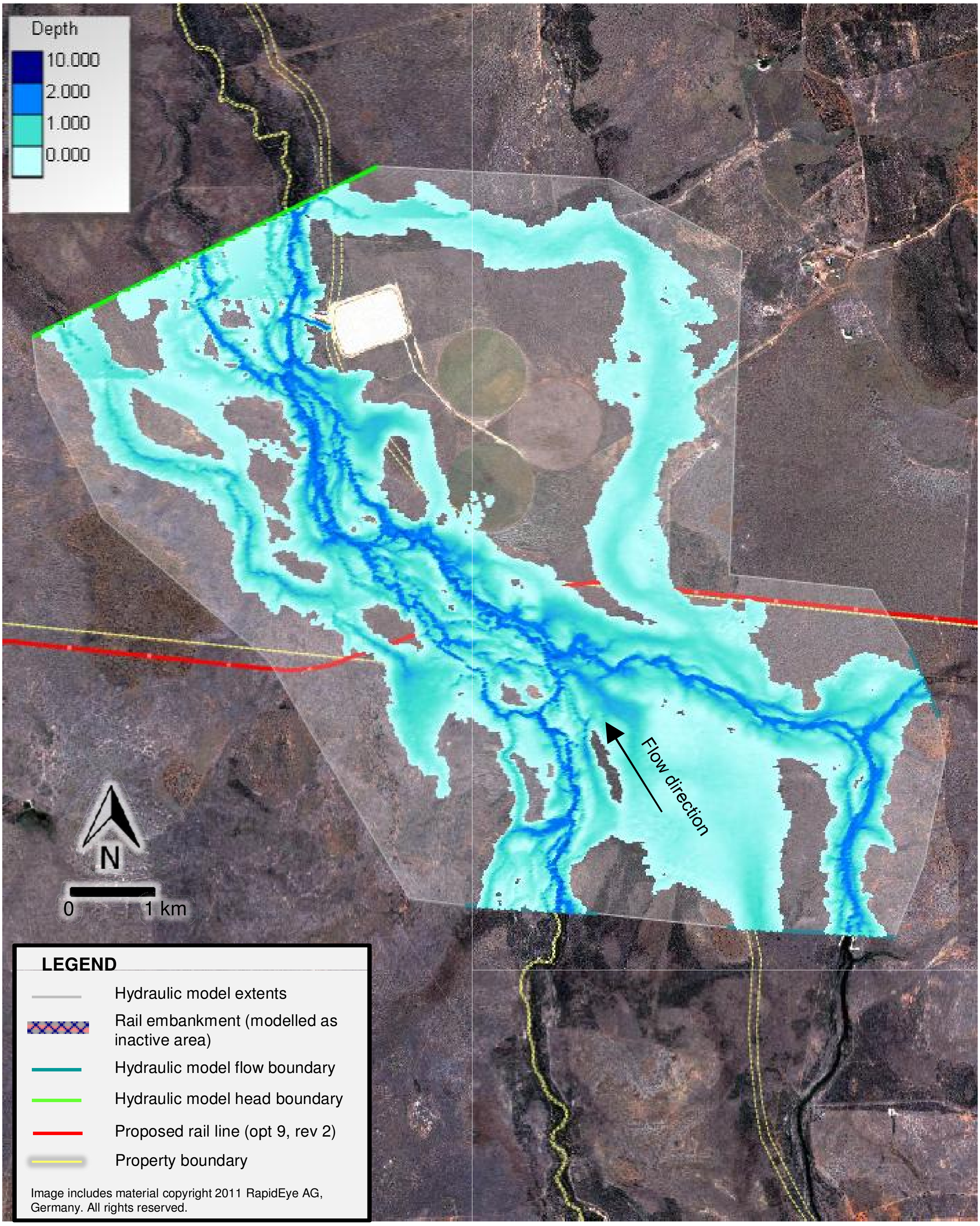

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CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings	
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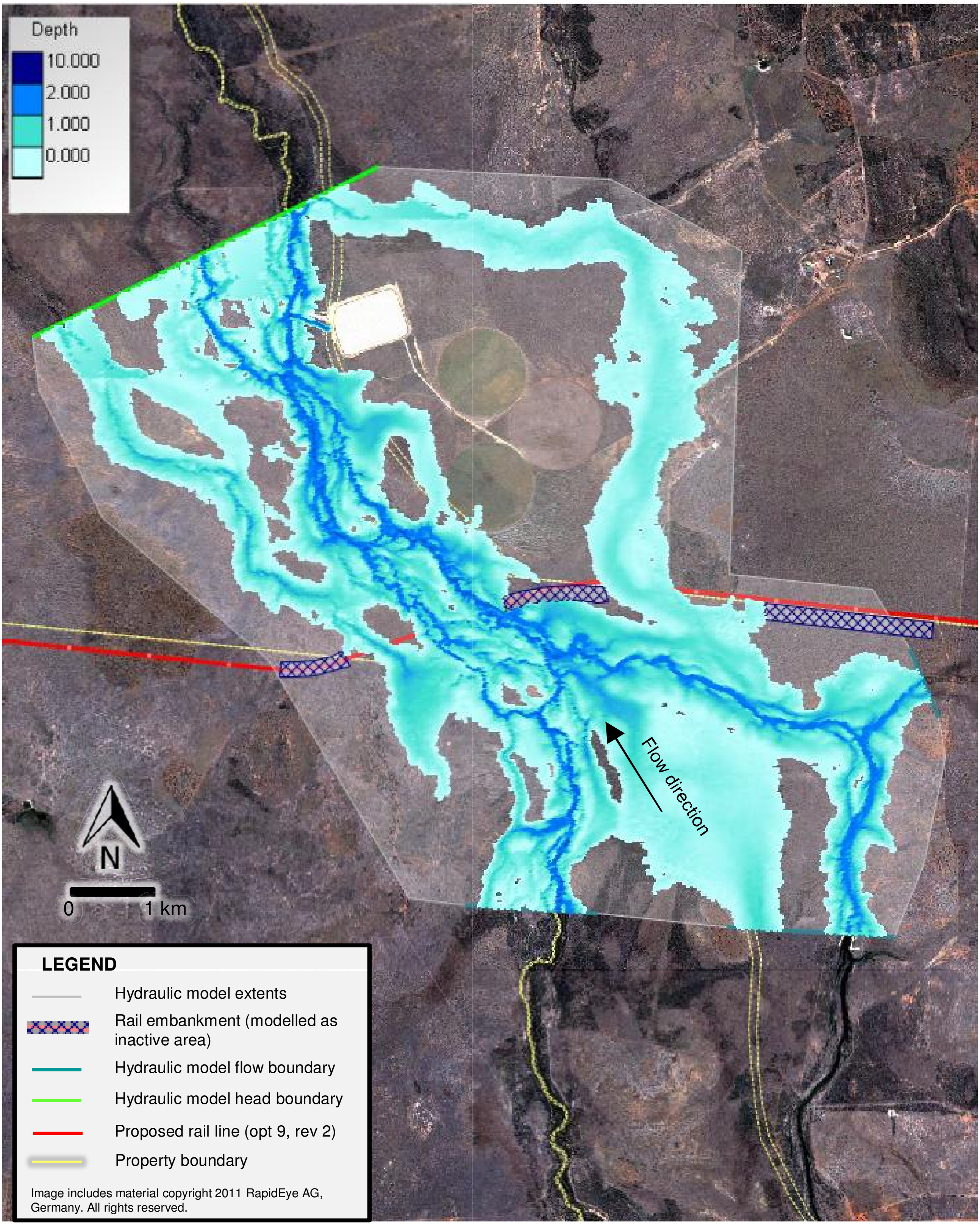

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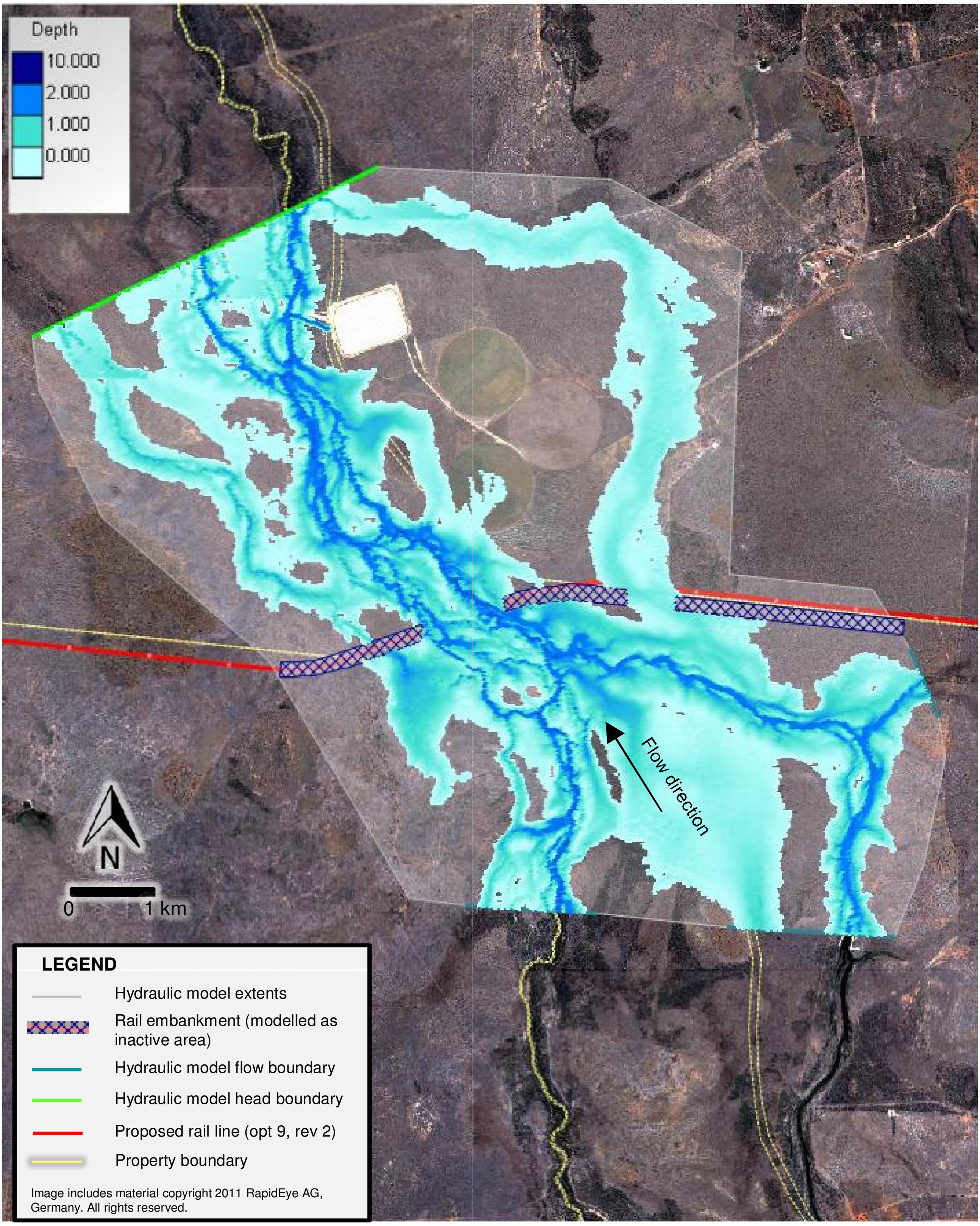

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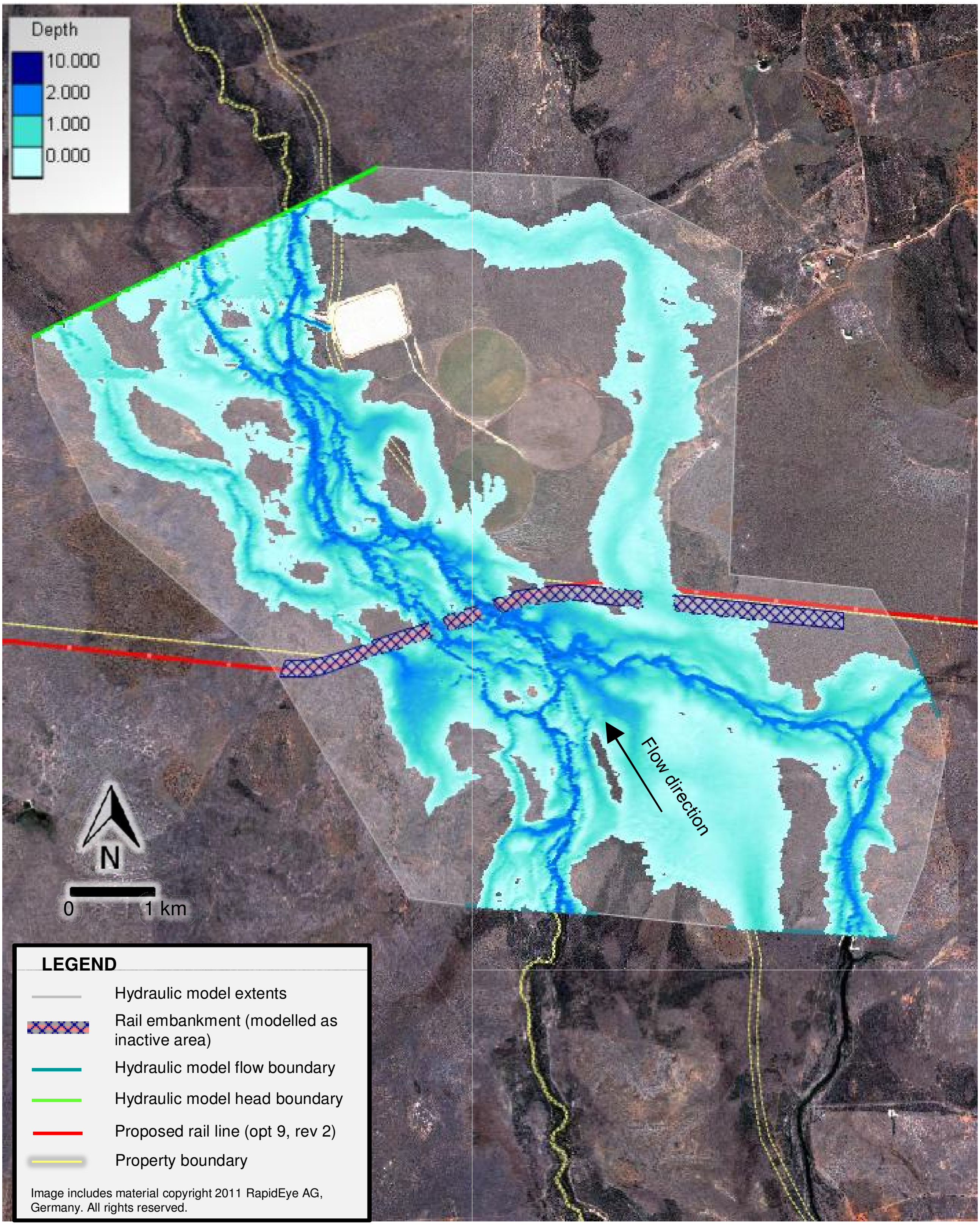

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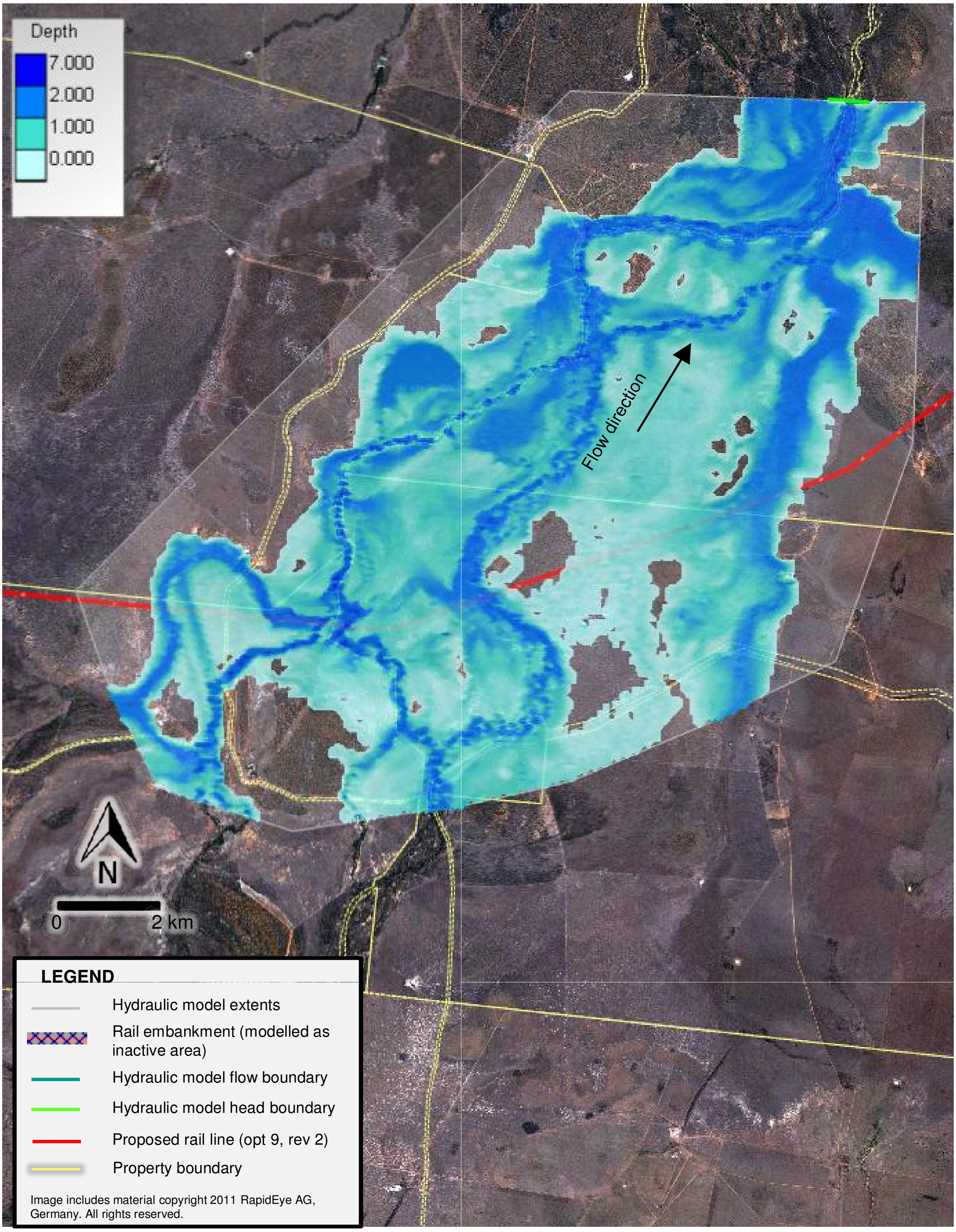

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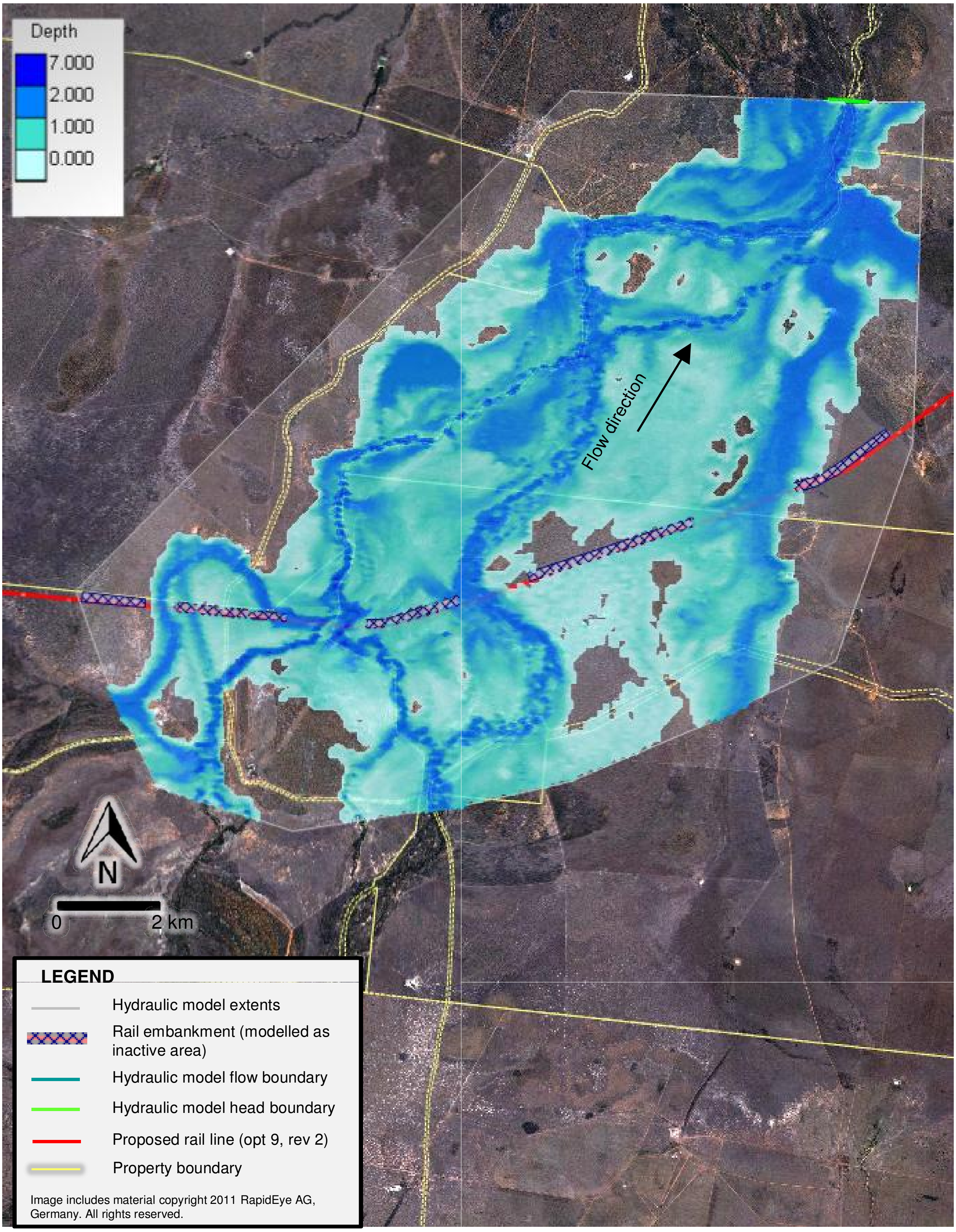

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	SCALE see above	SHEET SIZE A4	PROJECT No 117632041	REVISION 0	FIGURE No FIGURE 20

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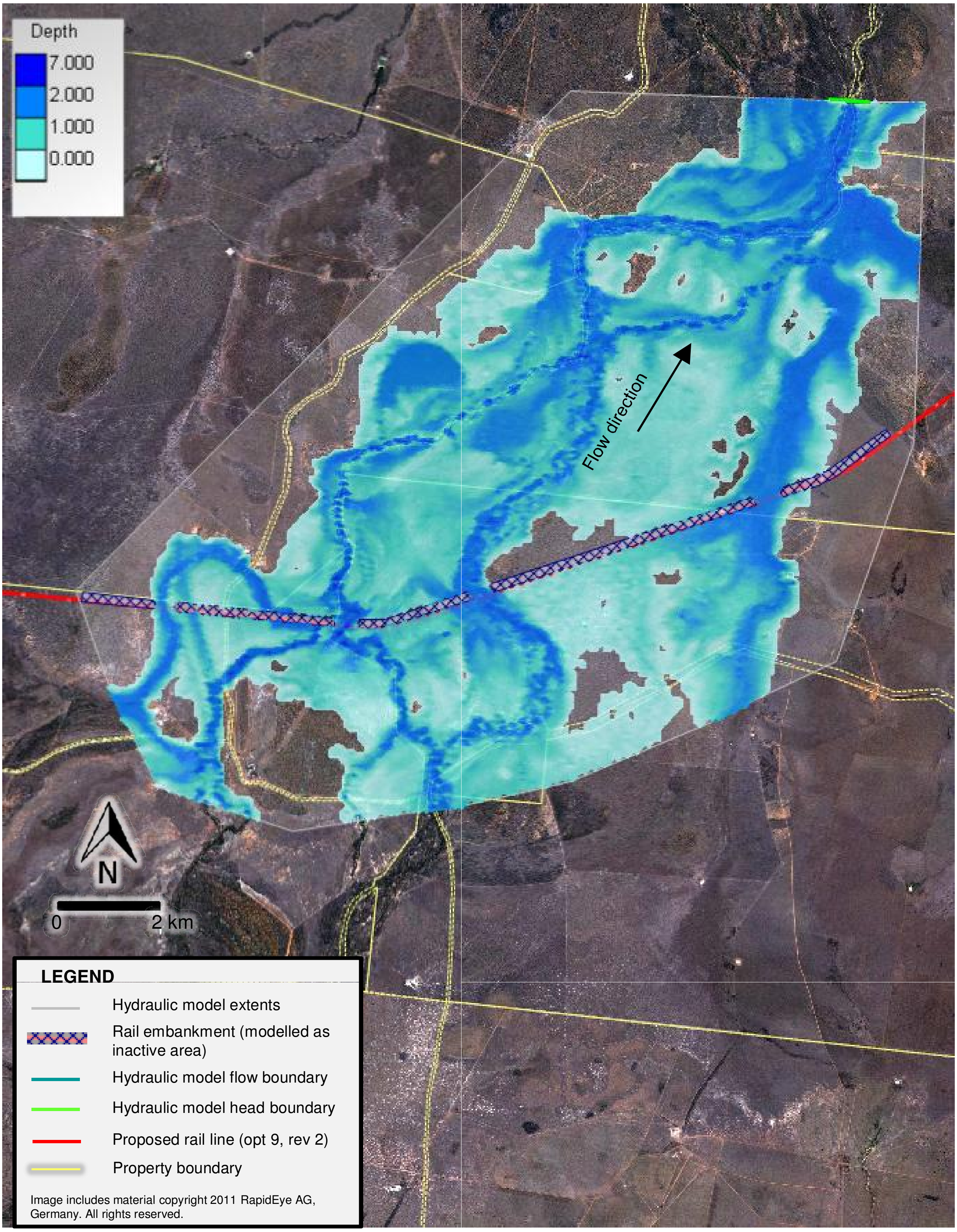

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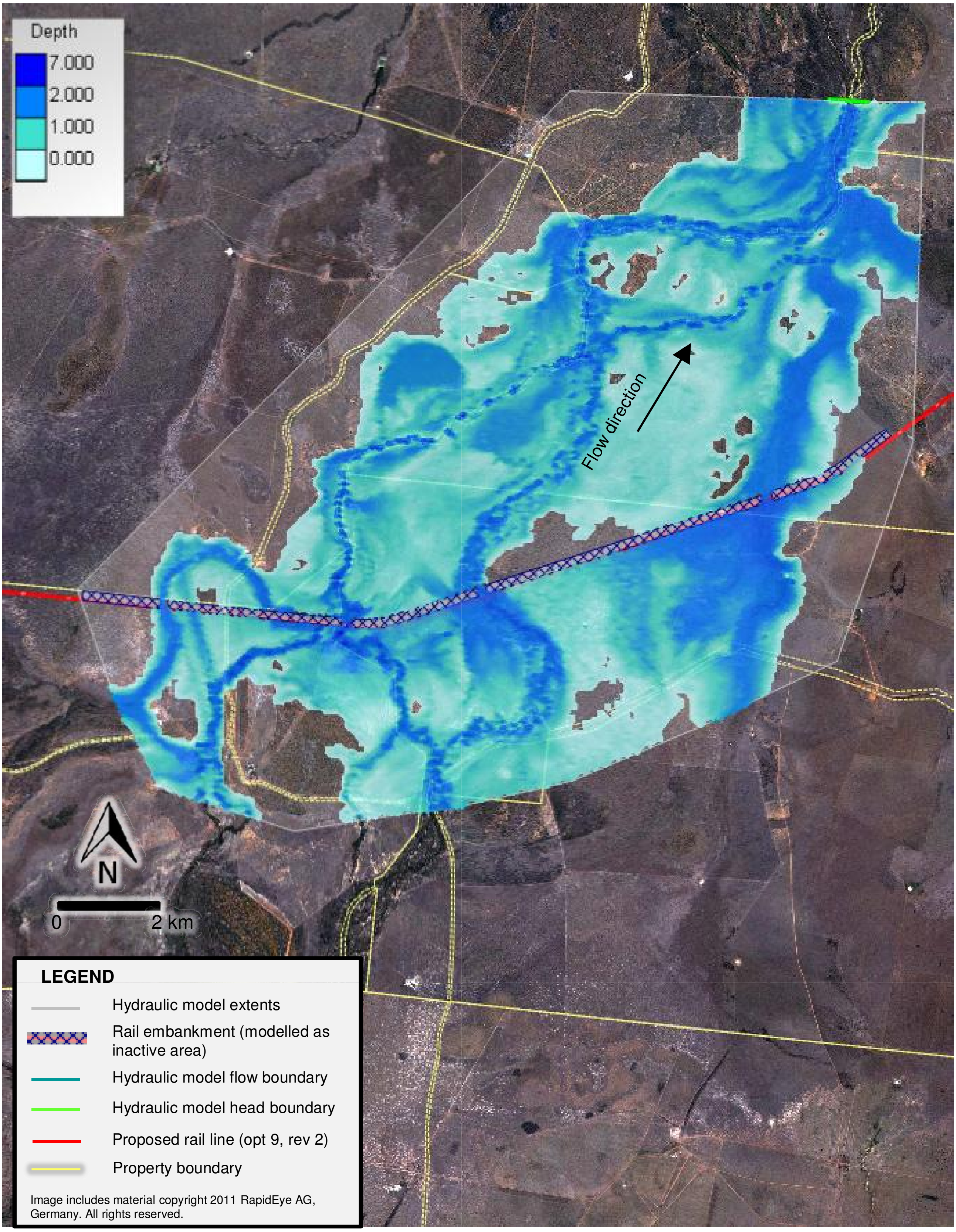

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CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings	
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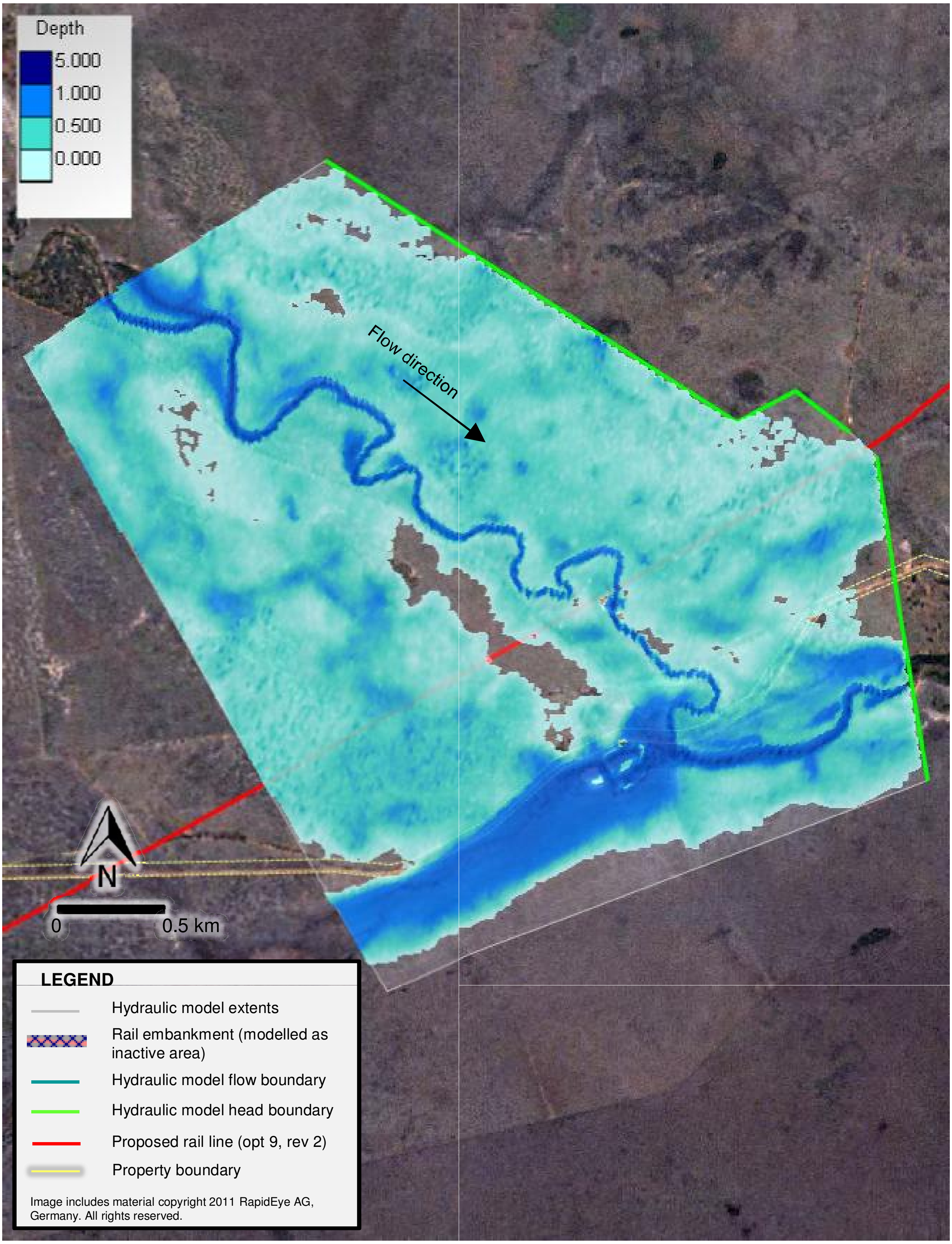

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	CHECKED SS	DATE 16 Dec 11		
	SCALE see above	SHEET SIZE A4	PROJECT No 117632041	REVISION 0 / FIGURE No FIGURE 21

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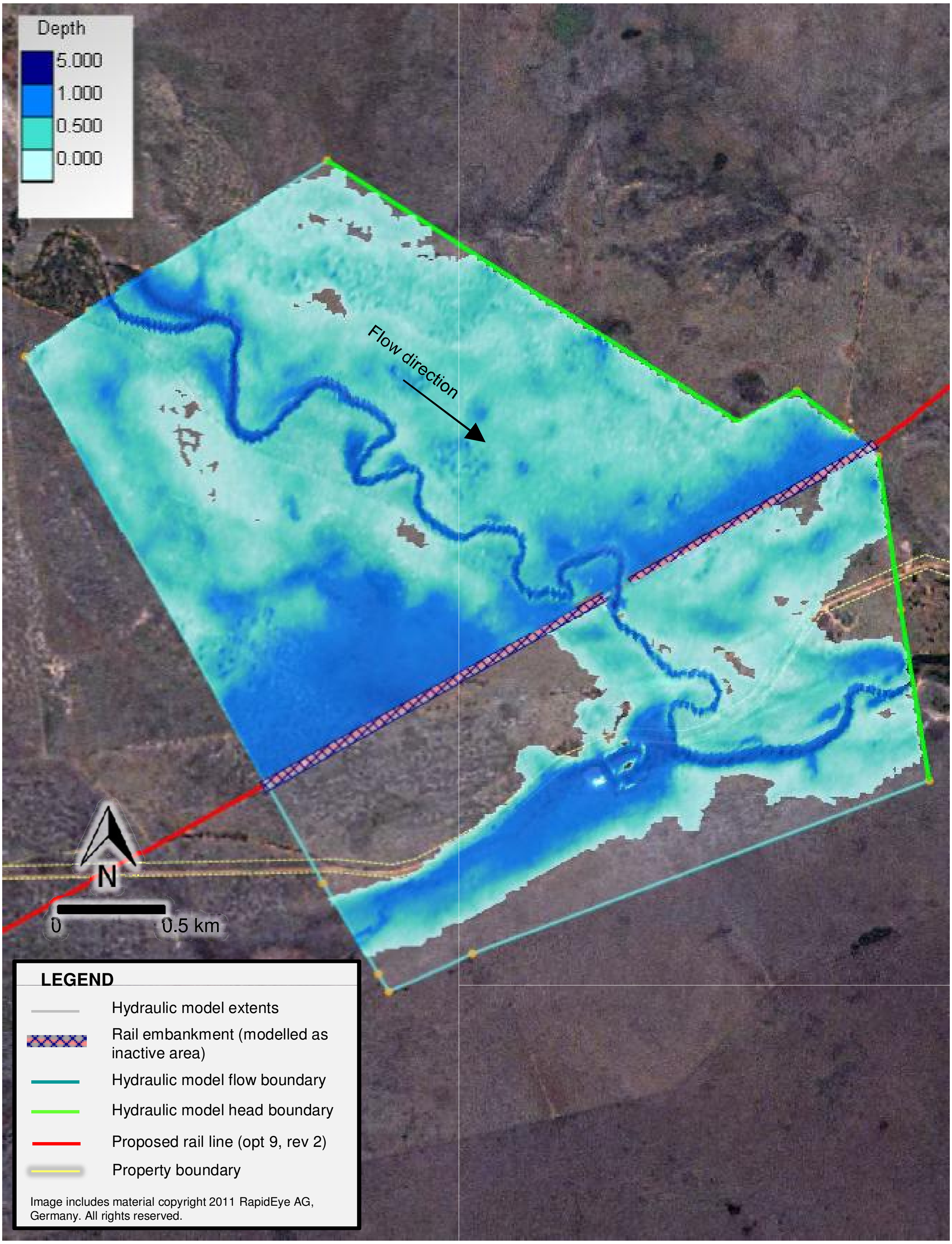

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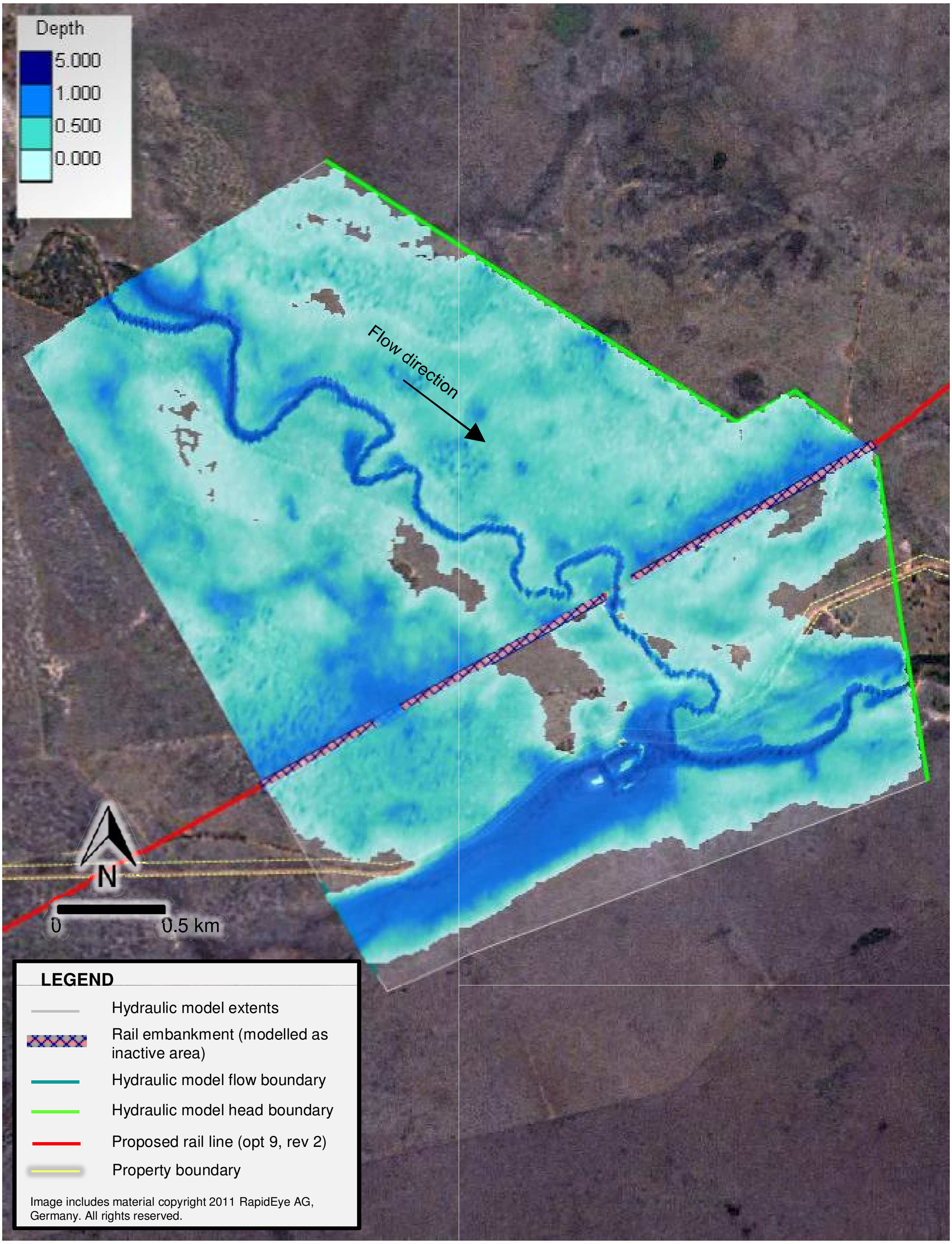

LEGEND

- Hydraulic model extents
- Rail embankment (modelled as inactive area)
- Hydraulic model flow boundary
- Hydraulic model head boundary
- Proposed rail line (opt 9, rev 2)
- Property boundary

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CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings			
DRAWN AL	DATE 16 Dec 11	TITLE North Creek 100 year ARI Flood Map Scenario 2 (260 m total span length)			
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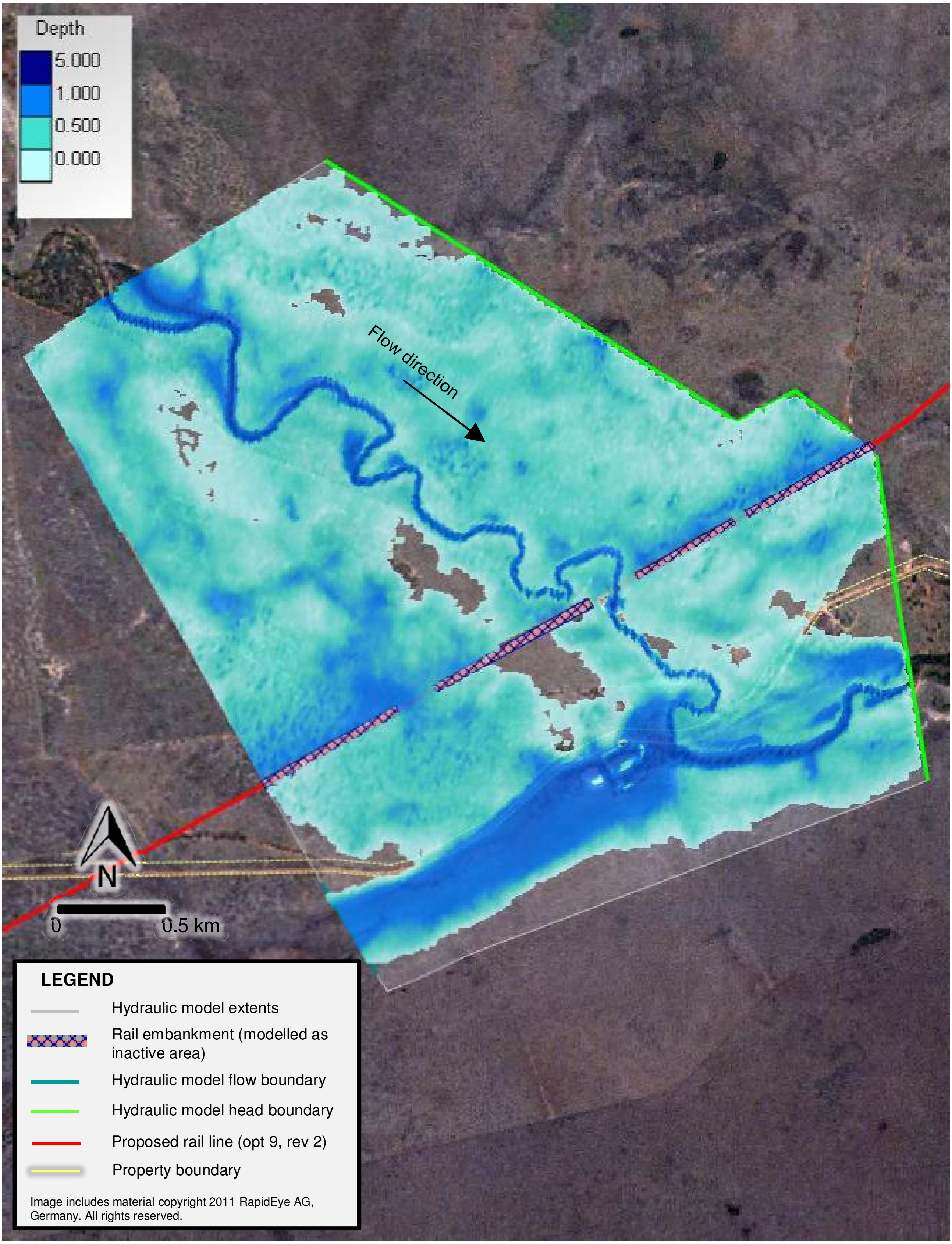

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CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings
DRAWN AL	DATE 16 Dec 11	TITLE North Creek 100 year ARI Flood Map Scenario 3 (520 m total span length)
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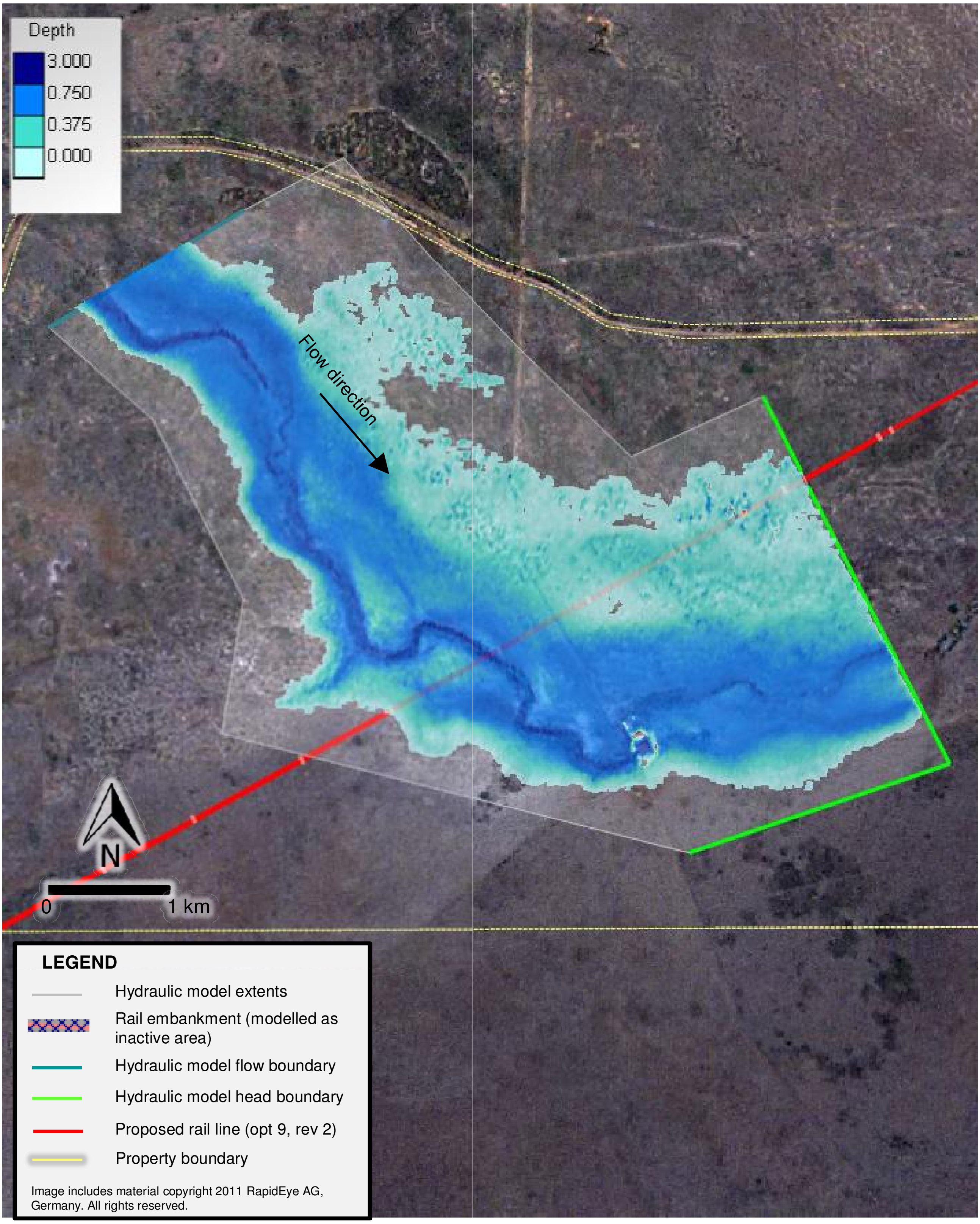

Golder Associates	CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings		
	DRAWN AL	DATE 16 Dec 11	TITLE Eight Mile Creek 100 year ARI Flood Map Existing Conditions		
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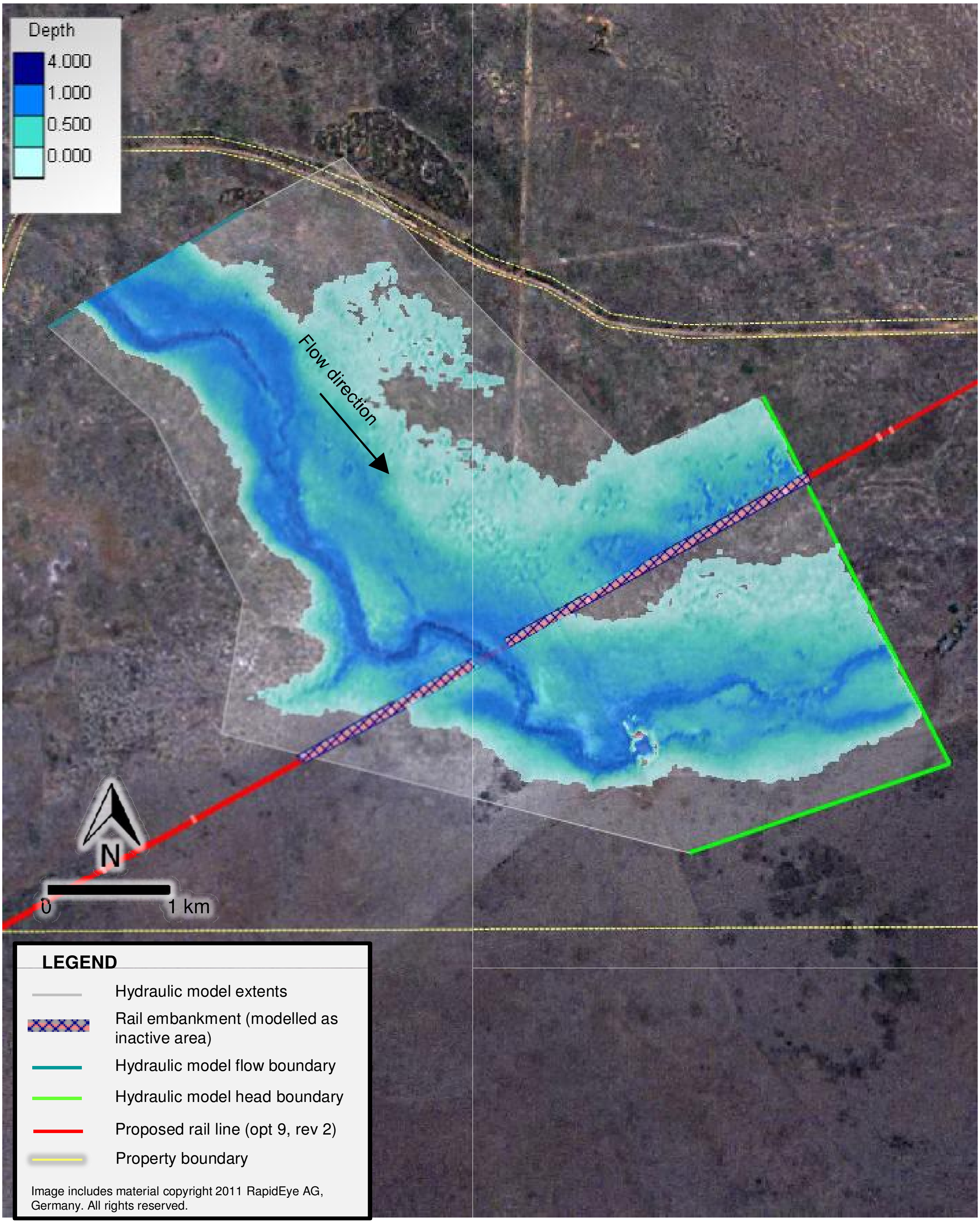

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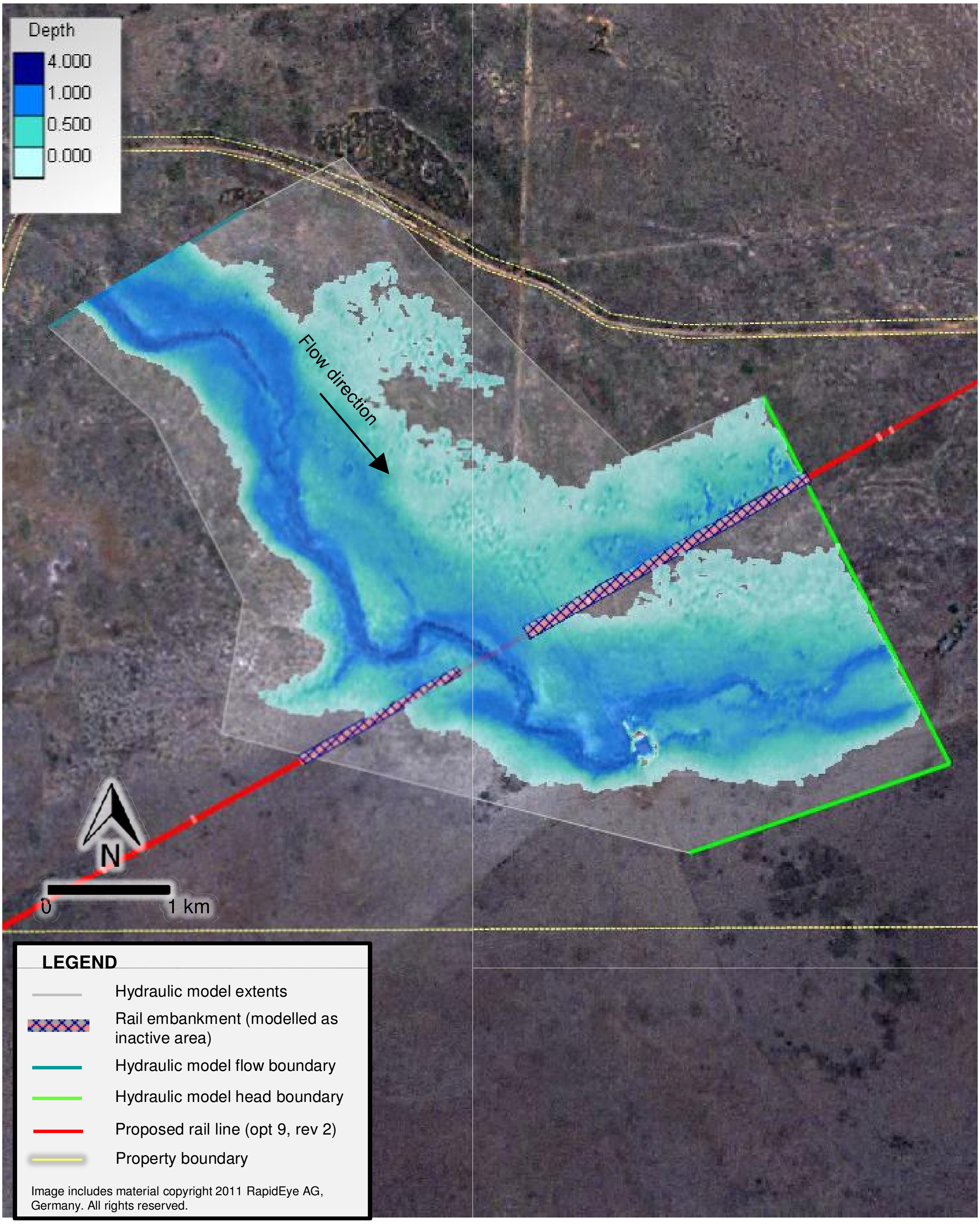

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	CHECKED SS	DATE 16 Dec 11	
	SCALE see above	SHEET SIZE A4	PROJECT No 117632041 / REVISION 0 / FIGURE No FIGURE 27

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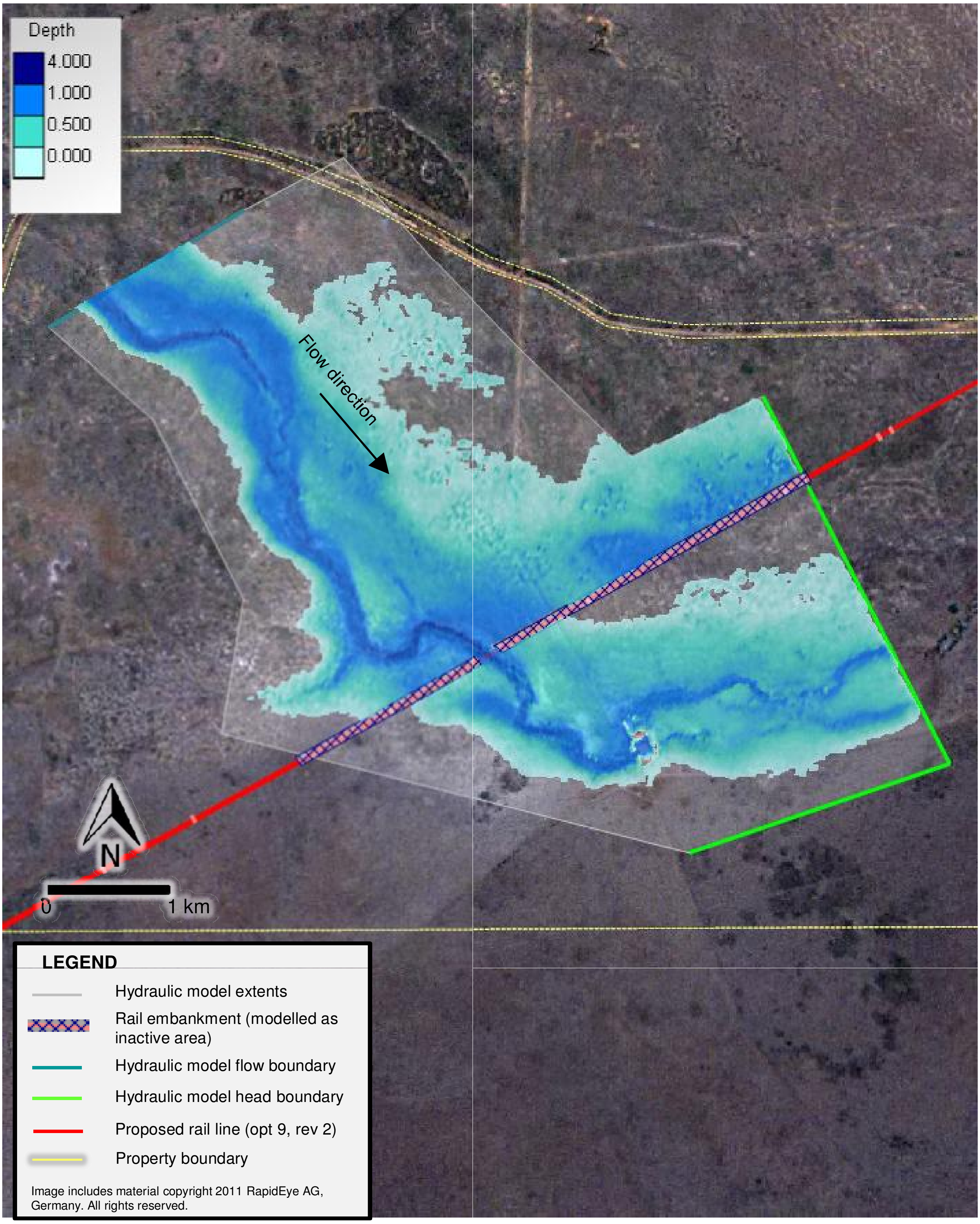

Golder Associates	CLIENT Adani Mining Pty Ltd		PROJECT Carmichael Mine – Preliminary Hydraulic Modelling of Major Watercourse Railway Crossings
	DRAWN AL	DATE 16 Dec 11	TITLE Eight Mile Creek 100 year ARI Flood Map Scenario 3 (85 m total span length)
	CHECKED SS	DATE 16 Dec 11	
	SCALE see above	SHEET SIZE A4	PROJECT No 117632041 · REVISION 0 · FIGURE No FIGURE 28

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APPENDIX B

Limitations

LIMITATIONS

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Appendix C

Licenced Water Takes

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Watercode	Watercourse	Authorisation Ref	Authorisation Type	Client Name	Purpose	Alloc. (ML)	Area (Ha)	Location Parcels
120.01.06.26.16.03	Alpha Creek	103511	Licence to take water	CD & LE Hewitt	Water harvesting			7/DM40
120.01.06.26	Belyando River	00933F	Licence to interfere by impounding-Embankment or Wall	KM & WD Appleton	Impound water			3308/PH45
120.01.06.26	Belyando River	48434F	Licence to take water	Southern Excavation Pty Ltd as Trustee	Domestic Supply			3/AY29
120.01.06.26	Belyando River	52623F	Licence to take water	GD & JM Hoch	Water harvesting			48/BE62
120.01.06.26.07.00+	Belyando River (Anabranch)	37407F	Licence to interfere by impounding-Embankment or Wall	K Goodwin & NK Thompson	Impound water			1/BF27
120.01.06.26z	Belyando River (Longreach Channel)	37488F	Licence to interfere by impounding-Embankment or Wall	RH & WTC Rostron	Impound water			1/BF51
120.01.06.26.08.05	Dyllingo Creek	604941	Licence to take water	Adani Mining Pty Ltd	Construction			
120.01.06.26.02.02	Fox Creek	28340F	Licence to interfere by impounding-Embankment or Wall	TJ & WG Dennis	Impound water			2/SP104491
120.01.06.26.02.02	Fox Creek	41328F	Licence to take water	SM & GJ Salmond	Stock			3500/PH748
120.01.06.26.02	Mistake Creek	0426439F	Licence to take water	BA Hall	Water harvesting			5070/PH1056
120.01.06.26.02	Mistake Creek	057819F	Licence to take water	MA, PJ & TJ Kirkwood	Water harvesting			4/SP116046
120.01.06.26.02	Mistake Creek	41234F	Licence to take water	BL, DJ, JL, LJ, MD & SL Hall	Irrigation		150	2/CP882192
120.01.06.26.02	Mistake Creek	41235F	Licence to take water	BL, DJ, JL, LJ, MD & SL Hall	Water harvesting			2/CP882192
120.01.06.26.02	Mistake Creek	46204F	Licence to take water	Kalang Pastoral Company CQ Pty Ltd	Irrigation, Water harvesting		200	2/RU78
120.01.06.26.02	Mistake Creek	52670F	Licence to interfere by diversion channel	BL, DJ, JL, LJ, MD & SL Hall	Divert the course of flow			2/CP882192
120.01.06.26.02	Mistake Creek	57717WF	Licence to interfere by impounding-Embankment or Wall	Frankfield Pastoral Company CQ Pty Ltd as trustee	Impound water			10/BL58
120.01.06.26.02	Mistake Creek	57718WF	Licence to interfere by impounding-Embankment or Wall	Frankfield Pastoral Company CQ Pty Ltd as trustee	Impound water			10/BL58
120.01.06.26.02	Mistake Creek	57746WF	Licence to interfere by impounding-Embankment or Wall	Kalang Pastoral Company CQ Pty Ltd	Impound water			2/RU78
120.01.06.26.02	Mistake Creek	57847F	Licence to take water	MA, PJ & TJ Kirkwood	Water harvesting			4/SP116046
120.01.06.26.02	Mistake Creek	57882F	Licence to take water	BL, DJ, JL, LJ, MD & SL Hall	Water harvesting			2/CP882192
120.01.06.26.02	Mistake Creek	57883F	Licence to take water	BL, DJ, JL, LJ, MD & SL Hall	Water harvesting			2/CP882192
120.01.06.26.02	Mistake Creek	57884F	Licence to take water	BL, DJ, JL, LJ, MD & SL Hall	Water harvesting			2/CP882192
120.01.06.26.02.01	Pelican Lagoon	0426441F	Licence to take water	BA Hall	Irrigation		300	5070/PH1056
120.01.06.26.02.01	Pelican Lagoon	174169	Licence to interfere by impounding-Embankment or Wall	BA Hall	Impound water			5070/PH1056
120.01.06.26.02.01	Pelican Lagoon	52622F	Licence to interfere by impounding-Embankment or Wall	New Twin Hills Pastoral Company Pty Ltd as Trustee	Impound water			656/SP138788
120.01.06.26.00+	UT Belyando River	37295F	Licence to take water	RH & WTC Rostron	Stock			1/BF51

Appendix D

Belyando River at Gregory Development Road - Gauge 120301B, Flood Frequency Analysis

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Carmichael Coal Project - Belyando River at Gregory Development Road Gauge 120301B - Pearson Flood Frequency Analysis			
RANK	VALUE	PROB (%)	ARI (1 in ..yr)
1	9.02	1.0	100
2	7.59	3.8	26
3	7.59	6.5	15
4	7.32	9.3	11
5	7.07	12.1	8
6	6.78	14.9	7
7	6.69	17.6	6
8	6.66	20.4	5
9	6.64	23.2	4
10	6.5	26.0	4
11	6.48	28.8	3
12	6.28	31.5	3
13	6.2	34.3	3
14	6.16	37.1	3
15	6.11	39.9	3
16	6.04	42.6	2
17	6	45.4	2
18	5.98	48.2	2
19	5.97	51.0	2
20	5.87	53.8	2
21	5.79	56.5	2
22	5.59	59.3	2
23	5.38	62.1	2
24	5.35	64.9	2
25	5.09	67.6	1
26	4.74	70.4	1
27	4.68	73.2	1
28	4.67	76.0	1

Carmichael Coal Project - Belyando River at Gregory Development Road Gauge 120301B - Pearson Flood Frequency Analysis

29	4.34	78.8	1
30	4.32	81.5	1
31	3.93	84.3	1
32	3.63	87.1	1
33	3.45	89.9	1
34	2.67	92.6	1
35	2.24	95.4	1

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Document Status

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