Adani Mining Pty Ltd

Carmichael Coal Mine
Preliminary Water Balance
EPC 1690 & EPC 1080

7 December 2012

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- *did not include any detailed design work, site visits, nor any testing or analysis;*
- *climate change is an emerging issue and the scope for this study does not cover potential climate change impacts on the mine operations.*

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- *information supplied by Adani being accurate and complete*

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Executive summary

Adani Mining Pty Ltd intends to build a large coal mining complex with 21 open cut pits and three underground working areas with a dedicated rail system from mine to port. As part of the EIS process for this development, a Preliminary Water Balance (PWB) assessment has been undertaken for the mine plan associated with Exploration Permit for Coal (EPC) 1690 and 1080. The PWB provides information on anticipated water volumes on the mine site in order to estimate water supply shortages or surpluses and required storages.

The PWB considers direct rainfall- runoff from active and disturbed mining areas within the site, groundwater inflow to open cut pits & underground mine operations, and various operational water demands & losses. This PWB does not consider runoff from catchments outside of the lease areas that transit the site via existing or proposed constructed overland flow paths or waterways.

The PWB includes 10 development stages of the mine plan over a time span of more than 90 years mine life.

The mine stages, general layout, extent of active mining areas, undisturbed and disturbed areas, voids, remediated voids & rehabilitated areas, and spoil areas in open cut pits were extracted from the mine plan generally described by Runge (2011) and amended by Adani (2012).

The PWB analysis uses monthly time increments based on long term historical climatic data (1890-2010).

The PWB analysis shows that despite the Carmichael Coal Project being a large mine development total volumes of water are quite manageable with monthly excess or deficit volumes in general levelling out to a significant degree. Largely due to the reuse of MAW, including groundwater inflows in the open cut pits and underground workings a relatively small volume of external water supply is required.

Despite the large reuse component there is a potential for large volumes of MAW to build-up in the mine water management dams. On an annual basis the average build-up of MAW is not huge, but as the mine will be operational for a long period MAW volumes would build-up significantly without controlled discharges to the environment.

Estimated average annually required discharges show that controlled discharges are expected to be well within discharge limitations (based on flow volumes of the receiving environment).

A preliminary assessment for performance of conventional stormwater treatment measures has been undertaken to estimate concept sediment basin sizes to treat stormwater runoff from spoil areas and rehabilitation areas for each mine stage.

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1. Introduction

1.1 Project overview

Adani Mining Pty Ltd has acquired an Exploration Permit for Coal (EPC) in the Galilee basin in Central Queensland and is intending to build a large coal mining complex with open cut and underground mines with a dedicated rail system from mine to port located at the central east coast of Queensland (QLD). The project is located in the Eastern Part of the Galilee basin, approximately 160 km northwest of Clermont and 550 km West of Mackay (refer to Figure 1).

Adani plans to develop the coal project towards producing up to 60 million tonnes of coal per year once fully operational, from concurrent open cut and underground mining operations.

1.2 Objectives

This Preliminary Water Balance (PWB) has been developed to support the EIS for the Project (mine). As such, the objectives are:

- Development of a PWB providing estimates of expected water volumes on site in order to:
  - Develop an understanding of possible water shortages or surpluses
  - Estimate required water storage volumes
  - Determine the requirement for controlled discharges of water from the Project site to the environment

1.3 Limitations

The PWB considers 10 mine phases that are considered as “stand still” stages as shown in Table 1:

- The mine development in between these stages has not been taken into account in the PWB analysis as this information is at this stage unavailable;
- Potential impacts of future long-term climate change have not been considered in this PWB;
- This study does not cover the design of pipe and pump infrastructure required as part of the water management on site; and
- The PWB focusses on the mine site only, with exception of the offsite potable water demand and excludes off site generated runoff that may transit the site in existing or constructed overland flow.

Table 1 Mine stages for the PWB

Stages	I	II	III	IV	V	VI	VII	VIII	IX	X
Years	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103

Table 1 provided stages are sourced from the Runge[1] (2011) report. For any future references note that staqe 2013 equates to year 1 of mining.

[1] Carmichael Macro Conceptual Mining Study - Report No.: ADV-BR-10370a / May, 2011

1.4 Study area

The Project (mine) Study Area comprises EPC 1690 and 1080, being approximately 250 km^2. The associated mine infrastructure, (i.e. camps, airstrip and new access roads) are located outside the EPCs (Figure 1). In the context of a mine discharge hazard assessment, the study area also includes the waterways that will receive the runoff from the study area that are tributaries of the Belyando River and the Carmichael River (itself a tributary of the former) and the affected reaches of these rivers. The Carmichael River is a large sub catchment (approximately 2,500 km^2 upstream of the mine lease) where land use is predominantly grazing. About 10% of the Carmichael River sub-catchment has remnant native vegetation cover (North Queensland Dry Tropics 2011). The Carmichael River bisects the lease area, running west to east. Rainfall in the Carmichael basin averages 529 mm per year but is irregular both in quantity and occurrence (SILO 2012).

The Study Area occupies a staggered strip between 5 and 10 km wide by 58 km long on the eastern face of a gently sloping north south running ridge overlooking the middle to lower reaches of the Belyando River (Figure 1). Topography ranges from 300 m to 370 m above sea level and is generally flat with little relief.

LEGEND

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

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

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

N

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance

Job Number	41-25215
Revision	A
Date	30-08-2012

Locality Map

Figure 1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\PWB\41-25215_562-01_rev_a.mxd 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: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA (2011); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (SP1 & 2) (2012). Created by: BW, JVC, CA

1.5 Legislation, standards and guidelines

1.5.1 Legislative requirements

The Project requires an environmental authority (EA) under the *Environmental Protection Act* (EP Act) as a 'significant project' under the *State Development and Public Works Organisation Act 1971* (SDPWO Act). A Water Management Plan (WMP) may be mandated within the conditions of the EA or in order to comply with the Environmental Protection (Water) Policy 2009 whereby environmental values (EVs) must be identified and protected by achieving associated water quality objectives (WQOs). The WMP then forms part of the Environmental Management Plan (EMP) for the project. According to the Department of Environment and Heritage Protection (DEHP) (2012) guidelines 'Preparation of Water Management Plans for Mining Activities' a water balance must be performed. Section 9.6.3 of the Terms of Reference (ToR) for the Carmichael Coal project specifically requests that a mine water balance to be performed.

The Project is also subject to approvals under the Mineral Resources Act 1989 (MR Act) which is administered by the Department of Natural Resources and Mines (DNRM).

1.5.2 Standards and guidelines

Guidelines and standards that apply to this PWB are:

- Best Practice Erosion and Sediment Control (IECA, 2008);
- Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012); and
- Guideline for 'Preparation of Water Management Plans for Mining Activities (DEHP, 2012).

1.6 Document status

This PWB has been developed as part of the environmental impact assessment (EIS) studies. It is expected that this PWB of EPC 1690 and 1080 mine plan will be further developed and refined during future project phases and that the final water balance will ultimately form an integrated part of the Mine WMP for the mine life of 90 years.

2. Project description

2.1 Key Project elements

An overview of the Project is provided in the form of a mine layout plan provided in Figure 2. Key elements of the project are outlined below:

- Adani is intending to build a large coal mining complex with open cut and underground mines with 21 pits and three underground working areas;
- Associated infrastructure (worker accommodation village) is outside of the lease area;
- The mine will be operational for almost 90 years (from 2013 till 2103);
- Adani plans to develop the coal project towards producing up to 60 million tonnes of coal per year once fully operational;
- Each pit is expected to produce 10 million tonnes per annum at peak production. The overall workable length of the mine will be approximately 58 kilometres; and
- The Carmichael Coal Project will employ 3000 personnel at the peak of mining activities during the mine life.

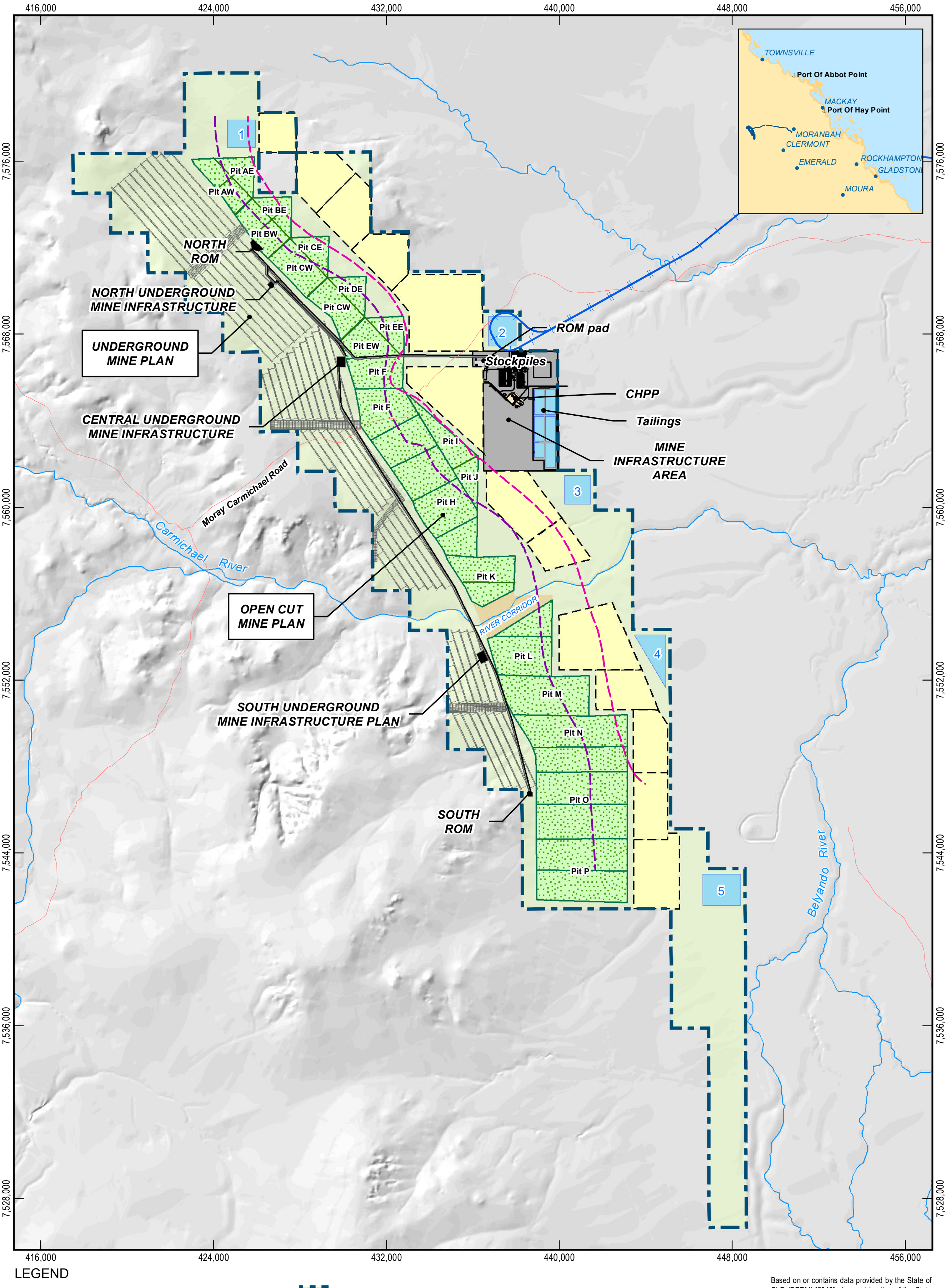
2.2 Mine plan

The following major mine infrastructure items influence inflows and outflows from the Project. Corresponding areas were calculated as per the mine plan for each stage to inform the quantification of inflows and outflows from the site as described in Section 3.2 and Section 3.3. The methodology of this quantification is described in the following sections below.

- Open cut pit areas;
- Underground working areas;
- Out-of-pit spoil areas;
- Haul roads;
- Mine affected water (MAW) storages;
- Industrial working area including the mine industrial area (MIA), the run of mine (ROM) coal area, coal handling and preparation plant (CHPP) and train load out (TLO) facility;
- Creek diversion channel(s);
- Flood protection infrastructure;
- Pumps and pipes.

Each of the above mentioned major infrastructure components are connected in some way to create the mine water management network. In the following sections each major water infrastructural component is described.

Appendix A contains drawings, showing the various mining activities during each of 10 mine stages assessed as part of the PWB.



LEGEND

- Local Road
- River / Watercourse
- AB1 Cropline
- D1 Cropline
- Project (Rail)
- Overland Conveyors
- Mine Lease Area
- Open Cut Blocks
- Out of Pit Waste Dumps
- Water Management Dams

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.

1:250,000 (at A4)

0 2 4 6 8

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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GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance

Job Number 41-25215
Revision A
Date 06-11-2012

Project Area

Figure 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: GA: Roads, Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3, Mine Layout / Infrastructure (2012). Created by: CA

2.2.1 Open cut pit areas

The mine plan consists of 21 open cut pits with the smallest pit area 153 hectares (Ha) and the largest pit area of 1,302 Ha (refer to Table 2). Each pit will have at least one pit sump or clearly defined low area where rainwater and groundwater inflow will be collected before being pumped out of the pit to the MAW storages (Water Management Dams (refer to Figure 2). The sump locations will change over time with the ongoing mining of the pit areas. The extent of active mining areas in open cut pits in various mine stages is given in Table 3. Similarly, the extent of disturbed mining areas in open cut pits over mine stages is given in Table 4**.**

Table 2 Total area of open cut pits

Name of Pit	Total Area (Ha)	Name of Pit	Total Area (Ha)
J	164	O	1,302
G	869	P	1,213
EW	304	EE	166
CW	346	K	514
AW	301	L	723
H	1,134	DE	169
I	259	CE	169
AE	153	BE	166
BW	336	F	357
DW	314	N	1,196
M	711		

Table 3 Extent of active mining areas (ha)

Stages	I	II	III	IV	V	VI	VII	VIII	IX	X
Years/Name of Pit	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
J	23.9	41.8	42.6	31.4	4.1					
G	23.5	30.3	38.7	84.0	84.5	42.1	22.5			
EW			39.2	31.5	9.8	12.6				
CW				27.7	36.7	22.7				
AW					39.7	26.8				
H						57.0		66.1		
AE							19.6			
BW							22.1			
DW							29.9	8.6		
M							25.4	15.7	14.7	
N							24.2		27.1	
O									36.5	
P									41.0	
EE									25.4	
K									67.9	
L									21.4	
I										
DE										
CE										
BE										
F										
Total	47.4	72.2	120.4	174.5	174.9	161.2	143.6	90.4	233.9	

Note that pits DE, CE, BE and F are not worked at the defined stages. Mining of these pits occurs in the ten year gaps between the defined stages.

For each proposed stage, disturbed Areas, areas that will have recently been mined (open cut pits) but will not yet have been rehabilitated, are shown on the drawings in Appendix A. The extent of undisturbed pit areas in Open Cut Pits over various mining stages is given in Table 5. Finally, the extent of rehabilitation, voids, remediated voids, and spoil areas in Open Cut Pits over various mine stages is given in Table 6.

Table 4 Extent of disturbed mining areas (ha)

Stages	I	II	III	IV	V	VI	VII	VIII	IX	X
Years/ Name of Pit	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
J		23.9	65.9	108.5	140.4					
G		23.5	53.8	92.5	176.5	476.8	382.3			
EW				39.2	70.6	237.2	148.4	40.8		
CW					27.1	264.0	337.7	344.5		
AW					39.7	226.6				
H						27.1	181.8	506.6	571.7	
I						113.0				
AE							47.8			
BW							215.0	289.6	327.5	
DW							108.2	293.9	309.3	
M							28.1	263.4	240.1	
N								46.5	404.7	
O										
P									195.7	
EE									87.0	
K									3.2	
L								42.8	392.3	
DE										
CE										
BE										
F										
Total		47.4	120	240	455	1,345	1,449	1,828	2,532	0

Table 5 Extent of undisturbed areas (not including rehabilitated areas) (ha)

Stages	I	II	III	IV	V	VI	VII	VIII	IX	X
Years / Name of Pit	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
J	140	99	56	24	20					
G	846	815	777	693	608	350	464			
EW	304	304	265	233	223	54	155	263		
CW	346	346	346	318	282	59	8	2		
AW	301	301	301	301	221	47				
H	1,134	1,134	1,134	1,134	1,134	1,050	953	562	563	
I	259	259	259	259	259	146				
AE	153	153	153	153	153	153	86			
BW	336	336	336	336	336	336	99	46	9	
DW	314	314	314	314	314	314	176	12	5	
M	711	711	711	711	711	711	658	432	457	
N	1,196	1,196	1,196	1,196	1,196	1,196	1,172	1,150	764	
O	1,302	1,302	1,302	1,302	1,302	1,302	1,302	1,302	1,266	
P	1,213	1,213	1,213	1,213	1,213	1,213	1,213	1,213	976	
EE	166	166	166	166	166	166	166	166	54	
K	514	514	514	514	514	514	514	514	443	
L	723	723	723	723	723	723	723	680	309	
DE	169	169	169	169	169	169	169	169	169	
CE	169	169	169	169	169	169	169	169	169	
BE	166	166	166	166	166	166	166	166	166	
F	357	357	357	357	357	357	357	357	357	
Total	10,819	10,747	10,626	10,452	10,236	9,195	8,551	7,203	5,706	

Table 6 Overview of extent key activity areas (ha)

Stages	I	II	III	IV	V	VI	VII	VIII	IX	X
Years/Areas	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Spoil Area (Ha)	840	1,564	2,849	3,378	3,695	3,695	2,929	3,526	2,497	
Rehabilitation Area (Ha)	0	0	0	0	0	333	412	108	216	0
MIA (Ha)	1,008	1,008	1,008	1,008	1,008	1,008	1,008	1,008	1,008	1,008
Tailings Area (Ha)	388	388	388	388	388	532	532	532	581	388
Remediated Void Areas (Ha)	0	0	0	0	0	0	0	50	373	753
Void Area (Ha)	0	0	0	0	0	0	0	208	0	1,546

2.2.3 Out of pit spoil areas

Out of pit spoil areas will be developed at several locations adjacent to the pits over the different mine stages as shown inFigure 2. Spoil areas are based on the preliminary mine design provided by Adani Mining and are likely to change with the further development of the mine design. Runoff from the spoil areas is directed by gravity towards sedimentation basins. The extent of spoil areas over various mine stages is provided in Table 6.

2.2.4 Haul roads

A main haul road is required between the pits and the ROM stockpiles. Temporary haul and access roads will also be constructed as the mining progresses. These roads will be extended and/or relocated as required as the pits are excavated and overburden dumps are built upwards and extended.

In addition to the haul road a sealed access road will also be built from the mining site to the village.

2.2.5 MAW storages

The MAW dams (Figure 2) will receive MAW from all disturbed areas of the site including active mining (open cut and underground) and disturbed areas. Water from these storages will be reused in the coal handling process when possible. MAW dam locations and surface areas have been provided by Adani as per the mine plan however the depth can be varied to optimise the storage capacity volume. The results of the water balance modelling provide a means of assessing the adequacy of proposed MAW storage dam capacities to enable maximisation of MAW reuse and minimisation of the frequency of controlled discharges to the environment. This study has suggested minimum MAW storage requirements for the six water management dams during each of the ten modelled phases of the mine development. Water balance calculations initially assumed zero seepage losses from the proposed storage facilities. However, based on direct guidance from Adani, this assumption was revised for the final water balance calculations which instead assume that 5% of the total water stored in the proposed dams is lost as seepage on monthly basis for the mine life. Groundwater inflows into the dams are assumed zero. Water balance calculations assumed actual evaporation from the MAW dams. As outline in the recommendation section, the PWB analysis will be updated and revised after getting the actual values of the seepage using the ground water model.

Finally, it has conservatively been assumed that 100 megalitres (ML) of water will be below dead storage in the MAW dams and this water could not be used for any mining operations. This volume allows for minimal water levels required to allow for pumping.

For calculating the net volume of MAW in the dams the following inflows and outflows have been included for each mine stage:

- inflows
  - 100% rainfall on the dam area;
  - runoff from active and disturbed mining areas (in open cut pits and MIA);
  - the groundwater inflow from underground working areas;
  - the groundwater inflow from open cut pits; and
  - return process water from tailings facility.
- outflows
  - evaporation;
  - seepage;

- dust suppression; and
- process water for CHPP

2.2.6 Mine Industrial Area, Coal Processing and Stockpile Area

The MIA will be constructed to the east of the mining operations and is likely to include site offices, workshop, hardstand area, water and waste water treatment plants, wash down facility and raw water dam. The ROM coal area will include a hopper, coal crusher and stockpiles. In general it will be a hub for human and vehicular movements.

The CHPP receives ROM which is sized and processed with finished product sent to stockpiles and rejects to waste disposal. The TLO will cater for loading of coal in the coal train.

The MIA, has an area of 1,008 Ha. With appropriate design of the MIA and appropriate environmental management it is unlikely that the whole area will produce MAW. Parking areas for light vehicles, for example, are not likely to produce MAW. It has been assumed conservatively that runoff from 50% (504 Ha) of the MIA area will be draining into the MAW storages.

2.2.7 Runoff diversion channels and pit flood protection

Several diversion channels will be constructed to convey the 100 year ARI design flood flows but give 1,000 year average recurrence interval (ARI) immunity around the open cut pits and underground working areas. This ensures that in events up to and including the 1,000 year ARI event clean water from the surrounding environmental will not enter the open cut pits or underground working areas. Details surrounding the diversion channels can be found in Appendix E Preliminary Flood Mitigation & Creek Diversion Design report. In Appendix A drawings showing the diversions and the stage when the diversions are required are provided.

2.2.8 Regional flood protection infrastructure

Levees will constructed around the Carmichael River to provide flood protection and immunity from a 1,000 year ARI design flood event in the Carmichael River. More detail is provided in Appendix E Preliminary Flood Mitigation & Creek Diversion Design report.

2.2.9 Pumps and pipes

Pumps and pipes will be required to empty pit and bund sumps and transfer raw and process water throughout the site. Pipe and pump capacities have not been estimated and are not used as a limitation to the transfer of water around the mine in this assessment.

2.3 Principles of water management

The proposed mine water management system will involve the management of three types of water:

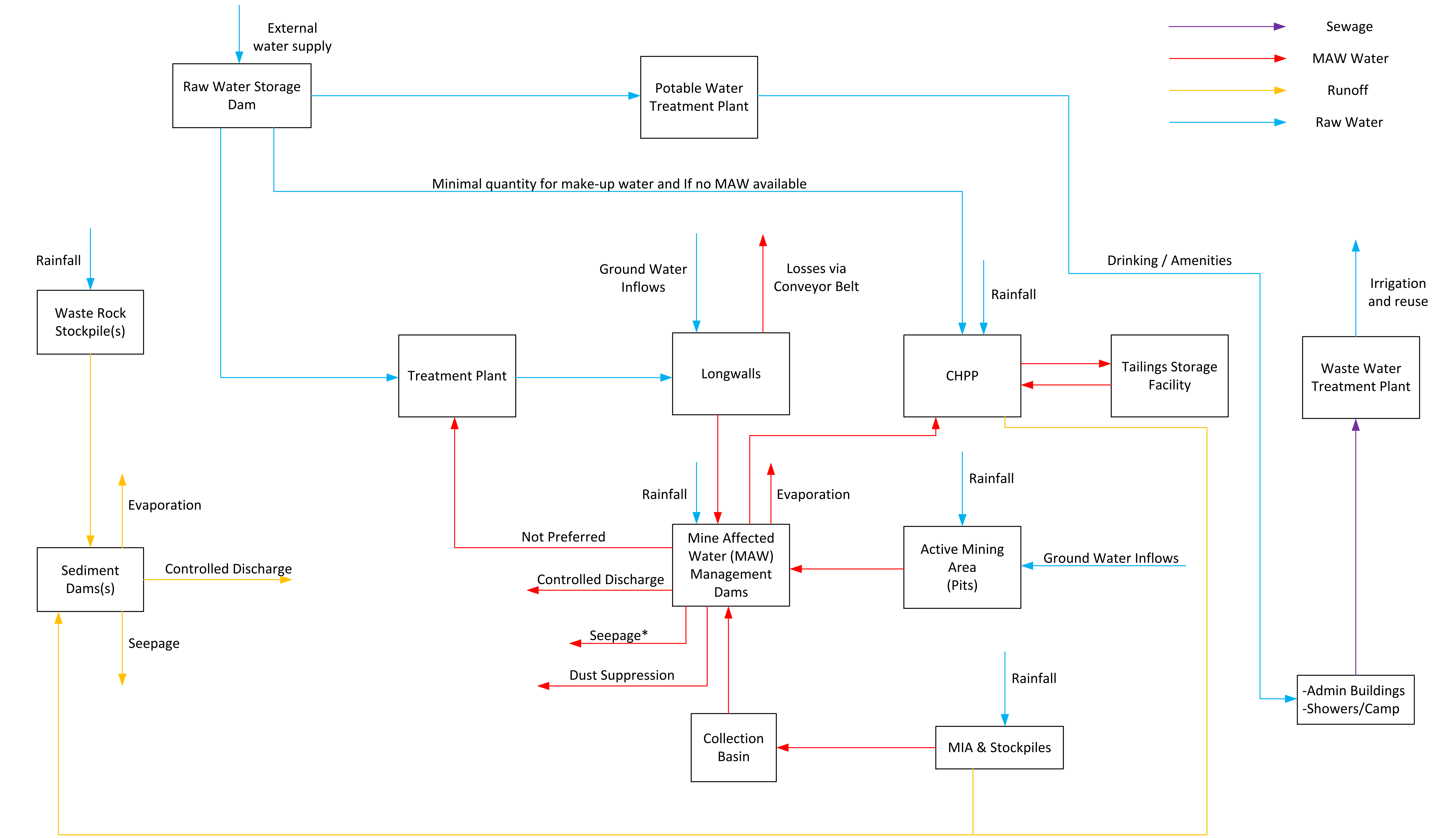
- Clean water - rainfall runoff from areas that are not disturbed by mining activities.
- Raw water (or external) supply - supplied through a pipeline from an external source. Raw water can with minimal treatment be treated to potable water standards;
- MAW - water that has been affected by the mine workings. MAW is available for reuse. MAW comprises:
  – Groundwater inflow from the pits;
  – Process water (used raw water or reused MAW) removed from the pits;
  – CHPP process water; and
  – Surface drainage water from catchment areas containing hazardous materials (e.g. workshop area and coal stockpile areas). These surface catchment areas are classed as ‘industrial’ catchment areas; and

The following Water Management Principles are proposed for the Project:

- Raw water will be delivered and temporarily stored in a raw water dam;
- MAW is to be retained on site and stored in facilities that are designed and managed in accordance with:
  – The guideline: Structures which are dams or levees constructed as part of environmentally relevant activities (DERM 2012)
  – The Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM 2012)
- All water entering or derived from an open cut pit or underground working areas is considered MAW;
- Runoff from disturbed catchments areas has to be treated to a sufficient level as defined in Section 3.4.2 before being released into the natural environment through controlled discharges
- Clean water runoff from undisturbed catchments areas is diverted around any mine workings or disturbed areas;
- Uncontrolled discharges are to be minimised and relate only to events larger than the design event for the DSA Discharges – refer to appendix C.
- Controlled discharges are in accordance with Environmental Authorities.
- In case of acid mine drainage (AMD), water needs to be treated through neutralization. The nature of exact treatment will depend upon the water quality;
- Each waste rock spoil area has a dedicated sedimentation basin that treats runoff to clean water;
- When spoil areas are rehabilitated in the later mine stages, the associated sediment basins will remain operational for a nominal minimum period of 10 years until vegetation cover is sufficient to mimic the pre-existing natural conditions; and
- Mine workings are protected from local stormwater runoff and regional flooding from Carmichael River and other water ways up to the 1000 year ARI event.

2.4 Water balance flows

In order to develop an understanding of the water management infrastructure stages, conceptual diagrams showing various mining activities and associated hydrological processes were developed for each mining stage. Figure 3 shows the conceptual diagram for the mine water management.



*5% seepage has been included in the PWB model. Should further assessments predict that MAW water quality will pose environmental harm then dams will be lined to minimise this volume.

No	Revision Note:* indicate signature on original issue of drawing or last version of drawing	Drawn	Checked	Approved	Date
A	INITIAL SETUP OF WATER BALANCE	26/10/12			

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Project: **CARMICHAEL COAL MINE**
Title: **WATER BALANCE SCHEMATIC**

Original Size **A3**
Drawing No: 41-24415-SK001
Rev: A

3. Preliminary water balance

3.1 Methodology

The PWB applies long term historical climate data from 1890-2010[2] in a MS-Excel modelling environment. The PWB model was set up using monthly time increments on the basis that:

- A daily time step model would lead to excessive volumes of data due to the extensive mine workings, with up to 21 open cut pits and 3 underground mines over the mine life of 90 years;
- Groundwater inflow information is available on monthly basis only; and
- The current level of detail of the mine plan does not justify a detailed daily time step model.

The PWB assessment considers water inflow and outflow parameters using long term historical monthly data from 1890 to 2010 over the 10 agreed mine stages, i.e. 2013, 2014, 2015, 2016, 2017, 2027, 2037, 2047, 2067 and 2103. The water balance parameters (such as evaporation, rainfall, groundwater inflow, and surface runoff) for each mine stage have been derived as described and detailed in the following sections. Any remaining water balance parameters, in particular water demands for various mining operations, not described for the mine stages in these sections are either provided directly by Adani or estimated by GHD by applying its knowledge of mine water management.

The PWB results are reported for each month in terms of the frequency of excess or shortage of mine water that requires containment or supplementary water supply in each of the 120 years (1890-2010) of simulation summarised by the 10, 50 and 90 percentile lines. Excess water is expected to be stored in MAW storage, while shortages indicated the need for external water supply.

The detailed procedures for calculation of all inflows and outflows parameters in the PWB assessment for each mine stage have been provided in the following sections.

[2] Source: Silo Website with location 22 09' S 146 24' E and elevation of 297 m. This location is approximately at the centre of the mine lease.

3.2 Inflows

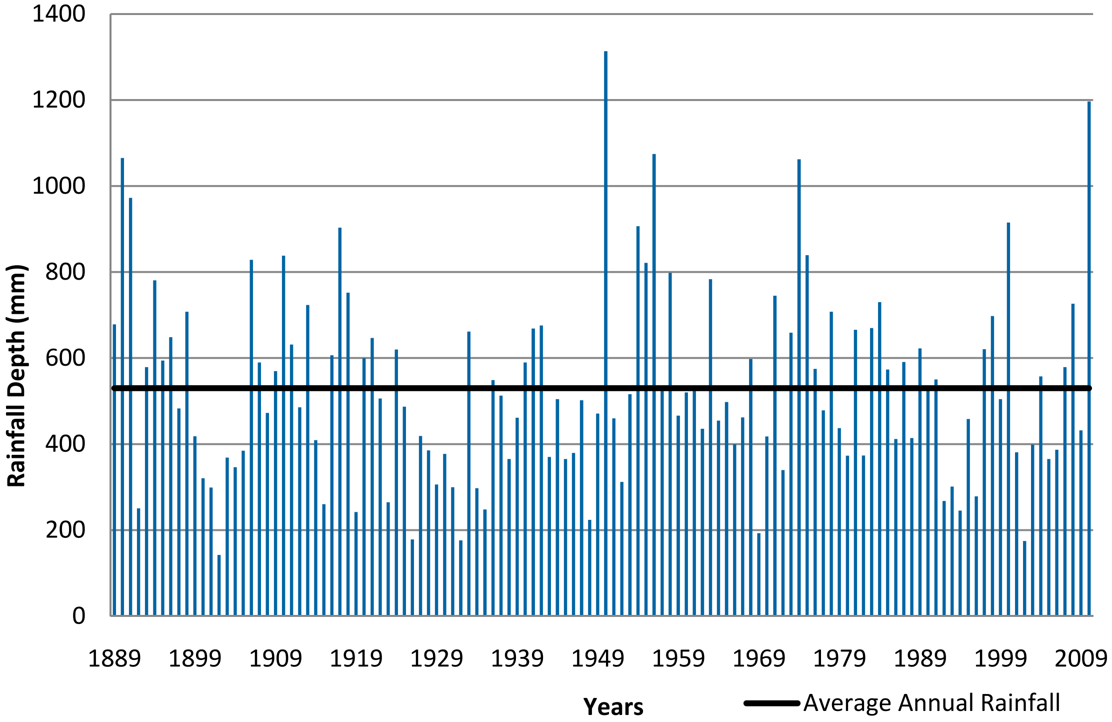
3.2.1 Raw water supplies

If no MAW is available, it is assumed that raw water from an external source is available. In the PWB analysis no external inflows have been included as one of the objectives is to develop an understanding of possible water shortages or surpluses at the various mine stages.

3.2.2 Rainwater

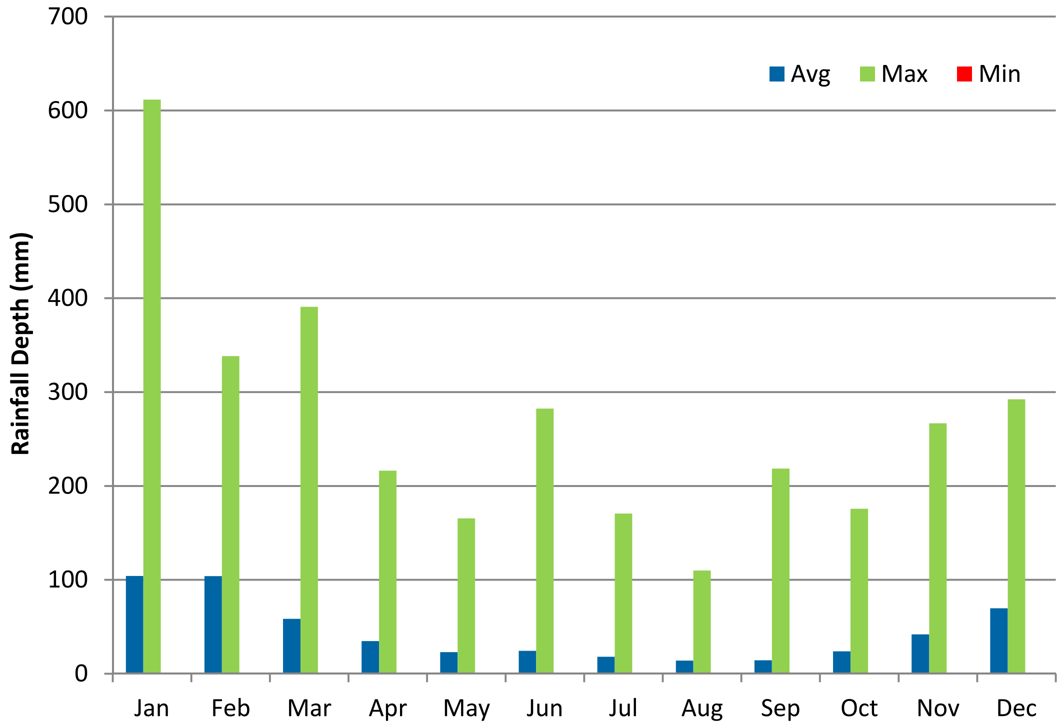
Long term (1890-2010) rainfall data for the mine site were extracted from the SILO website (22 09'S 146 24'E with elevation of 297 m) which provides interpolated values. The principal influence on the hydrological regime of the site is the patterns of rainfall. Rainfall monthly averages suggest a distinct wet season between December and March and dry season between June and October. On the long term, monthly rainfall varies from 0 mm in winter to 338 mm in summer. Annual rainfall (1890 – 2010) is shown in Figure 4.

Figure 4 Annual rainfall at the mine site (1890 – 2010)



The monthly totals of rainfall were calculated from the climatic time series data. The annual rainfall ranges from a low of 142 mm/year in 1902 to a high of 1309 mm/year in 1950 with an average of about 529 mm/year (with 1957 being a typical average year). The long term (1890-2010) mean, highest and lowest rainfall for all months is shown in Figure 5.

Figure 5 Variation in monthly rainfall at the mine site (1890 – 2010)[3]



3.2.3 Runoff

Rainfall will generate runoff from all areas of the mine lease area and this runoff forms an important component of the PWB. Runoff from undisturbed areas will be diverted to local creeks whilst runoff from disturbed areas of the mine (spoil dumps, and haul roads) will be captured in sediment basins. Runoff within open pits will drain to sumps and be pumped to the MAW storages.

Many runoff models have been developed for various hydrological settings. This study explored the possibility of using two runoff models, namely, Australian Water Balance Model (AWBM), and US Soil Conservation Service (SCS) for the project. The SCS Curve number (USDA-SCS 1972) method was chosen to calculate runoff for this project due to the availability of spatial images showing major soil types and land use classes for the study area. The SCS method computes direct runoff through an empirical equation that requires rainfall and a basin coefficient as inputs. The basin coefficient, known as the runoff curve number (CN) represents the runoff potential of the land cover soil complex.

The runoff (Q) has been calculated from the SCS method given below:

$$Q = \frac{(P - Ia)^2}{(P + S - Ia)} \qquad \boldsymbol{P > Ia}$$

$$Q = 0 \qquad P \leq Ia$$

Where:

P is accumulated rainfall (mm)

I_a is initial abstraction (mm) term which is generally assumed as: $I_a = 0.2 \times S$

[3] Minimum is close to zero and cannot be viewed at this scale.

S is the potential storage in soil (USDA-SCS 1972) and is calculated from:

$$S = \frac{25400}{CN} - 254$$

CN is the curve number relating to the soil group of the particular site which has been taken from the available standard tables that show this relationship. CN has a range from 30 to 100; lower numbers indicate low runoff potential while larger numbers are for increasing runoff potential.

Selection of curve number

The selection of CN has been based on the type of dominant surface type covering the area in combination with the knowledge of the hydrological soil groups, both affecting the runoff. The hydrologic soil group refers to the infiltration potential of the soil after prolonged wetting.

A digital spatial map was of the major soil types was obtained from the Australian Soil Atlas developed by Mackenzie and Hook (1992). For the selection of CN, there are two soil hydrological groups in the regional catchment: Kandosol and Vertosol as shown in Figure 6.

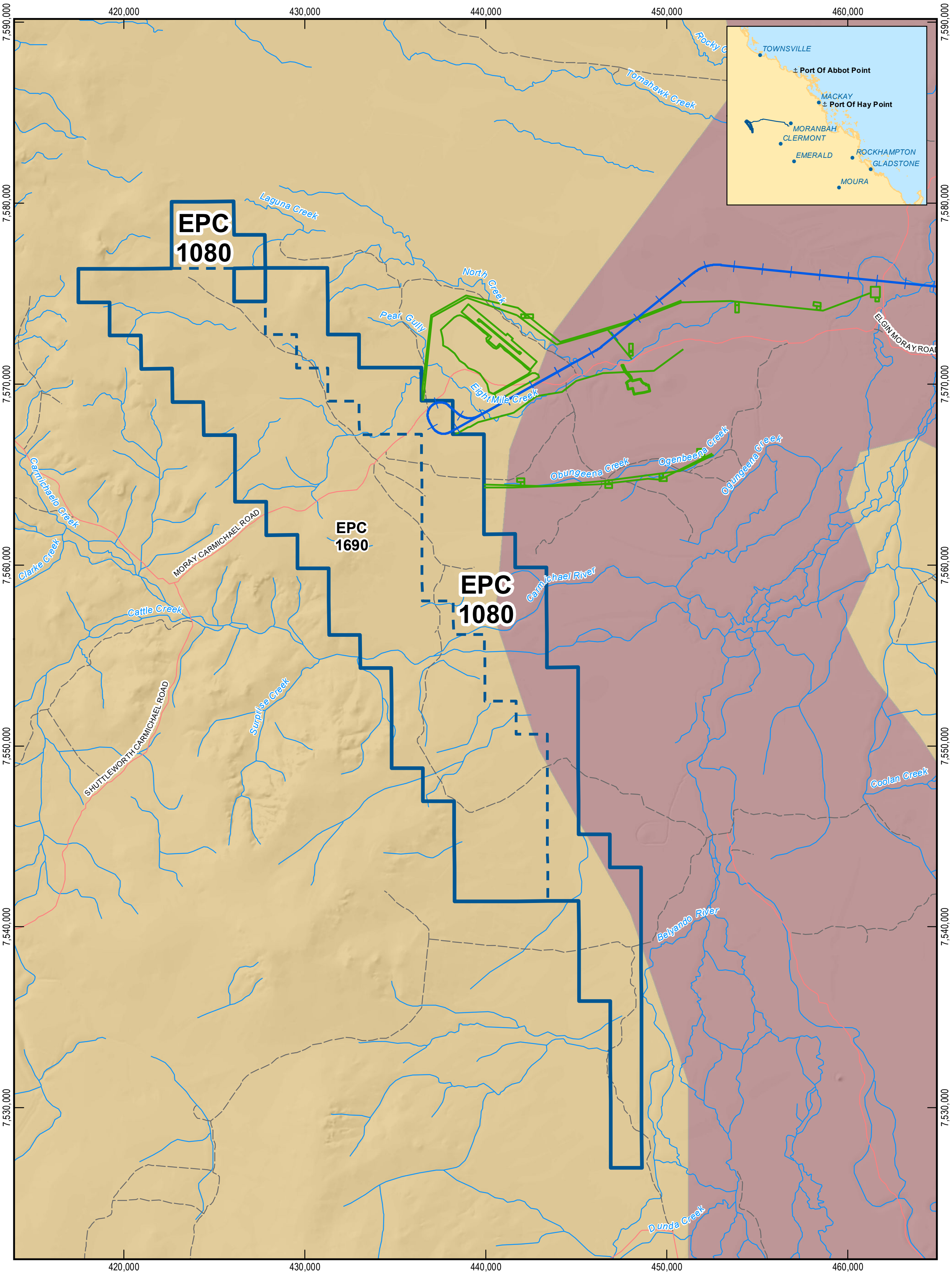
Kandosol soils are fine sandy soils which have low to moderate agricultural potential with moderate chemical fertility and water-holding capacity. These soils are found in poorly drained sites with rainfall between 300 mm and 1400 mm and in well-drained sites with rainfall between 250 mm and 1400 mm.

Vertosols are clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular structural aggregates. A digital soil map shows that majority of the area is under Kandosol soil while Vertosol only covers a small area.

Similarly, spatial land use and land cover classification map for 2004 were obtained from DERM spatial database which showed that 95% of the catchment area within the study area is within the category ‘production from relatively natural environments’ and only 5% area is under the ‘conservation and natural environments’ category.

For the mining area, a CN of 92 was selected for MIA area (1,008 Ha) having 85% impervious surface due to mining infrastructure and the area has an initial soil loss of 4.4 mm. For Open Cut Pits and Spoil areas, a CN of 77 for bare soil was selected with high infiltration rate and low runoff potential which has an initial soil loss of 15.2 mm. Finally, daily runoff from 1890-2010 was converted into monthly runoff for direct use in the PWB analysis for the mine site.

In accordance with the water management requirements, all stormwater runoff potentially contaminated with coal particles, hydrocarbons or other contaminants will be collected and stored in the MAW storage dams. Runoff generated from MIA, active & disturbed mining areas in open cut pits is considered as MAW in the water balance analysis.



LEGEND

- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine (Offsite)

Burdekin Soils

- Kandosols
- Vertosols

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.

1:300,000 (at A4)

0 2.5 5 7.5 10

Kilometres

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

N

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance

Job Number	41-25215
Revision	B
Date	26-10-2012

Soil Types in the Study Area

Figure 6

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\41-25215_564_rev_b.mxd 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: DME: EPC 1690 (2010), EPC 1080 (2011); DERM: QLD Combined Soils (2010); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Roads, Watercourses (2007); Adani: Alignment Opt9 Rev3 (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

3.2.4 Groundwater inflows in open cut pits

A full description of the groundwater model developed is provided in Volume 4 Appendix R of the EIS study (GHD, 2012). In this section only a brief overview of the methodology and the results is provided.

Predicted groundwater inflows to the proposed open cut are illustrated in Table 7. Annual predictions are provided for the period 2013 to 2017 i.e. the period during which annual mine plans are available. From 2017 to 2087 only decadal mine plans are available and hence accurate estimates of groundwater inflows can only be developed at 10 year intervals.

Predicted inflows are closely correlated with the modelled open cut active mining area which is based on the active areas shown on the conceptual mine plans included in the conceptual mining study (Runge, 2011).

Table 7 Groundwater inflow volumes in the opencut working areas (ML/month)

Open cut pit / stage	AE	AW	BE	BW	CE	CW	DE	DW	EE	EW	F*
2013	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	1.5	103.6	0
2016	0	0	0	0	0	17	0	0	0	54.3	0
2017	0	14.1	0	0	2.8	32.6	0	0	0	53.9	0
2027	0	11.3	0	0	0	12.9	0	0	0	54.7	0
2037	10.2	0	0	9.4	0	0.3	0	19.3	0	0	0
2047	0	0	0	0	0	0	0	24.5	0	0	0
2067	0	0	0	0	0	0	0	0	25.8	0	0
2103	0	0	0	0	0		0	0	0	0	0

* F is not active for any of the 10 analysed stages.

Open cut pit / stage	G	H	I	J	K	L	M	N	O	P	Total
2013	30.3	0	3	34	0	0	0	0	0	0	67.5
2014	48.8	0	0	33	0	0	0	0	0	0	81.4
2015	66.9	0	0	29	0	0	0	0	0	0	201.2
2016	79.4	0	0	27	0	0	0	0	0	0	177.4
2017	80	0	0	13	0	0	0	0	0	0	196.2
2027	77.1	50.3	0	13	0	0	0	0	0	0	219.6
2037	55.6	0	0	0	0	0	19	30.9	0	0	144.9
2047	0	71.1	0	0	5.2	0	13	0	0	0	114.1
2067	0	0	0	0	27	18.5	12	28.4	32.8	70.1	214.1
2103	0	0	0	0	0	0	0	0	0	0	0

3.2.5 Groundwater inflows in underground working areas

Only very limited information on the proposed underground mine development are available from the Runge report (Runge, 2011). To account and simulate for the gradual development of the mine through time, the following data and assumptions were adopted:

- Figures 6.8 and 6.9 from the Runge (2011) report were used to define the start and end years for mining operations from the North, Central and South underground mines
- Longwall production commences initially in Seam AB and is followed by production in Seam D with a lag time of up to five years
- Mine layouts for Seam AB and Seam D are understood to be identical
- Production from the Central mine will lag the starting operations from the North mine by one year. Whilst operations in the South mine will not start before 2039 as per Figure 6.9 in the Runge report (Runge, 2011)

It should be noted that information on the underground mine workings is largely limited to the planned final extent of the workings and the start and end date of each mine. No information is therefore available on the extent of the active underground mine workings in any of the intervening years. Hence for modelling purposes it was necessary to estimate the extent of the active working area at any time assuming that the panels are worked from north east to south west and at a constant rate. Model drain cells defining each longwall panel are turned on and off as production from the underground mines progresses.

Drain cells are only assigned to modelled layers representing the AB and D coal seams since the other under and overlying units are unlikely to be actively drained. Based on the modelled depth of the base of the D seam, at the western limit of the proposed underground mining areas, the underground mine workings will extend to depths of up to around 600 m below ground level. With reference to Runge (2011) the E and F seams are not planned to be mined and therefore simulation of dewatering of these seams has not been included in the model.

Collapse of overburden strata into previously worked longwall panels in underground mining areas typically leads to enhanced permeability in the overlying strata. This has been simulated in the groundwater flow model by altering the hydraulic conductivity of overlying layers as the underground mine develops. The extent of mining induced fracturing above the proposed mine workings has been assessed in a separate study undertaken by MSEC (MSEC, 2012). The results of this study suggest that a free draining fractured zone with a maximum height of approximately 150 meters is likely to develop above the underground longwall mine workings. This zone is likely to be characterized by intense vertical fracturing. The fractures tend to be connected thus creating the potential for direct groundwater inflows from the overburden to the workings. Conceptual models for the free draining fractured zone (MSEC, 2012; Guo et al., 2007) suggest an increase in vertical hydraulic conductivity whilst variation in horizontal hydraulic conductivity is generally considered to be negligible.

For modelling purposes the free draining fractured zone has been simulated by increasing the natural (pre-mining) vertical hydraulic conductivity by a factor of up to 50 based on the findings of the CSIRO (Guo et al., 2007).

Predicted groundwater inflows to the underground working areas are shown in Table 8.

Table 8 Groundwater inflow volumes in the underground working areas (ML/month)

Underground Working Areas / Stages	North Mine (North Panels)	North Mine (South Panels)	Central Mine (Central Panels)	Central Mine (North Panels)	Central Mine (South Panels)	South Mine (North Panels)	South Mine (South Panels)*	Total
2013	0	0	0	0	0	0	0	0
2014	82.6	0	0	0	0	0	0	82.6
2015	104.3	0	0	145.1	0	0	0	249.4
2016	101.8	0	0	122.4	0	0	0	224.2
2017	194.4	0	0	104.6	0	0	0	299
2027	145.4	0	0	104.6	0	0	0	250
2037	122.2	36.4	57.6	46.4	0	0	0	262.6
2047	0	89.8	56.1	0	26.1	79.3	0	251.3
2067	0	0	0	0	0	0	0	0
2103	0	0	0	0	0	0	0	0

* South Panels are mined in between PWB stages

Modeling Assumptions and Uncertainty

When interpreting and using the predictions summarised above it should be noted that any numerical model predictions are subject to a degree of uncertainty, due to a range of factors including uncertainty in model input data and the simplifications and limitations inherent in all numerical modelling work. In addition parameter uncertainty represents a major source of variability in all numerical groundwater models. For the current model the calibration uncertainty has been reduced and the model parameters optimised through the use of stochastic modelling and automated calibration techniques. Whilst this calibration minimises parameter uncertainty, it cannot be eliminated entirely, in part since the model calibration may not be sensitive to some parameters which significantly affect the model predictions. Detailed sensitivity analysis results undertaken as part of groundwater model development for the project suggest that the predicted groundwater inflows shown in Table 7 and Table 8 may have an associated accuracy of + or – 50%.

In this specific case it should also be noted that the inflow predictions to the open pit do not allow for evaporation losses from the proposed open cut pits. Whilst it is recognised that evaporation losses could be significant, actual losses will be dependent on the design of the dewatering and in pit water management systems as these influences the surface area of any in-pit storages, corresponding water availability and pumping regime.

Predictions of inflow to the underground mine workings assume that the underground access areas will not receive any surface runoff water from the surrounding catchment since these will be protected by a levee, however, the access area will receive (direct) rainfall water. The access points are small in area and the volume of rainfall contribution from direct rainfall on the underground access area into underground working areas was not included in the PWB analysis.

The preliminary inflow predictions are based on groundwater modelling undertaken using a porous media groundwater flow model MODFLOW and assuming a constant long term average groundwater recharge rate of 0.3 mm per year. As such predicted inflows take no account for groundwater flow fluctuations which may occur:

- Where fracture flow systems are intersected by the developing mine workings; and/or
- During prolonged dry or wet periods i.e. periods when rainfall and hence groundwater recharge is substantially higher or lower than the modelled long term average.

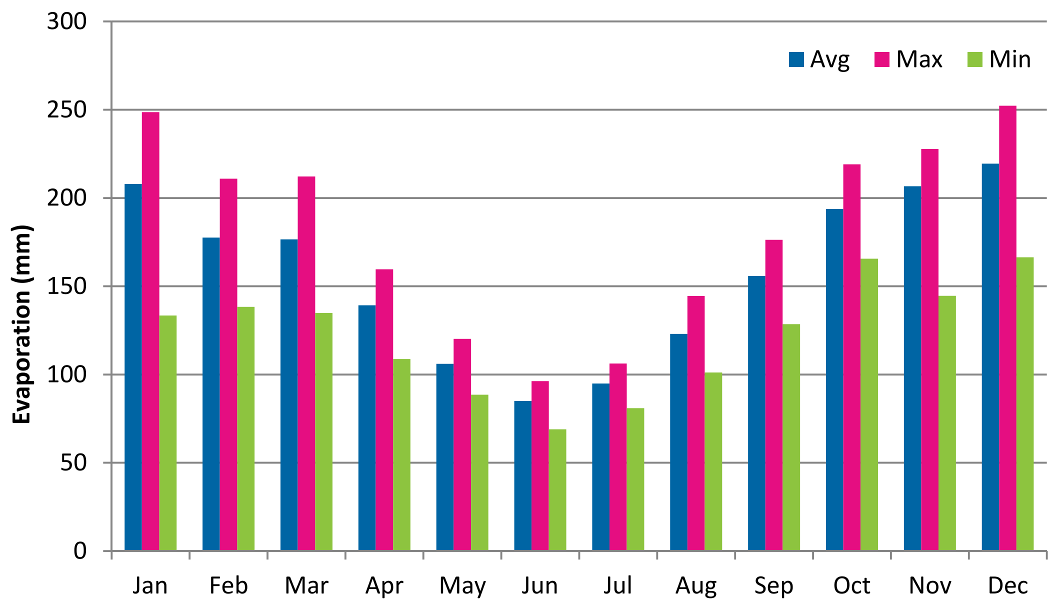
3.3 Outflows

3.3.1 Evaporation

Daily Morton's Lake Evaporation data from 1890-2010 were obtained from the Queensland Government's SILO Data Drill service. Morton's Lake Evaporation is a method of calculating lake evaporation based on the conceptual and empirical relationship between areal and potential evaporation with the potential to include climatic observations. This daily evaporation data was converted into monthly evaporation for the PWB analysis. The Moreton's Lake Evaporation data shows variation from year to year with the highest evaporation being 2,034 mm (1935), and the lowest evaporation being 1,616 mm in 2010. The long term average monthly evaporation ranges from 85 mm in June to 219 mm in December (Figure 7) and this has been adopted for the PWB.

Evaporation will take place from all open water bodies on the mine site. Evaporation has been incorporated into the PWB assessment for the water bodies including tailings dams, and MAW storage dams. Losses due to evaporation are calculated based on the average monthly evaporation values, from 1890-2010. Evaporation from the raw water dam and the pit sump(s) have not been taken into account in the PWB due to lack of design information at this stage. Impacts of this are expected to be minor as these structures are expected to be small in comparison with the overall site.

Figure 7 Variation in monthly evaportaion for the mine site



3.3.2 Volume of water required for dust suppression

Water available from MAW storages will be used for the dust suppression of mine haul roads and active mining areas. In addition, the MAW will also be used as process water in the wash plant. If no MAW water is available, it is assumed that water from an external source is available.

Mine haul roads

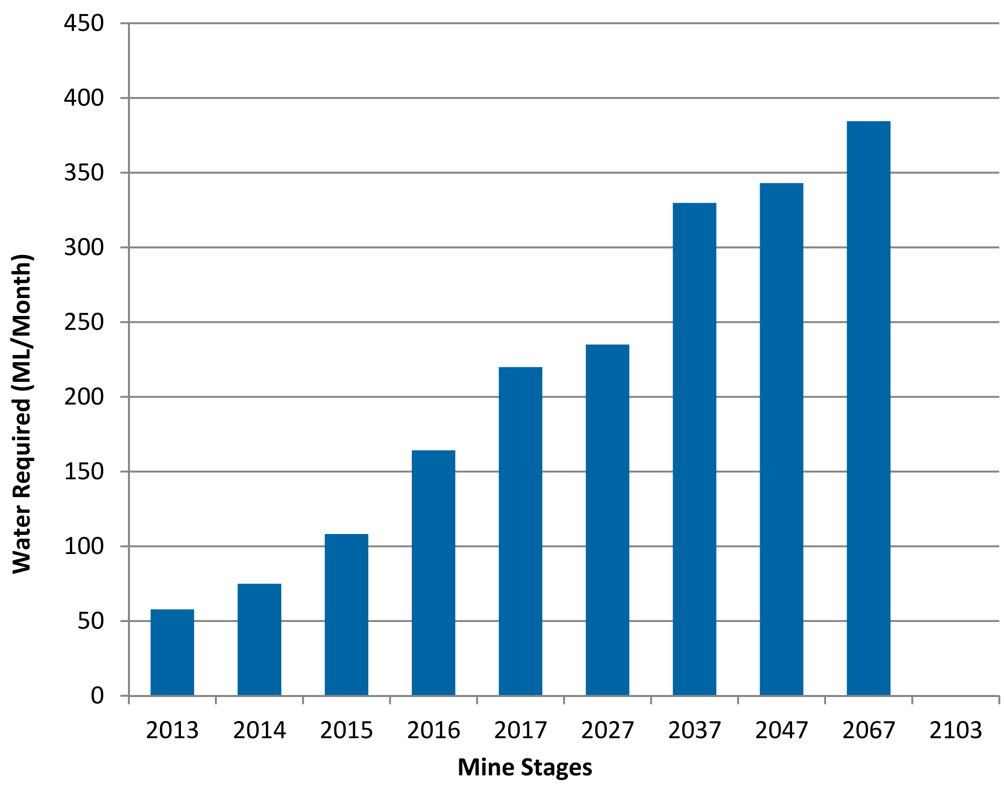
For each of the mine stages the main haul road has been identified for each of the modelled mine stages. In Appendix A the haul roads are shown for each of the 10 stages. The lengths of the main haul roads are provided in Table 9.

Table 9 Main haul road lengths (km)

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Length	9.23	11.95	17.27	26.20	35.07	37.49	52.60	54.71	61.33	0

The width of the main haul road is assumed to be 40 m, which was used to calculate the area of mine haul roads for each PWB stage. Historical climate data shows that on average there are 33 rain days at the mine site. It is assumed that dust suppression on the main haul roads is required year round, with exception of these 33 days per year. Historical climatic records (1890-2010) show that average daily evaporation is 5.15 mm. It has been assumed that a water depth 10% greater than the long term daily evaporation (1890-2010) is required for the dust suppression. The volumes of water required for dust suppression of mine haul roads for all mining stages is given in Figure 8**.**

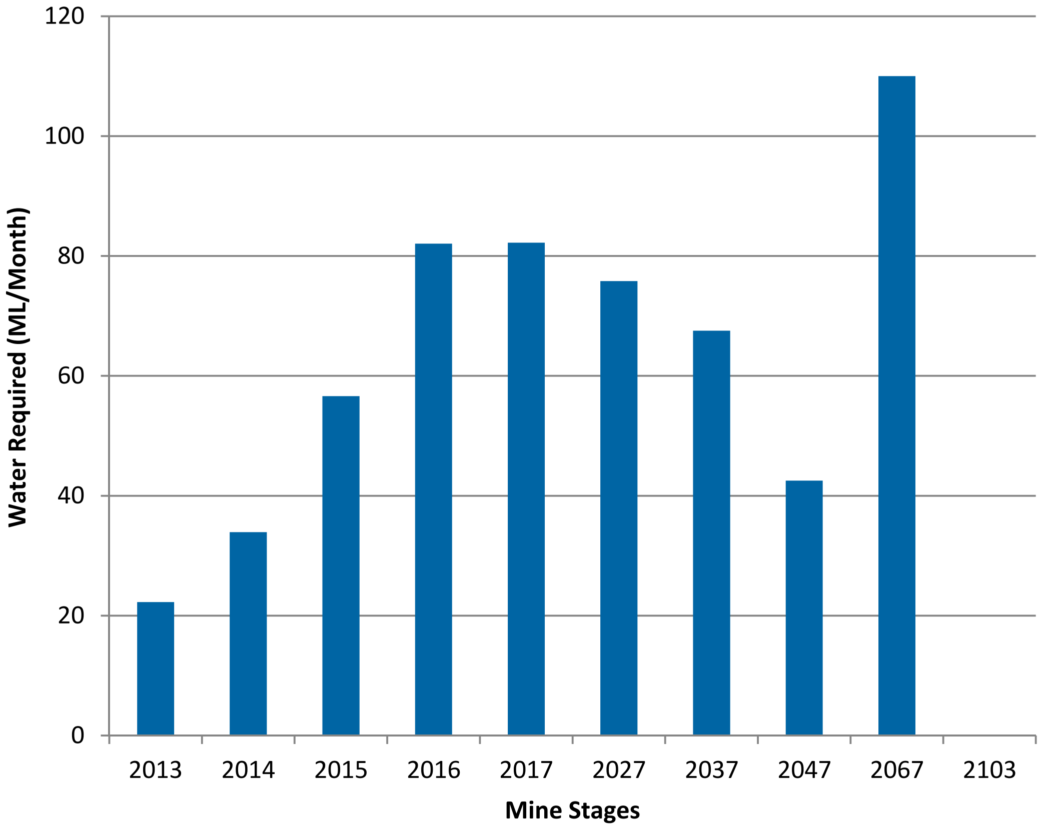
Figure 8 Average monthly volume of water required for dust suppression on haul roads



3.3.3 Active mining areas

It is assumed that dust suppression is required on 30% of the active mining areas[4]. The active mining areas for various mine stages are provided in table 3. It is assumed that water for dust suppression is required for whole year, with exception of the average 33 rain days as previously mentioned. The historical climatic records (1890-2010) of the project site show that average daily evaporation is 5.15 mm. It has been assumed that a water depth 10% greater than the long term daily evaporation (1890-2010) is required for the dust suppression of all mine stages. The volumes of water required for the dust suppression in active pit areas for all mining stages is given in Figure 9.

Figure 9 Average monthly volume of water required for dust suppression of the active ming areas



[4] % provided by Adani

3.3.4 Process water requirements

Water demand for the washplant is assumed to be 125 L/ROMt and it has been assumed that 30% of the process water is available for reuse with the remaining lost due to evaporation, or being 'locked' in the tailings[5]. Water usage for coal production is linked to the 'wash plant feed volumes' mentioned in the Runge (2011) report, with no water required for coal washing until 2018 (the first five mine stages: 2013, 2014, 2015, 2016 and 2017). In Table 10 wash plant feed volumes and water usages for each of the 10 stages are provided.

Table 10 Process water requirements*

Stages	CHPP feed (tonnes)	Total CHPP process water usage (ML/month)
2013	0	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0
2027	6,139,405	64
2037	6,072,350	63
2047	8,992,250	94
2067	15,787,923	164
2103	0	

3.3.5 Potable water

The following assumptions have been made regarding the potable water usage:

- Net potable usage at the worker accommodation village: 350 litres per person per day
- Net usage at the mine (open cut pits): 40 litres per person per day
- Net usage at the underground mine: 100 litres per person per day
- Net usage at the mine (construction): 40 litres per person per day

Table 11 shows the expected number of people during the 10 mine stages at the open cut pits, underground workings, for construction and at the camp. In the same table volumes potable water are also provided. Note that potable water would normally be sourced from a 'clean' water source, in this case groundwater (bore) or from an external water source. At this stage, as the scope of the PWB is to provide information on potential surplus or shortages of water at the mine site potable water has been included as a water usage only without any regard of the source.

[5] Assumptions provided by Adani

Table 11 Potable water demands

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Worker Accommodation Village Water Demand (ML/Month)										
Workforce	393	1,060	1,224	1,571	1,457	1,305	1,253	1,252	1,063	237
Water Demand	4.2	11.32	13.07	16.77	15.55	13.93	13.38	13.37	11.35	3
Open cut Pits Mine Water Demand (ML/Month)										
Workforce	143	263	329	545	595	811	843	782	948	237
Water Demand	0.2	0.3	0.4	0.7	0.7	1	1	1	1.2	0.3
Construction Water Demand (ML/Month)										
Workforce	250	700	700	700	500	0	0	0	0	0
Water Demand	0.3	0.9	0.9	0.9	0.6	0	0	0	0	0
Underground Mine Water Demand (ML/Month)										
Workforce	0	97	195	326	362	494	410	470	115	0
Water Demand	0	0.3	0.6	1	1.1	1.5	1.3	1.4	0.4	0
Total Potable Water Demand (ML/Month)										
Water Demand	4.7	12.8	14.9	19.3	18	16.4	15.7	15.8	12.9	2.8

3.3.6 Water required for underground mining operations

Adani has provided the volume of water required for the various underground mine operations for the mine stages of the mine plan. Table 12 provides the volumes assumed required for the underground mining operations. The provided volumes include water requirements for machinery, spray system on conveyors and roof bolting.

Table 12 Volume of water required for underground mining operations (ML/month)

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Water Required	40.4	40.4	95.5	95.5	114.4	114.4	114.4	114.4	114.4	0

3.3.7 Water requirements for construction

The volume of water required for construction provided in Table 13 provide the volumes required for construction activities.

Table 13 Volume of water required for construction (ML/month)[6]

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Water Required	41.7	83.3	83.3	166.7	166.7	0	0	0	0	0

3.3.8 Water requirements for vehicle washing

GHD has consulted the Runge (2011) report for the type and numbers of vehicles and equipment during each mine stage over the mine life. Based on a combination of GHD's experience and information provided by the Australian Car Washing Association and Adani the washing frequency and the volumes required for each wash per vehicle has been identified. Table 14 provides a summary of water demands for vehicle washing. Total volume of water required for washing vehicles varies from 0.11 ML/month in 2013 to 3.74 ML/month in 2067.

Table 14 Volume of water required (ML/month) for washing vehicles

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Water Required for Light Vehicles - Washing Frequency (Daily)										
Light Vehicles	0	123	123	123	135	135	135	135	135	0
Water Required	0	1.12	1.12	1.12	1.23	1.23	1.23	1.23	1.23	0
Water Required for Buses (Light and Large) - Washing Frequency (Daily)										
Vehicles (Light and Large)	0	18	18	18	18	18	18	18	18	0
Water Required	0	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0
Water Required for Minor and Major Equipment - Washing Frequency (Monthly)										
Minor and Major Equipment	1	10	24	32	44	76	71	71	99	0
Water Required	0.01	0.11	0.26	0.35	0.48	0.82	0.77	0.77	1.07	0
Water Required for Minor and Major Equipment - Washing Frequency (Quarterly)										
Minor and Major Equipment	25	64	102	124	134	178	196	158	240	0
Water Required	0.09	0.23	0.37	0.45	0.48	0.64	0.71	0.57	0.86	0
Water Required for Minor and Major Equipment - Washing Frequency (Six Monthly)										
Minor and Major Equipment	2	4	6	8	9	11	13	11	16	0
Water Required	0	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0
Water Required for Minor and Major Equipment - Washing Frequency (Yearly)										
Minor and Major Equipment	2	40	42	45	48	51	58	57	58	0
Water Required	0	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0
Total Water Usage (ML/month)	**0.11**	**2.00**	**2.29**	**2.46**	**2.74**	**3.25**	**3.27**	**3.13**	**3.74**	**0**

[6] Volumes provided by Adani

3.3.9 Seepage from MAW dams

A steady constant seepage loss of 5% of the total water stored in the proposed dams has been assumed as dam designs have not been finalised. In reality seepage losses will vary over time, depending largely on water depth in the storages, and depth of the sediment layer at the bottom of the storages. The negative environmental effects of seepage are a product of water quality which is largely unknown at this stage but will generally be minimised as groundwater will be drawn towards the mining area for the duration of mining. During detailed design of the dams there may be a requirement for lining to reduce the potential seepage.

In future design stages seepage acceptability of seepage losses will need to be further investigated as part of the dam designs and acceptability from a regulatory point of view.

3.3.10 Water demands for rehabilitation

As part of the rehabilitation process newly planted vegetation will require irrigation in the first year after planting in order to achieve required survival rates. Based on a report from Greening Australia (2000) a density of 2,500 plants per ha is required in arid zones. The Government of South Australia, Department of Natural Resources[7] states that:

- watering is best done only in the first year after planting
- in the first year plants should be watered at least once or twice
- a volume of 5 litres per plant a watering event is optimal.

It has been assumed that watering will take place twice in the first year after planting. Therefore water demands for rehabilitation are 25,000 L/ha for the first year of rehabilitation only. In Table 15 the water demands for rehabilitation are provided.

Table 15 Volume of water required for rehabilitation (ML/month)

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Rehabilitation Area (Ha)	0	0	0	0	0	333	412	108	216	0
Water Demand (ML/month)	0	0	0	0	0	1.4	1.7	0.5	0.9	0

3.3.11 Water demands for conveyors

Water demand for the conveyors is provided in Table 16.

Table 16 Volume of water required for conveyors (ML/month)[8]

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Water Demand (ML/month)	0	2.4	5.1	95.1	103.8	250.7	253.3	254.4	266.3	0

[7] http://www.nynrm.sa.gov.au/LandBiodiversity/Protectingbiodiversity/Tipsonwateringyourrevegetation.aspx
[8] Numbers provided by Adani

3.4 Sediment basins

The preliminary assessment of the performance of conventional stormwater treatment measures has been undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 5.1 (eWater, 2012) software, which represents the currently accepted industry norm for such assessments. eWater describes the functionality and use of the software as follows:

"As an aid to decision-making, MUSIC predicts the performance of stormwater quality management systems. It is intended to help organisations plan and design (at a conceptual level) appropriate urban stormwater management systems for their catchments"
(Source: www.toolkit.net.au/music).

The treatment of runoff from spoil areas is based on the assumption that the primary pollutant entrained in such runoff will be sediment. Based on past experience with similar projects and preliminary indications from site geochemical investigations, it is considered that runoff from the spoil areas will not be otherwise contaminated. Any soils or materials that are found to cause acid or saline runoff will be appropriately managed through other means such as not locating AMD-causing wastes on the outside of stockpiles. This will minimise AMD or highly saline inputs to the sedimentation basins. Volume 4 Appendix V Acid Mine Drainage indicates that AMD-producing soils are unlikely, however if required the sedimentation basins may be treated with lime. If the proportion of contaminated material is small, the preferred management option would be by storing it within the waste heap and away from the surface or batters or removed to alternative treatment and/or disposal.

3.4.1 Methodology

Catchments representing spoil areas were derived from the mine plan. Each catchment has been conceptually modelled as part of the water quality assessment process using the MUSIC software package. Based on a historical rainfall record, the software simulates the generation of runoff and associated pollutants from the catchments and quantifies the subsequent performance of the proposed sedimentation basins. This approach was selected over the approach outlined in the Best Practice Erosion and Sediment Control Guideline (International Erosion Control Association Australasia, 2008) as it entails an analysis of rainfall, runoff, evaporation, and treatment processes over an extended period of real-world conditions.

Further assessment of the need for a Design Storage Allowance (DSA) was undertaken in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012). Preliminary spillway design, guided by design criteria derived from this manual, is based on Rational Method calculations for the relevant design storm event.

All source and treatment nodes are modelled according to the recommendations of the MUSIC Modelling Guidelines (Water by Design, 2010) where possible, with supplementary data obtained from the Draft MUSIC Modelling Guidelines for New South Wales (BMT WBM Pty Ltd, 2010). Hazard assessments of the design sedimentation basins indicated that none would be regulated structures, as calculated in Appendix B.

3.4.2 Water quality objectives

The Environmental Protection Policy (Water) 2009 outlines the establishment of EVs and WQOs for waters throughout QLD. Waters near the Project Area are not listed within Schedule 1 of the Policy. Draft EVs and WQOs are proposed in the Burdekin Water Quality Improvement Plan (Dight, 2009) consistent with the Queensland Water Quality Guidelines (DERM, 2009) (QWQG) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) (ANZECC) however none of these contain a guideline for suspended solids in ‘upland streams’ in the Central Coast region. In the absence of WQOs, Section 14 of the Carmichael Coal Mine and Rail Study - Mine Surface Water Quality report outlines the draft WQOs from Dight (2009) and the results of monitoring undertaken to date in the Carmichael River. However, further monitoring would be required to derive statistically representative baseline values for the establishment of local concentration-based WQOs.

The Urban Stormwater Quality Planning Guidelines (DERM, 2010) (USQPG) were prepared to support State Planning Policy 04/10 Healthy Waters. These Guidelines contain load-based reduction targets for key pollutants, including total suspended sediment. While primarily focused on urban development, this guideline is considered suitable for the purpose of preliminary basin sizing with a view to protecting the downstream environment from sediment. The USQPG load-based targets were set such that compliance would contribute to the protection and achievement of the EVs and WQOs throughout QLD. The establishment of load-based objectives is supported by the ANZECC guidelines, wherein the importance of considering loads rather than concentrations is emphasised for certain stressors including suspended particulates where toxic effects are not the primary cause of environmental harm. Compliance with these targets will help to minimise adverse impacts on the downstream environment that would otherwise result from an increased rate and depth of sediment and the smothering of organisms. Table 17 below outlines the specified load reduction targets for QLD’s “Western Districts” (Figure 2.5 of the USQPG).

Table 17 Water quality objectives

Pollutant	Minimum reduction in mean annual loads from unmitigated development (%)
Total suspended solids (TSS)	85
Total phosphorus (TP)	70
Total nitrogen (TN)	45
Gross pollutants > 5mm	90

For the purposes of this modelling, sediment basins will be sized to meet and exceed the load reduction target for TSS. Based on the expected pollutant constituents of spoil area runoff, untreated runoff is considered relatively “clean” with respect to TP and TN and as such it is generally impractical to treat for these pollutants to the level specified.

3.4.3 MUSIC soil parameters and pollutant generation

As the spoil areas defined in the mine plan can be considered homogenous in terms of their general surface and soil characteristics, a single set of soil and pollutant export parameters were applied. Soil parameters were assumed to be equivalent to those for a typical commercial or industrial area as outlined in the MUSIC Modelling Guidelines (refer to Table 18 below). Pollutant generation parameters (refer to Table 19) were set according to those recommended for an "unsealed road" and "eroding gullies" as defined in the Draft MUSIC Modelling Guidelines for New South Wales. In the absence of any detailed data for the calibration of runoff and pollutant export, these values were adopted as broadly representative of the expected characteristics of the non-rehabilitated spoil areas. As recommended by the MUSIC User Manual, the serial correlation coefficient was left as the default value (zero) in all cases.

Table 18 Soil and runoff parameters

Parameter	Adopted Value
Rainfall threshold (mm)	1
Soil storage capacity (mm)	80
Initial storage (% capacity)	10
Field capacity (mm)	18
Infiltration capacity coefficient a	243
Infiltration capacity coefficient b	0.6
Initial depth (mm)	50
Daily recharge rate (%)	0
Daily baseflow rate (%)	31
Daily deep seepage rate (%)	0

Table 19 Pollutant generation parameters

Parameter	Concentration (Log10[mg/L])	
	Mean	Std. Dev.
TSS base flow	1.20	0.17
TSS storm flow	3.0	0.32
TP base flow	-0.85	0.19
TP storm flow	-0.30	0.25
TN base flow	0.11	0.12
TN storm flow	0.34	0.19

3.4.4 MUSIC key assumptions

The modelling presented in this section is based on the following key assumptions.

Runoff from each spoil area and its subsequent equivalent rehabilitation will be directed via gravity to an individual sediment basin located within each spoil area. Locations of the sediment basins are presented in the maps in Appendix A. No runoff from external catchments or other areas of the site will enter the sediment basins. Spoil and rehabilitation areas are assumed to be 100% pervious, given that no compaction will be undertaken.

When spoil areas are rehabilitated in the later mine stages, the associated sediment basins will remain operational for a nominal minimum period of 10 years until vegetation cover is sufficient to mimic the pre-existing natural conditions.

For the purposes of preliminary storage volume assessment and PWB, each sediment basin is assumed rectilinear with a length to width ratio of 3:1, and a broad-crested weir as the sole outlet.

3.4.5 MUSIC hydrology

Historical climate data used for this assessment was obtained from the Bureau of Meteorology for the Twin Hills weather station (see table 19 below). This weather station is located approximately 60 km to the east of the site, and is the nearest available site to offer 6-minute rainfall pluviograph data. Accordingly, the MUSIC model utilises six-minute rainfall time steps, while monthly averages were calculated for evapotranspiration (see Table 21 below).

Table 20 Rainfall data – Twin Hills 36047

Date Range	Mean Annual Rainfall (mm)	Mean Annual Evapotranspiration (mm)
Dec 1971 – Dec 1980	580	1949

Table 21 Calculated monthly average evapotranspiration

Month	Monthly Average Evapotranspiration (mm)
January	205.3
February	150.2
March	155.7
April	141.9
May	107.3
June	82.9
July	93.1
August	131.2
September	183.6
October	205.6
November	248.4
December	238.4

The MUSIC model features individual source nodes to represent each spoil area. “Generic” source nodes were utilised, with soil, rainfall, and pollutant parameters defined as per Table 18 and Table 19. A summary of the remaining source node parameters is included in Table 22, along with the mine stage at which the area appears and the name of the associated sediment basin.

Table 22 Spoil area catchments - source nodes

Stage	Year	Basin/Node ID	Area (Ha)
I	2013	N1	840
II	2014	N1	840
II	2014	N2	724
III	2015	N1	840
III	2015	N2	724
III	2015	N3	1285
IV	2016	N1	840
IV	2016	N2	724
IV	2016	N3	1285
IV	2016	N4	530
V & VI	2017&2027	N1	840
V & VI	2017&2027	N2	724
V & VI	2017&2027	N3	1285
V & VI	2017&2027	N4	530
V & VI	2017&2027	N5	317
VII	2037	N1	840
VII	2037	N2	724
VII	2037	N3	1285
VII	2037	N4	530
VII	2037	N5	317
VII	2037	N6	458
VII	2037	N7	515
VII	2037	S2	464
VII	2037	S3	450
VIII	2047	N2	724
VIII	2047	N5	317
VIII	2047	N6	458
VIII	2047	N7	515
VIII	2047	S2	464
VIII	2047	S3	450
IX	2067	N2	724
IX	2067	N6	458
IX	2067	N7	515
IX	2067	N8	400
V	2067	S1	914
IX	2067	S2	464
IX	2067	S3	450
IX	2067	S4	488
IX	2067	S5	695

3.4.6 Sediment basin characteristics

As discussed above, sediment basins should be constructed prior to the commencement of operations within the corresponding spoil areas to treat stormwater runoff from these areas as well as the rehabilitation areas. The location of a sediment basin at the low point of the spoil area has been selected such that the basin will discharge to either an adjacent diversion drain or a creek as indicated on the maps in Appendix A. The basins will accept gravity runoff from the contributing area, and local diversion drains will be constructed to ensure that no external catchment runoff is captured. Each basin will have a total pool depth of 2 m, consisting of 1 m depth for sediment to settle and 1 m for the accumulation of captured sediment. For the purposes of this preliminary volumetric sizing the basins are assumed to be broadly rectangular, with a length to width ratio of three to one. Outflows will be controlled by a weir, with bunds and embankments established to provide 0.5 m freeboard above the spillway design flow rate water surface level. Overflows will be conveyed through a trunk drainage channel within the mine site and eventually discharge to the nearest downstream creek diversion or waterway, whichever is closest. For the purposes of MUSIC modelling, the sediment storage volume has been excluded from the permanent pool volume. The details of each basin are outlined below in Table 23.

Table 23 Sediment basin parameters

Basin	Surface Area x 1000 m2	Extended Detention Depth (m)	Permanent Pool Volume x 1000 m3	Basin Width (m)	Basin Length (m)
N1	251	0.5	251	289	868
N2	217	0.5	217	269	807
N3	385	0.5	385	358	1075
N4	158	0.5	158	229	688
N5	95	0.5	95	178	534
N6	137	0.5	137	214	641
N7	154	0.5	154	227	680
N8	119	0.5	119	199	597
S1	274	0.5	274	302	907
S2	139	0.5	139	215	646
S3	135	0.5	135	212	636
S4	146	0.5	146	221	662
S5	208	0.5	208	263	790

3.4.7 Music results

Based on the modelling outlined above, the overall treatment performance of the proposed sediment basins at each stage was assessed against the relevant design objective (i.e. 85% removal of mean annual TSS load). Results from the modelling are presented in Table 24.

Table 24 Music modelling results

Stage	Source TSS Load	Residual TSS Load	TSS Reduction Required	TSS Reduction Achieved
	x 106 kg/yr	x 106 kg/yr	%	%
I	2.91	0.255	85	91.2
II	5.47	0.466	85	91.5
III	10.2	0.888	85	91.3
IV	12.1	1.06	85	91.2
V,VI	13.2	1.17	85	91.1
VII	21.7	2.32	85	89.3
VII	12.2	1.43	85	88.2
IX	19.9	2.11	85	89.4

The results show that the proposed sediment basins are sufficiently sized to meet and exceed the load-based reduction targets for TSS adopted for the purpose of this report. Revised modelling will be necessary if runoff and pollutant generation characteristics of the spoil areas are later found to differ significantly from assumptions.

To assess compliance with any future-derived concentration-based WQOs, careful statistical analysis of MUSIC modelling results will be necessary to ensure a meaningful basis for comparison. Such analysis should consider the site conditions preceding and during monitoring, including rainfall and stream flow, and also appropriately consider the differences between discharge and receiving environment pollutant concentrations.

A number of sediment basins are proposed to treat surface runoff from the spoil areas throughout the operational period of the mine and continuing throughout the initial periods of rehabilitation. For these sediment basins, hazard assessment is required in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM, 2012). More detail about the hazard assessment and DSA calculations are provided in Appendix C.

4. Preliminary water balance results

The results of the PWB analysis are presented in this section. For each mine stage, the results are presented in terms of net monthly water balance (inflow – outflow) showing either a deficit or a surplus at the end of each month. Where possible, for consecutive PWB stages, monthly excess or deficit volumes have been analysed cumulatively. This has largely to do with the limitations of the available mine plan that include information for a limited number of years of the mine life. No information is available on intermediate years. In order to allow for an estimation of potential controlled discharges a high level –worst case scenario - assessment has been included.

4.1 Results interpretation

The PWB assessment considers water inflows and outflows at the Carmichael Coal Mine using long term historical monthly data from 1890 to 2010 over the 10 agreed mine stages, i.e., 2013, 2014, 2015, 2016, 2017, 2027, 2037, 2047, 2067 and 2103.

The results of the water balance are reported for each month in terms of the frequency of excess or shortage of mine water that requires containment or supplementary water supply in each of the 120 years of simulation summarised by the 10, 50 and 90 percentiles. Excess water is expected to be stored in a MAW dam, while shortages indicated the need for external water supply to top up. As the stages 2013 to 2017 are consecutive, monthly PWB results are carried over in consecutive years. However, this does not apply for the other stages (2027, 2037, 2047, 2067 and 2103) where no (mine plan) data is available for intermediate years. For these stages the results as shown in Table 25, Table 26 and Table 27 do not include excess water or deficits carried over from previous months or years.

The 10th percentile represents the net volume (surplus or deficit) that according to the PWB analysis will occur for 10% of all months, while the 50th and 90th percentile show the surplus or deficit expected for respectively 50% or 90% of the months over the length of the period for which climatic data is available, i.e. 120 years (1890 – 2010). A positive value indicates the surplus that will not be exceeded in more than the stated percentile of months, whereas a negative value indicates the shortfall that will be exceeded in the stated percentile of months.

The percentiles relate to climatic circumstances, but as the PWB analysis includes other not climate related inflows, like groundwater, the climatic patterns are not reflected in the outcomes of the PWB as a linear function. The 10th percentile results are fairly constant on a monthly basis as the associated rainfall is less than evaporation. Rainfall inflows into the PWB are even for the 50th percentile analysis strongly influenced by other aspects like groundwater inflows and evaporation. Rainfall does become a significant factor for the 90th percentile as major rainfall events are included in this analysis.

The PWB assumes a 100 ML dead storage volume in the water management dams (MAW). This volume has been included in the net deficit / surplus calculations on a monthly basis. So, if there is less than 100 Ml available in the combined water management dams (MAW) it is assumed that no MAW water is available for reuse. This explains the constant values for stage 2013, 10th percentile (refer to table). The net surplus / shortage shown in Table 25, Table 26 and Table 27 considers the storage of water in different dams in various stages as given in section 4.4.

For a more rigorous definition of risk of excess or deficit the frequency of excess mine water would need to be fitted to an appropriate statistical distribution and values expressed in terms of an annual exceedance probability. However, such statistical analysis has not been carried out for this study

4.2 Preliminary water balance results

The results of the PWB analysis are presented in both tabular format (Table 25 to Table 27) and in figures (Figure 10 to Figure 19) . Both the tables and the figures show the net monthly water balance results for each of the 10 mine stages included in the PWB on a monthly basis. Results are presented on a monthly basis and are shown for the 10th, 50th and 90th percentile. Note that:

- Positive values indicate excess water is available and negative values represent shortfalls in demand which would require a supplementary water supply.
- Volumes presented from November 2013 up till October 2017 are cumulative. In case of an excess volume at the end of a month, this water is carried over as a start volume for the next month. Later stages have no 'start' volume at the beginning of the year.

Table 25 10th percentile, water balance results (ML)

Stages	2013	2014	2015	2016	2017		2027	2037	2047	2067	2103
November	-167	-231	-203	-174	-337		-571	-665	-754	-943	-3
December	-167	-188	-142	-392	-331		-490	-556	-624	-848	36
January	-167	-165	-116	-347	-282		-410	-494	-547	-772	133
February	-167	-157	-105	-352	-325		-397	-485	-481	-702	170
March	-167	-181	-107	-359	-355		-440	-516	-596	-807	54
April	-167	-199	-170	-395	-442		-516	-541	-660	-895	-3
May	-167	-207	-173	-425	-506		-499	-611	-534	-880	-3
June	-167	-194	-130	-403	-530		-422	-631	-473	-889	-3
July	-167	-215	-64	-391	-514		-374	-640	-444	-935	-3
August	-167	-213	-50	-410	-457		-358	-591	-481	-939	-3
September	-167	-213	-48	-348	-395		-320	-528	-501	-936	-3
October	-167	-211	-43	-292	-325		-377	-513	-607	-925	-3

Table 26 50th percentile, water balance results (ML)

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
November	-167	-181	-153	20	-286	-481	-534	-563	-783	161
December	-114	-96	-28	16	-212	-288	-294	-292	-489	477
January	-62	-45	46	91	-116	-149	-107	56	-229	726
February	8	51	246	206	69	112	131	579	162	840
March	-33	44	332	306	65	163	102	496	52	611
April	-61	15	369	238	25	130	-29	342	-164	267
May	-77	-63	351	126	-86	76	-141	217	-312	157
June	-70	-81	398	194	-17	148	-73	337	-257	107
July	-105	-84	455	262	-10	217	-69	361	-321	91
August	-161	-109	528	288	20	319	-71	345	-382	-1
September	-167	-170	526	247	-43	275	-152	262	-555	-3
October	-167	-165	478	161	-91	254	-161	192	-606	94

Table 27 90th percentile, water balance results (ML)

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
November	-59	-49	28	353	37	-171	-101	97	57	898
December	193	180	304	637	326	230	402	991	723	1,411
January	665	598	706	1,051	752	680	944	1,587	1,259	2,125
February	1,211	1,155	1,419	1,602	1,344	1,347	1,570	2,318	1,813	2,455
March	1,155	1,121	1,491	1,644	1,370	1,496	1,603	2,617	1,874	1,724
April	990	963	1,412	1,475	1,104	1,319	1,226	1,943	1,321	1,138
May	790	824	1,397	1,401	1,041	1,269	1,112	1,860	1,110	625
June	737	708	1,424	1,281	984	1,270	1,010	1,707	917	746
July	788	748	1,461	1,270	1,038	1,280	985	1,774	946	631
August	547	595	1,398	1,158	970	1,213	1,070	1,765	898	534
September	337	407	1,416	1,217	860	1,200	956	1,728	849	482
October	99	295	1,265	1,044	758	1,068	768	1,448	543	608

Figure 10 Stage 2013, water balance results (ML/month)

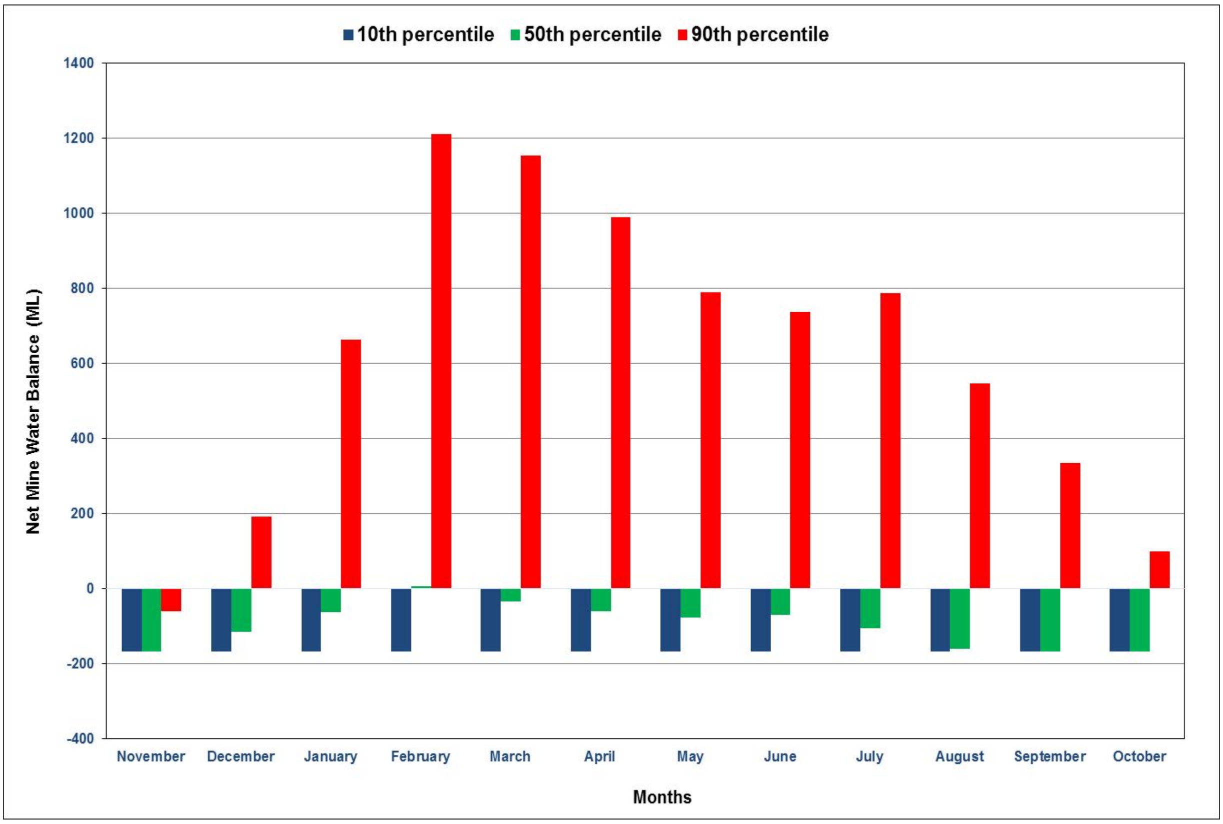


Figure 11 Stage 2014, water balance results (ML/month)

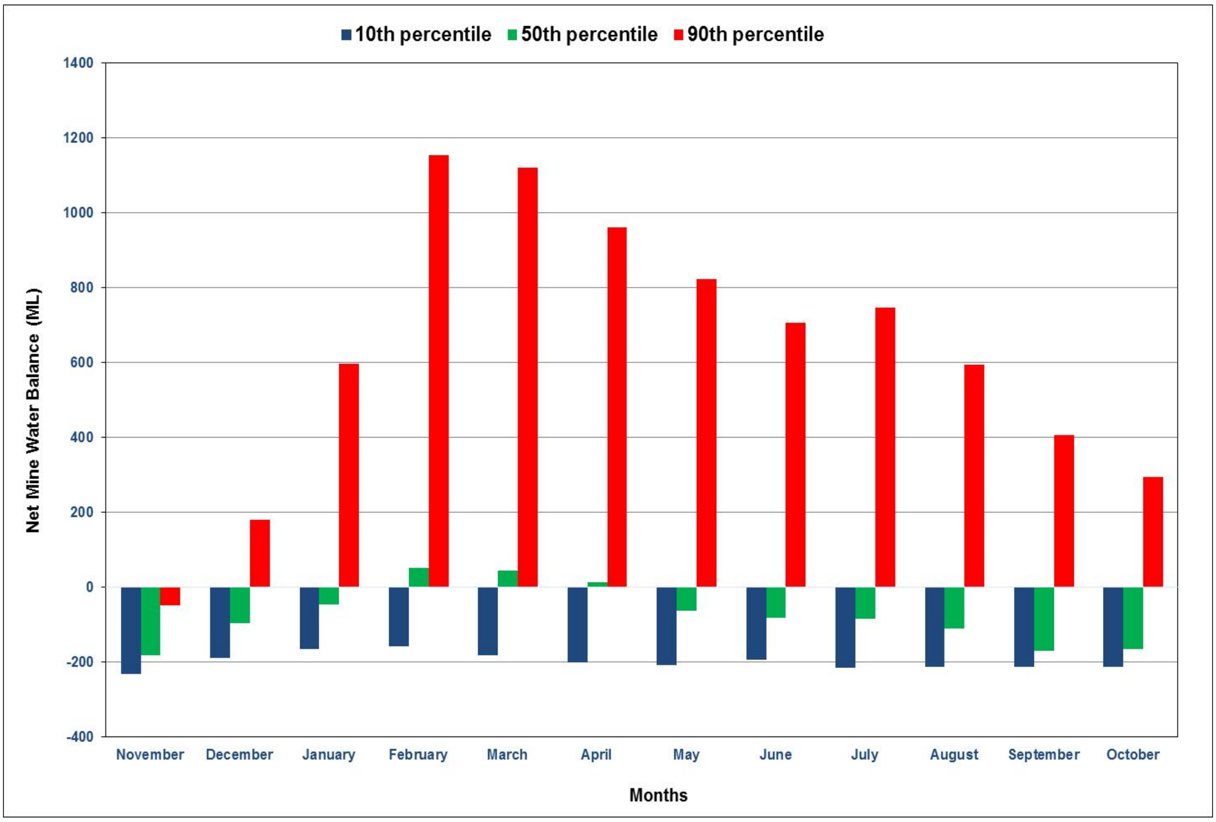


Figure 12 Stage 2015, water balance results (ML/month)

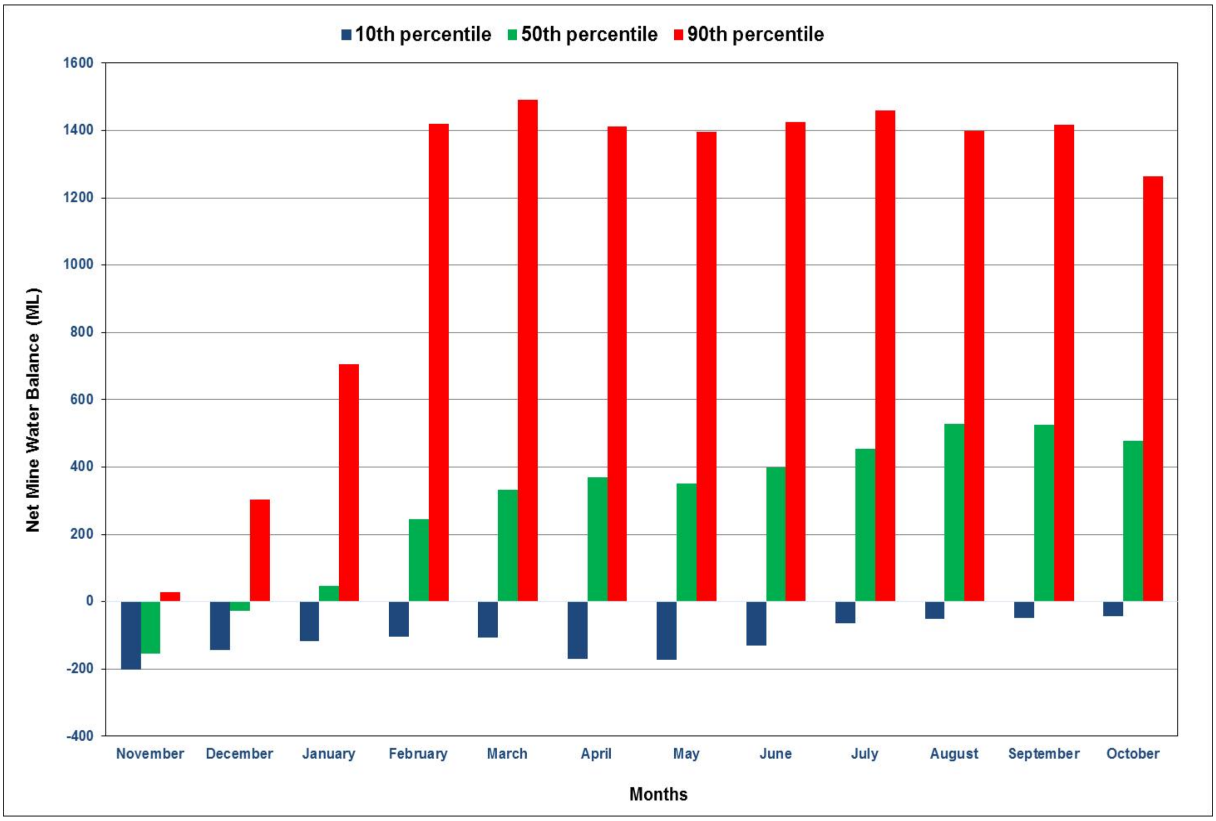


Figure 13 Stage 2016, water balance results (ML/month)

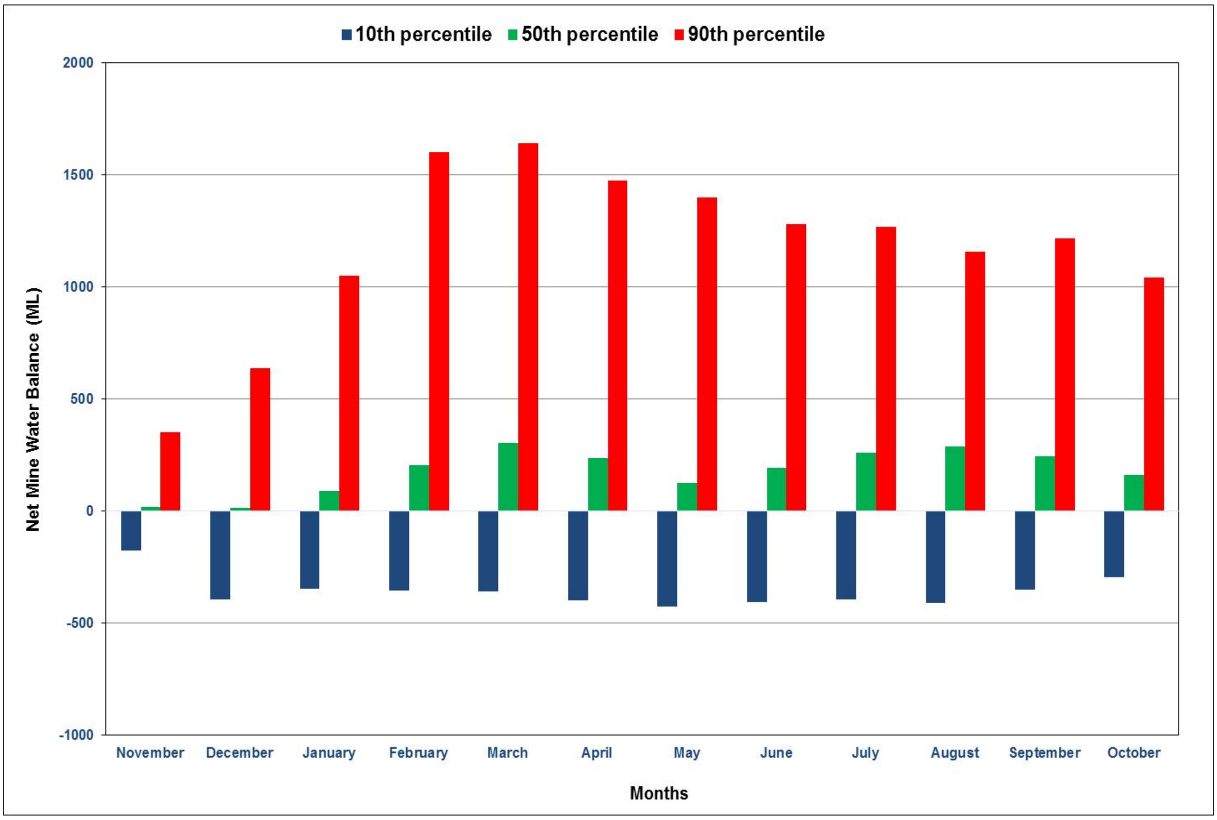


Figure 14 Stage 2017, water balance results (ML/month)

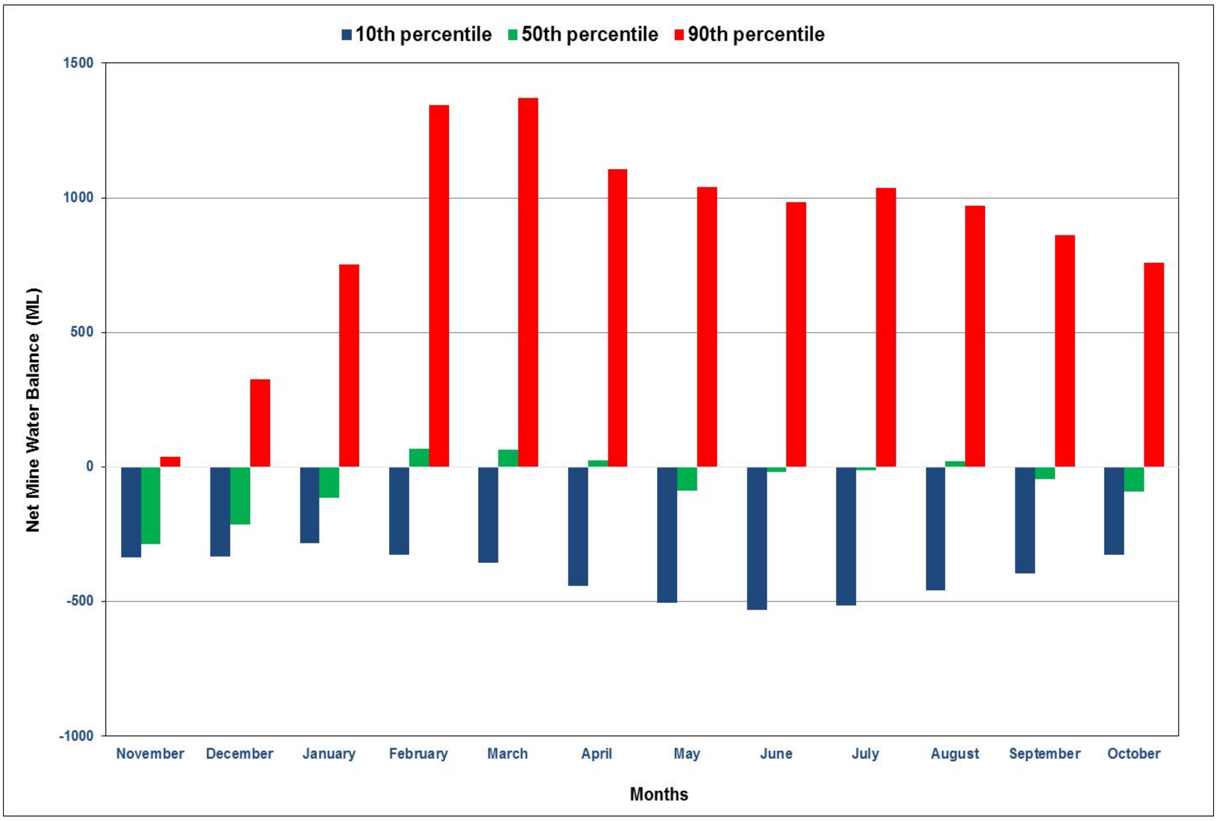


Figure 15 Stage 2027, water balance results (ML/month)

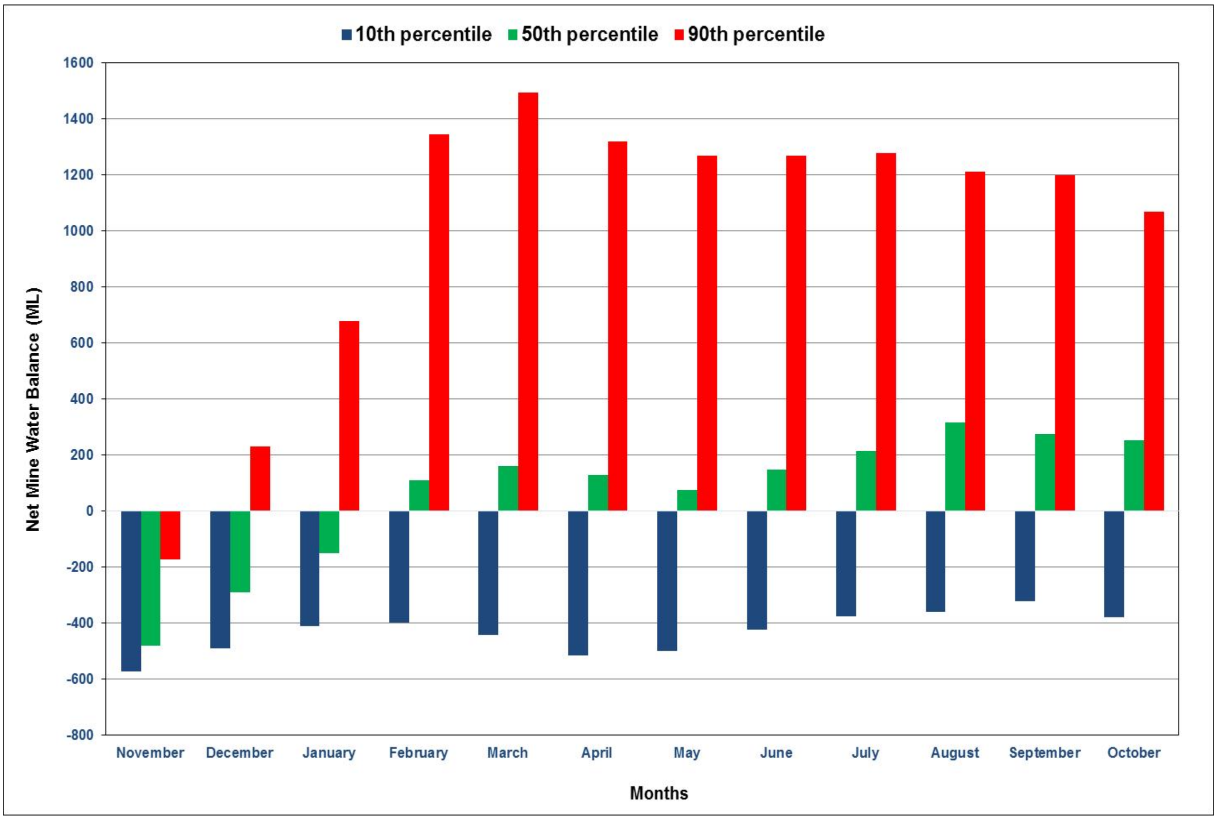


Figure 16 Stage 2037, water balance results (ML/month)

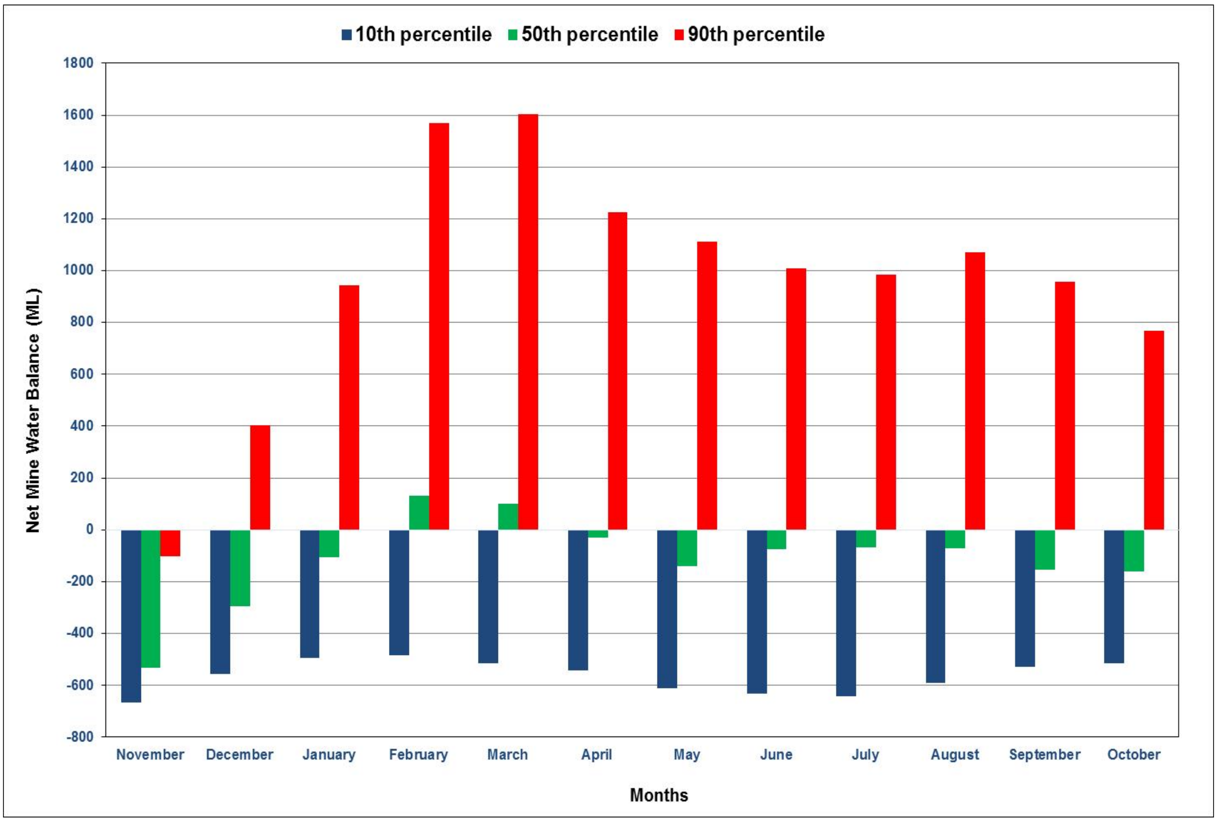


Figure 17 Stage 2047, water balance results (ML/month)

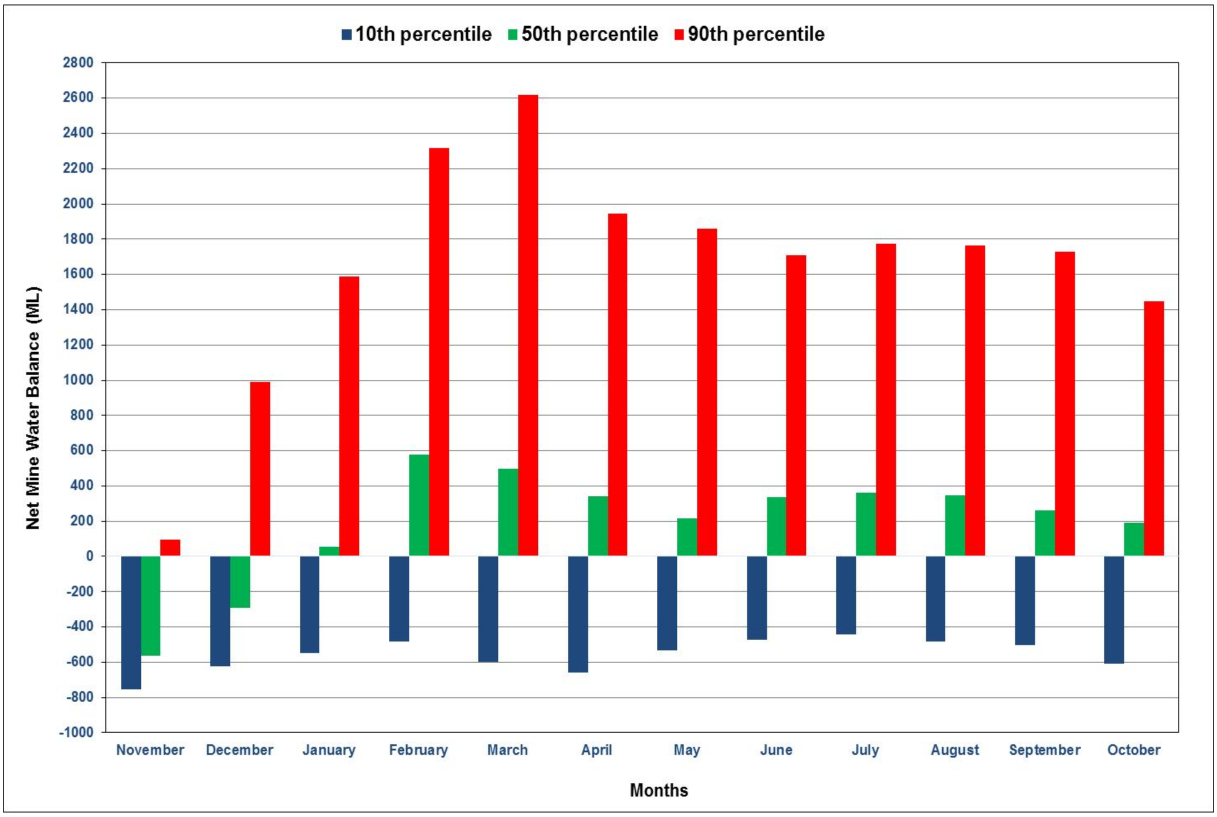


Figure 18 Stage 2067, water balance results (ML/month)

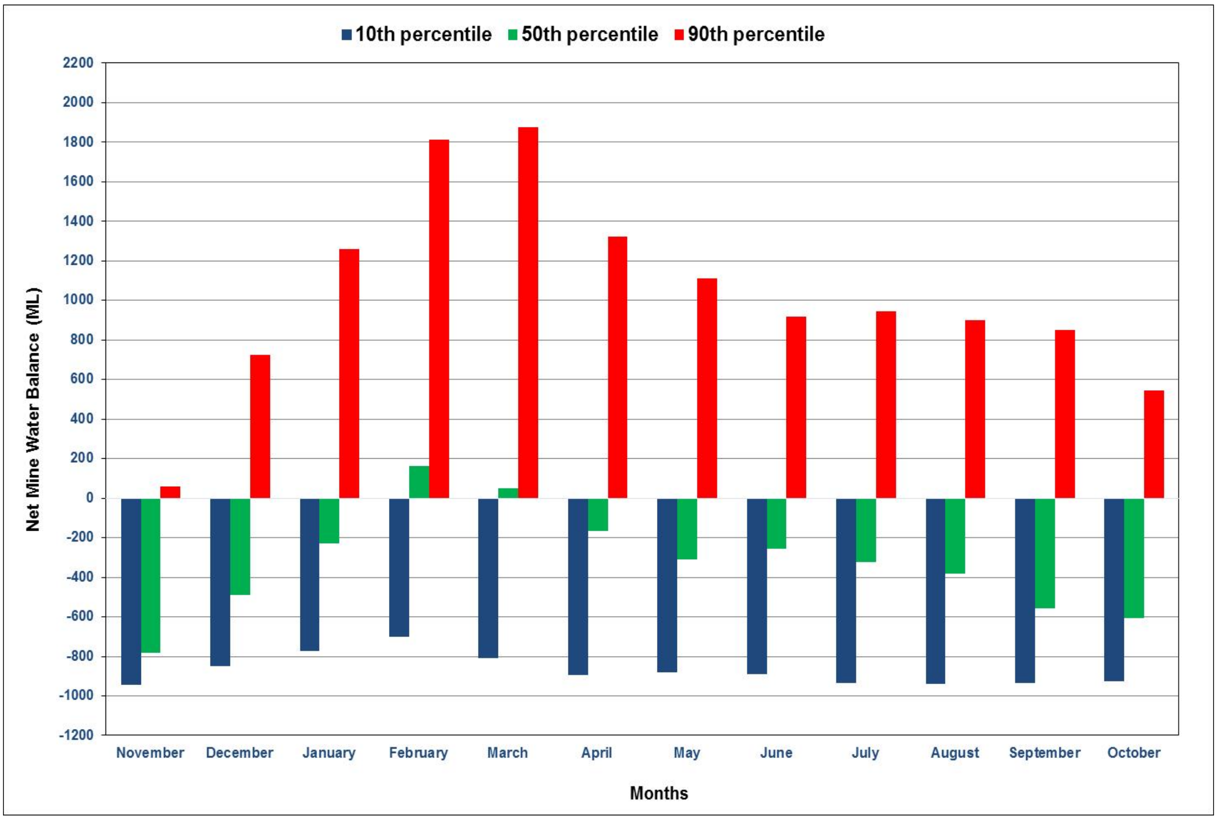
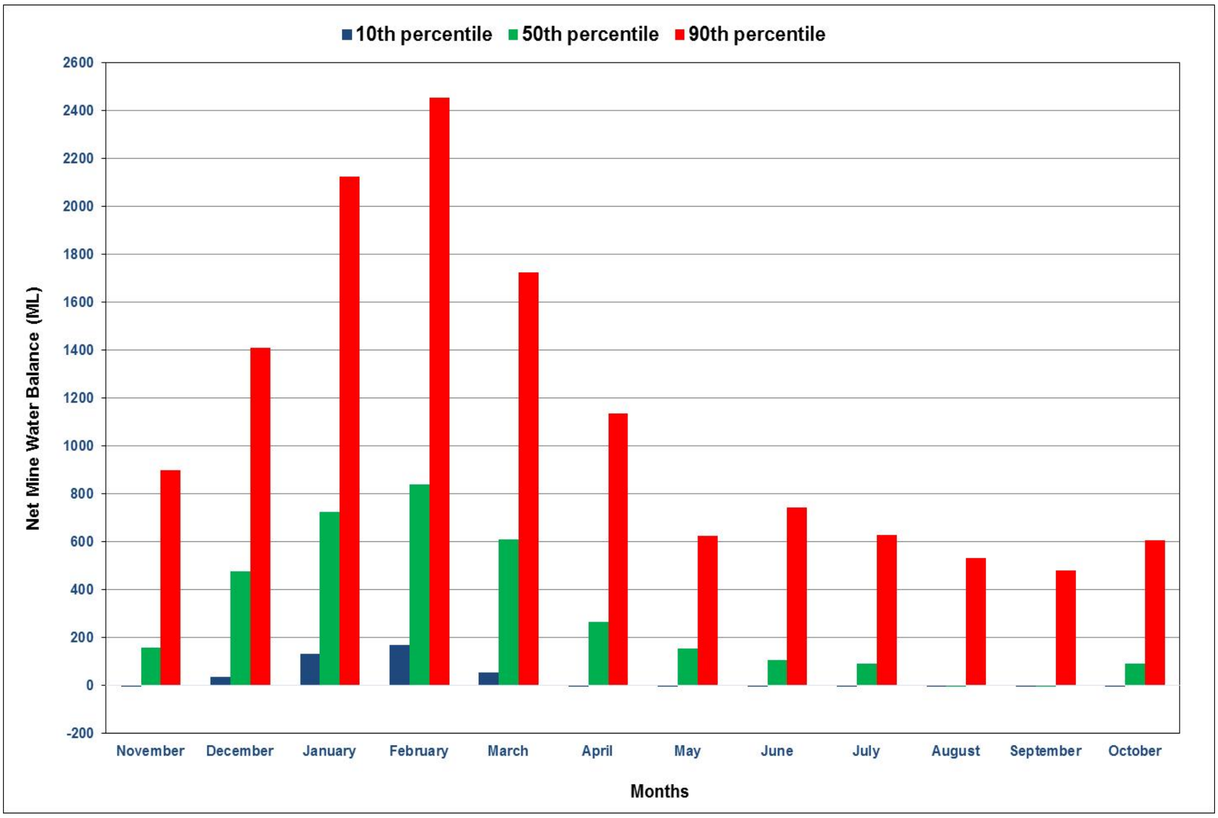


Figure 19 Stage 2103, water balance results (ML/month)



4.3 Raw water demands

As part of the PWB analysis raw water demands are estimated. It is assumed that the following flows are sourced from raw water at all times:

- potable water
- 10% of the process water for the CHPP
- All water required for the underground workings

Any deficits indicated in the PWB are assumed to be compensated by raw water as well. Table 28 shows estimated total raw water requirements on annual basis.

Table 28 Raw water requirements (ML/Annum)

Stages	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Potable Water Demand	56	154	179	232	216	197	188	190	155	34
10% of CHPP process water	0	0	0	0	0	77	76	113	197	0
Water required for underground workings	485	485	1,146	1,146	1,373	1,373	1,373	1,373	1,373	0
PWB deficit	244	226	103	0	292	590	601	454	1,906	0
Total Raw Water Demand	785	864	1,428	1,378	1,881	2,236	2,238	2,129	3,630	34

4.4 Volumes of Mine Affected Water in the water management storages and controlled releases

Within the PWB analysis volumes of Mine Affected Water in the water management dams are analysed. The water management dams (storages) are shown in Figure 2. These dams are spread over the mining area and will be active depending on the locations of the mining activities. For the analysis of volumes in these storages the active mining areas are linked to (nearby) dams. Table 29 shows which dams are active for each stage.

Table 29 Water management dams versus mine stages

	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
Dam 1				Active	Active	Active	Active	Active	Active	Active
Dam 2	Active	Active	Active	Active	Active	Active	Active	Active	Active	Active
Dam 3	Active	Active	Active	Active	Active	Active	Active	Active	Active	Active
Dam 4							Active	Active	Active	Active
Dam 5								Active	Active	Active

For each dam the average and maximum volume has been analysed using 120 years of PWB analysis for each mine stage. Table 30 shows the results. In Appendix C DSA calculations for the dams are provided.

Table 30 Average and maximum MAW volumes in the water management dams

Mine Stages		Dam 1	Dam 2	Dam 3	Dam 4	Dam 5	Total
2013	Average		274	589			863
	Maximum		404	2,352			2,756
2014	Average		336	595			931
	Maximum		429	2,392			2,821
2015	Average		405	978			1,383
	Maximum		442	2,900			3,342
2016	Average	256	399	1,064			1,719
	Maximum	389	437	3,193			4,019
2017	Average	282	426	852			1,560
	Maximum	394	477	2,935			3,806
2027	Average	288	416	1,026			1,730
	Maximum	414	473	2,944			3,831
2037	Average	308	391	844	289		1,832
	Maximum	423	439	2,789	409		4,060
2047	Average	309	322	1,217	329	358	2,535
	Maximum	431	429	3,570	434	575	5,439
2067	Average	277	278	913	330	449	2,247
	Maximum	414	408	3,314	442	615	5,193
2103	Average	240	248	301	246	355	1,390
	Maximum	386	400	430	403	574	2,193

4.5 MAW Accumulation and Controlled Discharge Requirements

As stated in in earlier sections the PWB analysis covers the first five stages, up till 2017, consecutive. Total volumes of MAW in the dams are easily extracted for these stages. However in the PWB included stages 2017 and 2027, there is a gap of 10 years in the PWB analysis. In order to develop a first conservative understanding of volumes of MAW during the life of mine a worst case scenario has been developed. The scenario assumes that the maximum MAW volume of the two mine stages is applicable for all intermediate years. In other words, for the intermediate years between stage 2017 and 2027 it has been assumed that all intermediate years (9) produce the maximum MAW volume of 2,944 ML. Table 31 shows the build-up of MAW water in the storages if this methodology is applied for all stages and dams. Note that no controlled releases from the MAW storage are included in the presented volumes in Table 31.

Table 31 Cumulative maximum volumes of MAW in the water management dams

Mine Stages	Dam 1	Dam 2	Dam 3	Dam 4	Dam 5	Total
2013		404	2,352			2,756
2014		429	2,392			2,821
2015		442	2,900			3,342
2016	389	437	3,193			4,019
2017	394	477	2,935			3,806
2027	4,559	5,242	32,381			42,182
2037	4,655	5,173	32,227	409		42,464
2047	4,744	4,816	39,269	4,771	575	54,175
2067	9,039	8,986	74,713	9,291	12,917	114,946
2103	14,884	14,675	116,428	15,888	22,103	183,978

Volumes presented in Table 31 clearly show that the build-up of MAW is the most significant in Dam 3. Primary reason for this is that stormwater from the MIA area (50% of 1,008 ha – refer to section 2.2.6) drains into this dam. Future design of the stormwater management of the MIA should aim to improve this MAW flow by reducing the area generating MAW.

The dedicated MAW storages cover a relatively large area of the mine footprint and significant storage volumes are available, with final volumes to be dictated by a detailed water balance to be undertaken as part of detailed design. Location and surface area of the MAW storages have been provided by Adani. Table 32 shows the net volumes possible in the five largest MAW storages at various design depths. Storage depths can be varied by excavating the MAW dams without the need to raise wall height.

Table 32 Net volumes available for MAW storage (ML)

Storage	Volume at 10 m storage depth (ML)	Volume at 15 m storage depth (ML)	Volume at 20 m storage depth (ML)	Volume at 25 m storage depth (ML)
1	16,696	24,756	32,626	40,310
2	17,300	25,656	33,819	41,792
3	15,962	23,662	31,176	38,507
4	17,193	25,575	33,816	41,915
5	24,820	36,878	48,704	60,301
Total volume (ML)	91,972	136,527	180,141	222,825

Note that the above volumes assume a 5 meter high dam wall. (i.e. 15 m storage depth assume 5 meter above ground and 10 meter below ground storage)

While Table 32 shows that it is theoretically possible to build large enough MAW dams to contain MAW within the proposed mine, the cumulative volumes shown in Table 31 indicate that it is desirable to have the ability to discharge MAW to the environment under controlled conditions so that MAW inventory does not build up over time. This strategy will also reduce risks associated with failure of MAW dams and very extreme weather events. Both of these hazards have a very low likelihood of occurring but significant consequence if the hazard does occur, and hence any methods to reduce risk should be considered.

.

As MAW has, higher electrical conductivity then the receiving environment (other potential contaminants can be treated in the storages), controlled releases must occur on high flow events in the receiving environment such that a high level of dilution can be provided instantaneously. This strategy is utilised in the Bowen Basin (DEHP 2012 Model Water Conditions for Coal Mines in the Fitzroy Basin) and has also been applied in conditions for the Alpha Coal Mine (Alpha 2012)Maximum allowable controlled releases of MAW to the environment are basically depended on water quality aspects (chiefly electrical conductivity) of both of the MAW and of the receiving water and on the volume of water in the receiving waterways. Only limited information is available on the electrical conductivity of MAW for the Carmichael Coal project; however an analysis of flow volumes in the Carmichael River and Belyando River indicates that both rivers have sufficient high flow events to provide a level of dilution equivalent to that required in conditions for the Alpha Coal Project (Alpha 2012). This analysis is available in Appendix D.

The controlled releases volume analysis allows for a conservative estimate based on:

- Catchment analysis based on the Quantile Regression Technique
- Alpha Coal Mine discharge conditions, with no discharges when the in-channel flow of the receiving waterway is less than 5 m^3/s (Alpha 2012)

In summary there is the potential to release an estimated average of 12,000 ML annually into the Carmichael River and 96,000 ML annually to the Belyando River under these conditions. Potential average discharges are naturally highest during the wet season.

In order to prevent build-up of MAW in MAW dams, a conservative assumption is that in each of the modelling years, water that builds up over the year would need to be released, that is, a strategy of maintaining the MAW dams at close to empty is adopted. In reality, this is an overly conservative assumption as some water inventory will in fact be maintained on the site to buffer against dry years.

However, adopting this worst case scenario in relation to the need to discharge MAW, Table 30 shows the MAW build up in each of the modelled years. The maximum produced volume of MAW relates to Dam 3 for stage 2047 and concerns 3,570 ML annually (refer to Table 30). This volume relates to approximately 30% of the, conservatively estimated, available discharge capacity (maximum discharge allowance) into the Carmichael River and approximately 4% for the Belyando River, based on the strategy of only discharging on high flows when sufficient dilution is available.

From a continuity perspective it is preferred to have a buffer of MAW in the storages to supply the CHPP during a dry spell. With an average water demand (over the 10 mine stages assessed in this PWB) of almost 7,000 ML per year this volume is potentially significant, depending on actual groundwater inflows and the reliability of the external water supply source. This strategic reserve has not been included in any of the above calculations, and hence discharge requirements are likely to be less than estimated. Further, as the water inventory on site is also depending on rainfall, in wetter years when the inventory is higher, there will be more opportunities to discharge.

Considering all the above provided information it is concluded that MAW volumes on the mine site are manageable as no excessive build-up of MAW volumes are expected and estimate required discharges are well below estimated maximum discharges that can be attenuated within the Carmichael/Belyando system.

5. Conclusion and recommendations

5.1 Conclusion

The PWB analysis shows that despite the Carmichael Coal Project being a large mine development total volumes of water are quite manageable with monthly excess or deficit volumes in general levelling out to a significant degree. Largely due to the reuse of MAW, including groundwater inflows in the open cut pits and underground workings a relatively small volume of external water supply is required.

Detailed sensitivity analysis results undertaken as part of groundwater model development for the project suggest that the predicted groundwater inflows may have an associated accuracy of + or – 50%. With groundwater being one of the more important inflows of water this uncertainty affects the certainty of the water balance significantly.

Despite the large reuse component there is a potential for large volumes of MAW to build-up in the mine water management dams, particularly if a series of wet years occurred. On an annual basis the average build-up of MAW is well within what might be able to be stored on the mine site, but as the mine will be operational for a long period MAW volumes could build-up significantly without the ability to make controlled discharges to the environment.

Estimated average annually required discharges show that controlled discharges are expected to be well within discharge limitations (based on flow volumes of the receiving environment).

The PWB concerns a first high level water balance assessment that needs detailing in any future development stages. Detailing of the (storm) water management infrastructure will allow for further refining and optimising the mine water management. A better understanding regarding water quality aspects should be developed as well.

5.2 Recommendations

The following recommendations are relevant;

- As groundwater inflows form an important input to the water balance any future updates of the groundwater model should be included in the water balance;
- Future groundwater modelling should also allow for developing a better understanding of potential seepage losses of any water storage facilities and the potential environmental consequences of these. Seepage acceptability needs to be investigated as part of the dam designs as well.
- Further iterations of the water balance should be used to optimise the storage volumes in the MAW dams;
- An external water supply of sufficient reliability needs to be established for the mine operations, especially to ensure mine operations during a dry period;
- Due to the planned long period of mine operations potential impacts of climate change on the mine operations should be assessed;
- When more groundwater quality data and geotechnical data becomes available it should be used to develop an understanding of expected water quality in the MAW storages over time and how this may affect discharge to the environment;
- As part of the future design stages a WMP will need to be developed in accordance with DEHP guidelines;

- Detail the stormwater management design for the mine site with a strong focus on minimizing areas producing MAW. In particular the area of the MIA.
- The PWB does not address the impacts of the mine operations starting at the beginning of a dry or wet period. It also does not address the consequences of a dry period on the flows in the Belyando and therefore on the availability of external water supply. The potentially significant risks of this kind should be addressed in future water balance analyses; and
- It is strongly recommended that, for further development stages, the PWB is replaced with a more detailed water balance, preferably in GoldSIM, incorporating a stochastic rainfall model to create a robust assessment of available water volumes over time and possible effects of variations in rainfall on these volumes. As this model will, as does the PWB, depend on the level of detail of the mine plan it is recommended to set up the model for the first 10 years of the mine operations for which the best level of detail will be available. This model will allow for a more detailed understanding of the water management regarding aspects like: staged construction of the MAW storages, required pump capacities and locations over time and lengths of pipelines.

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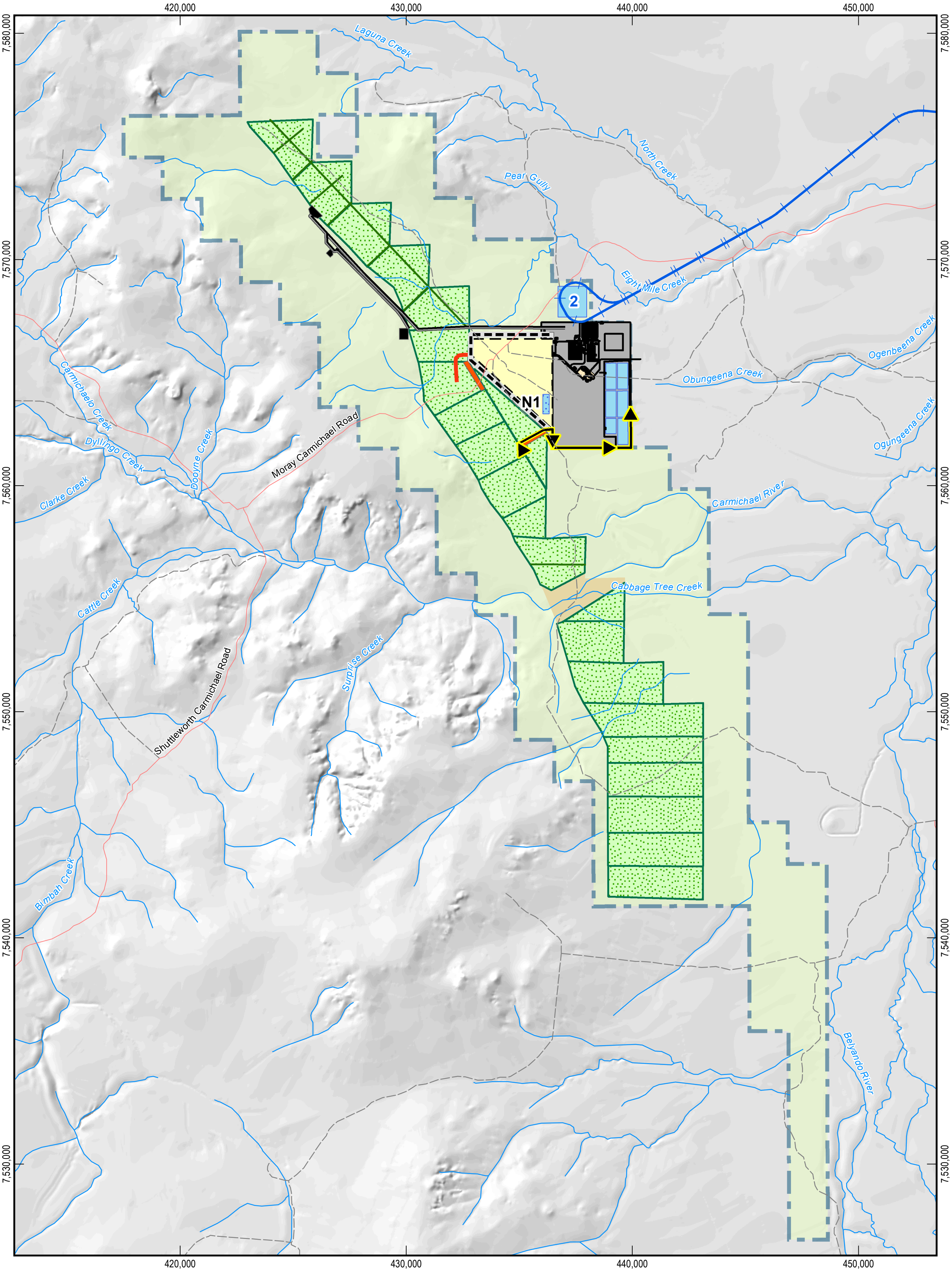
Appendices

Appendix A Mine stages, diversion drains and sediment basins



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Active Mining Area
- Out of Pit Waste Dumps
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

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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GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2013

Job Number	41-25215
Revision	A
Date	30-08-2012

Figure A1

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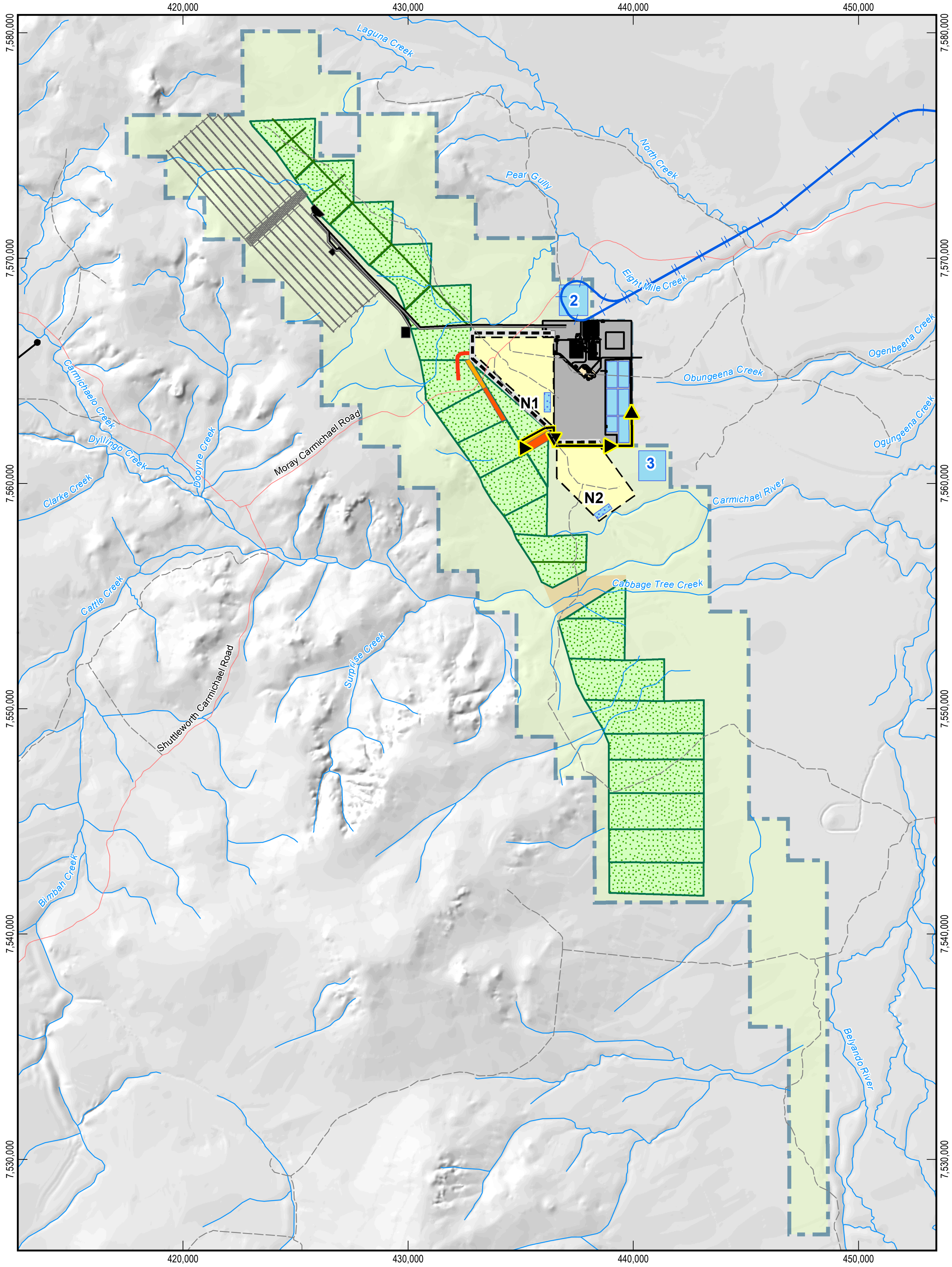

LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Levee	Disturbed Mining Area	Mine Lease Area
Watercourse	Haul Road	Water Management Dams	
Overland Conveyors	Out of Pit Waste Dumps	Sediment Basins	

1:240,000 (at A4)

0 2 4 6 8

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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Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress Plot - Year 2014

Job Number	41-25215
Revision	A
Date	30-08-2012

Figure A2

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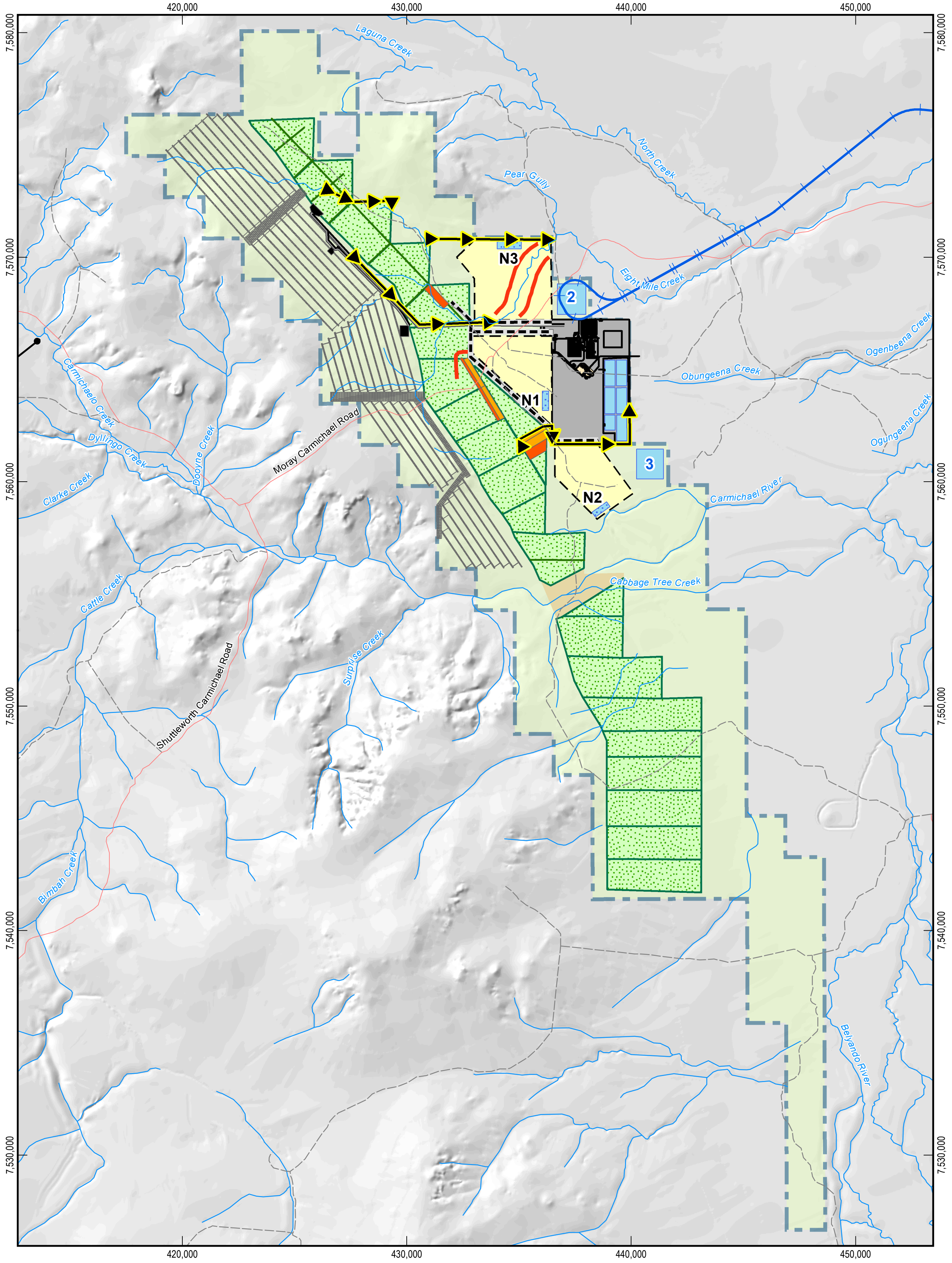

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

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0 2 4 6 8

Kilometres

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Grid: Map Grid of Australia 1994, Zone 55

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2015

Job Number	41-25215
Revision	A
Date	30-08-2012

Figure A3

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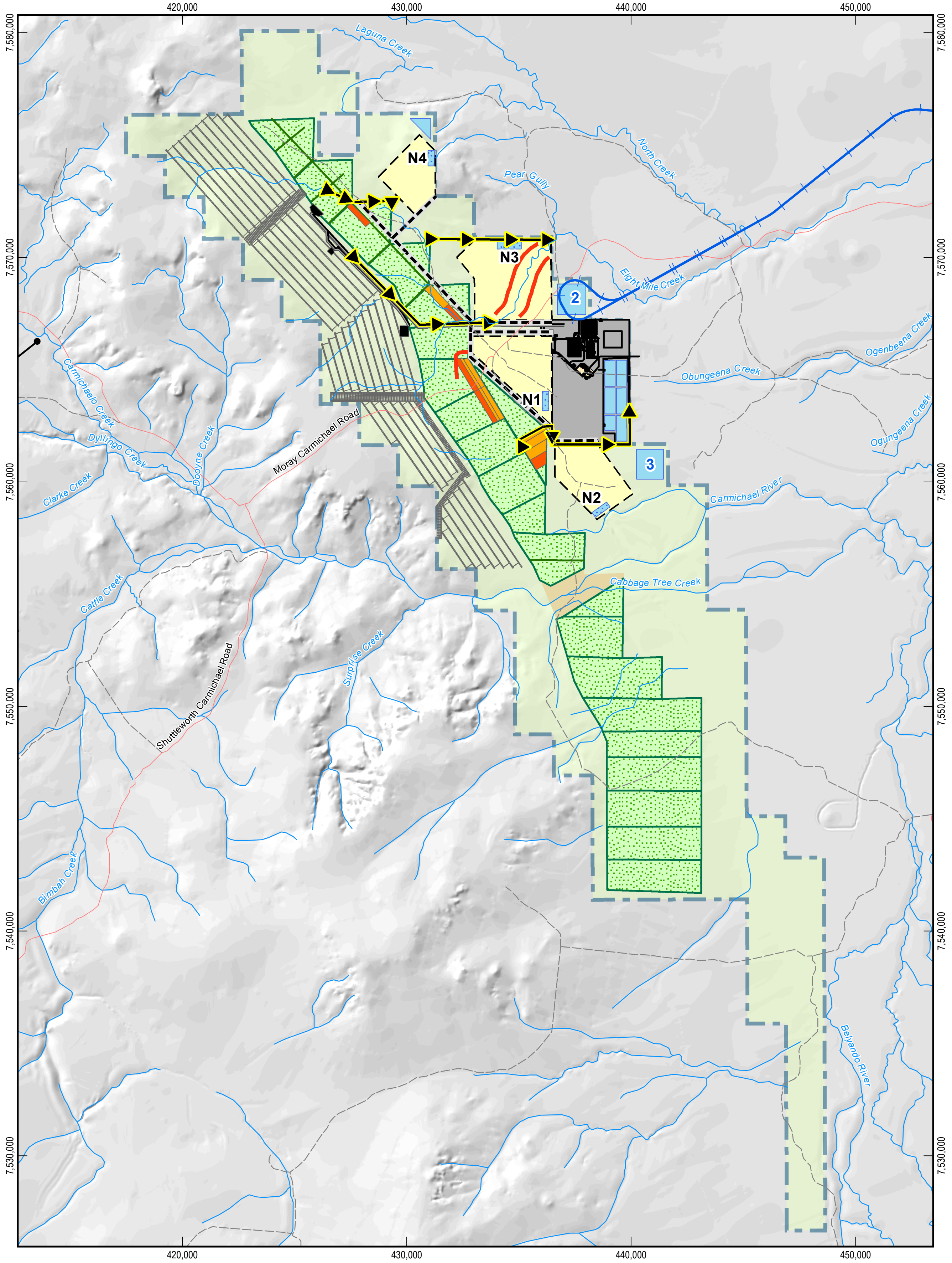

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

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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GHD adani

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Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2016

Job Number	41-25215
Revision	A
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Figure A4

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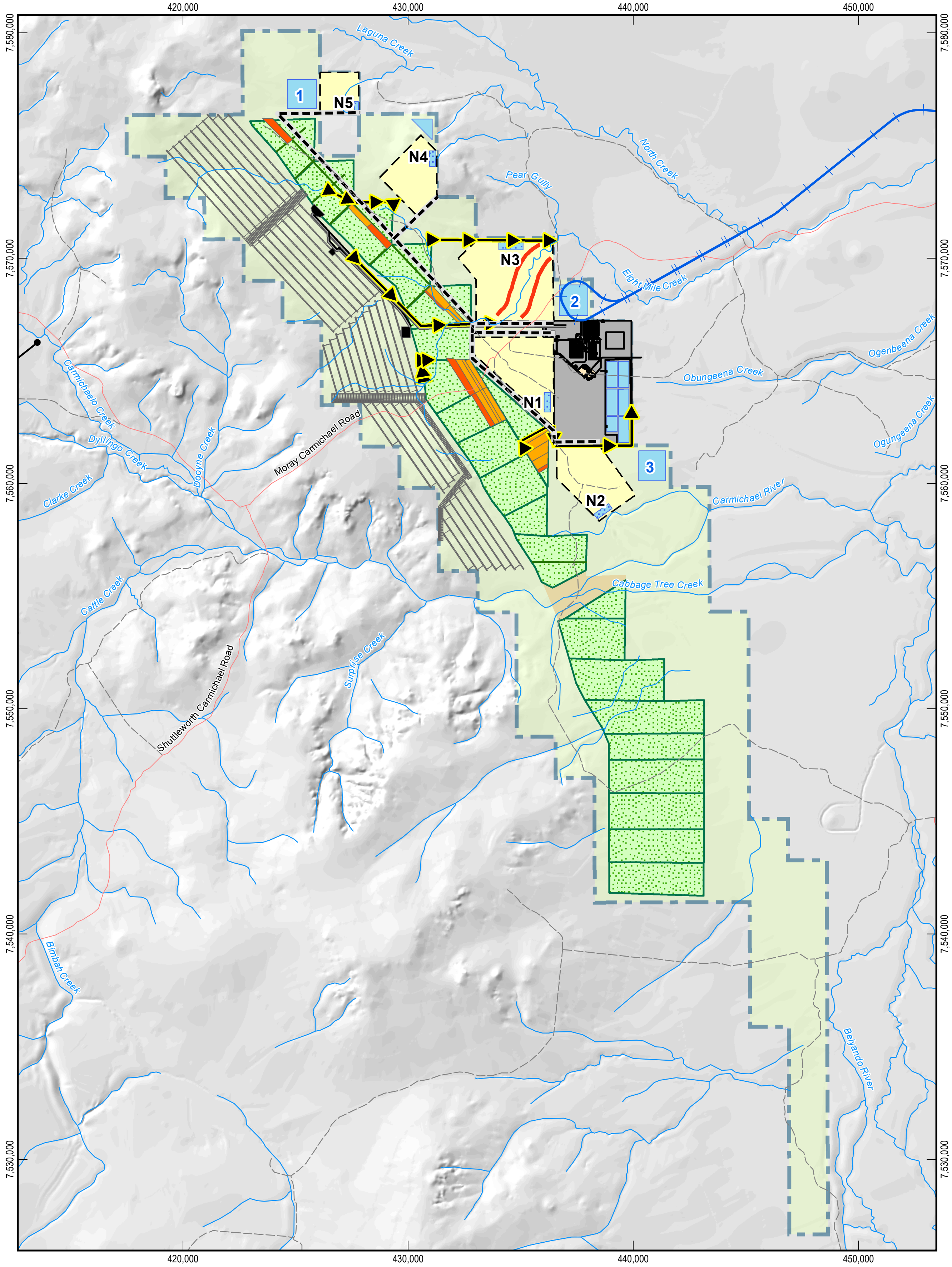

LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Levee	Disturbed Mining Area	Mine Lease Area
Watercourse	Haul Road	Water Management Dams	
Overland Conveyors	Out of Pit Waste Dumps	Sediment Basins	

1:240,000 (at A4)

0 2 4 6 8

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
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2017

Job Number | 41-25215
Revision | A
Date | 03-09-2012

Figure A5

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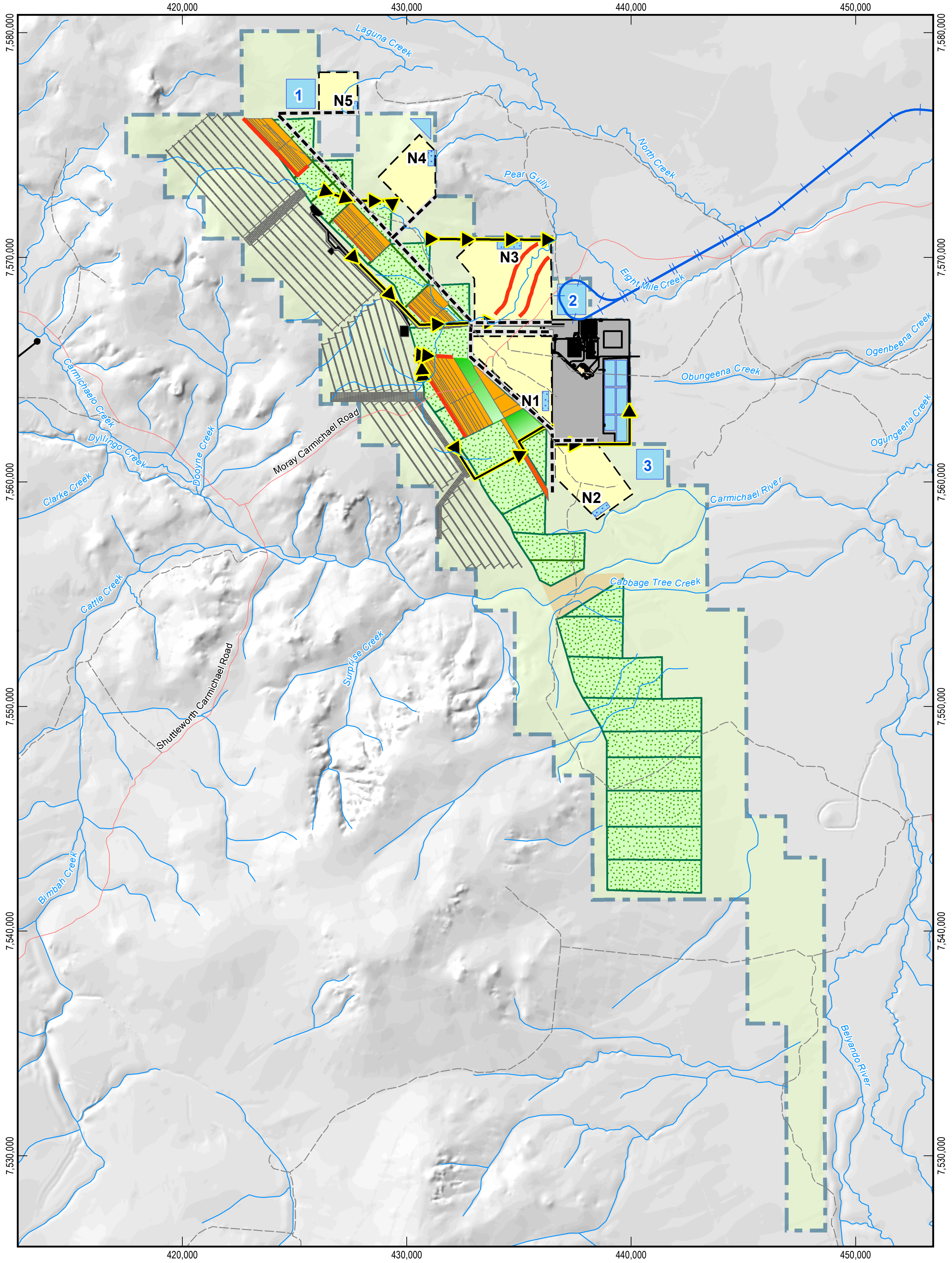

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Sediment Basins
- Water Management Dams
- Proposed Diversion
- Area Under Rehabilitation
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2027

Job Number	41-25215
Revision	A
Date	03-09-2012

Figure A6

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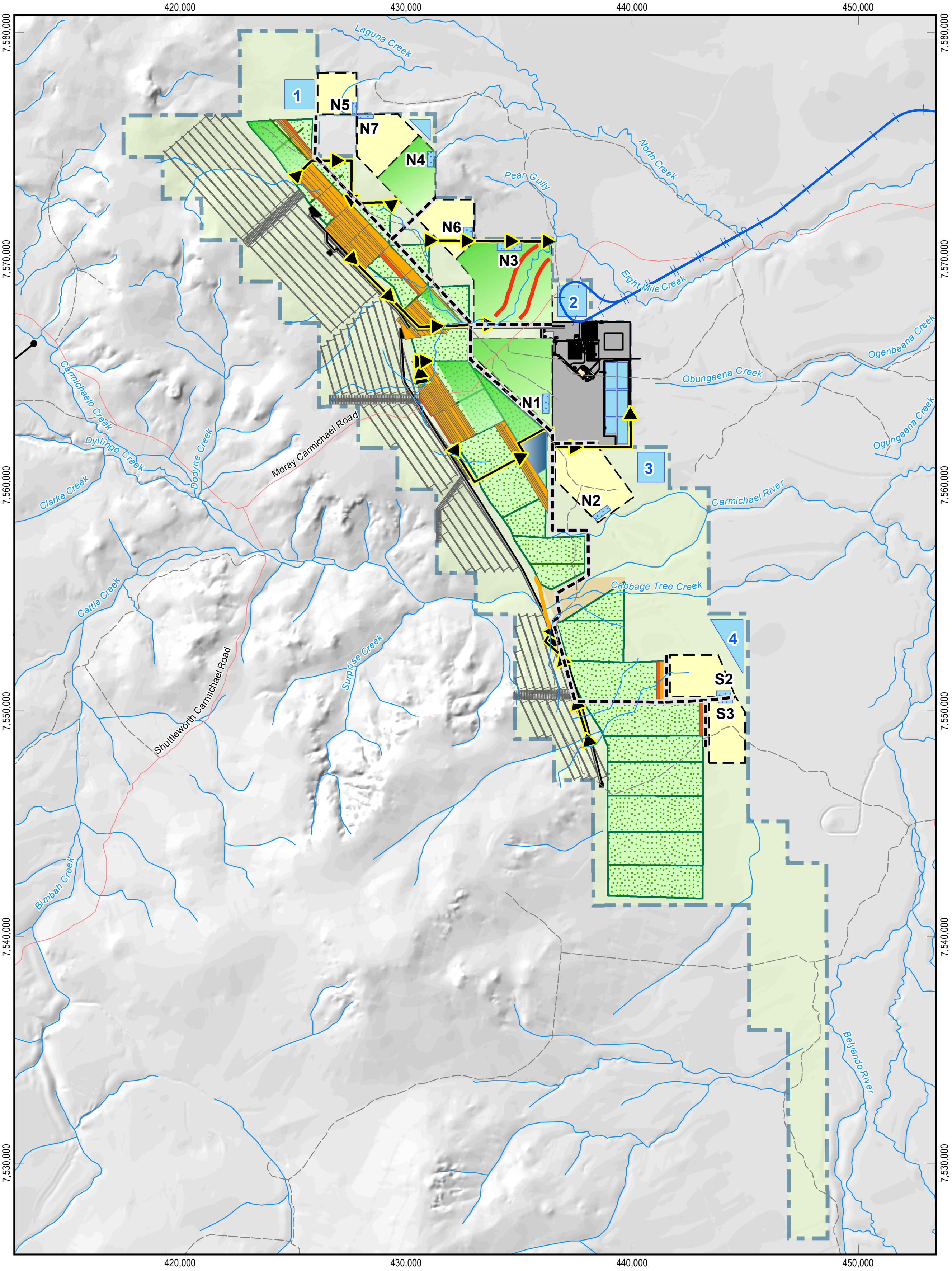

LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Haul Rd & Conveyor Crossing	Disturbed Mining Area	Area Under Rehabilitation
Watercourse	Levee	Sediment Basins	Mine Lease Area
Overland Conveyors	Haul Road	Water Management Dams	
	Out of Pit Waste Dumps		

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1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2037

Job Number	41-25215
Revision	A
Date	03-09-2012

Figure A7

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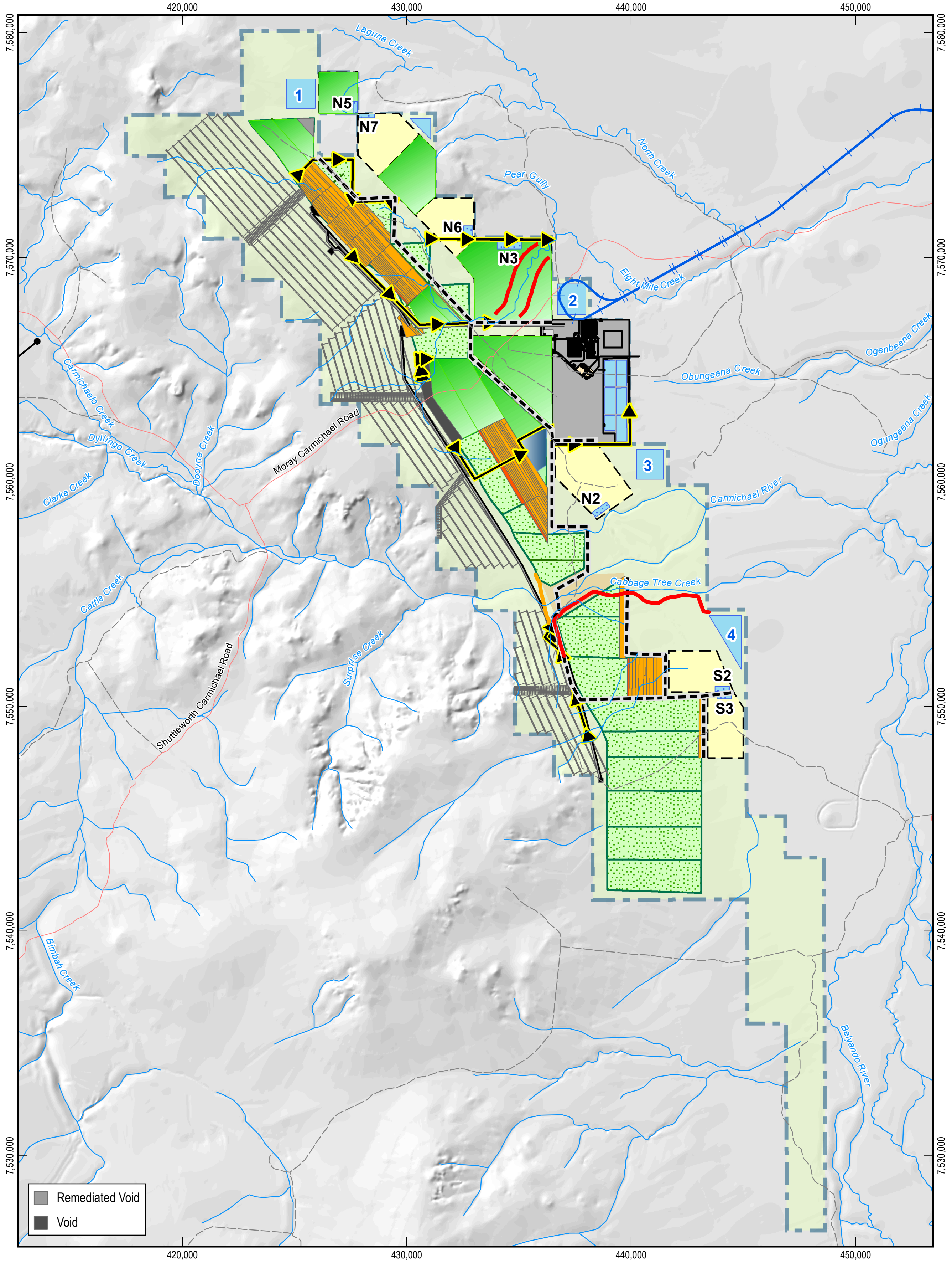
Adani: Alignment Opt9 Rev3, Mine Layout/Infrastructure (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Haul Rd & Conveyor Crossing	Disturbed Mining Area	Out of Pit Waste Dumps
Watercourse	Levee	Water Management Dams	Area Under Rehabilitation
Overland Conveyors	Haul Road	Sediment Basins	Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

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
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2047

Job Number	41-25215
Revision	A
Date	03-09-2012

Figure A8

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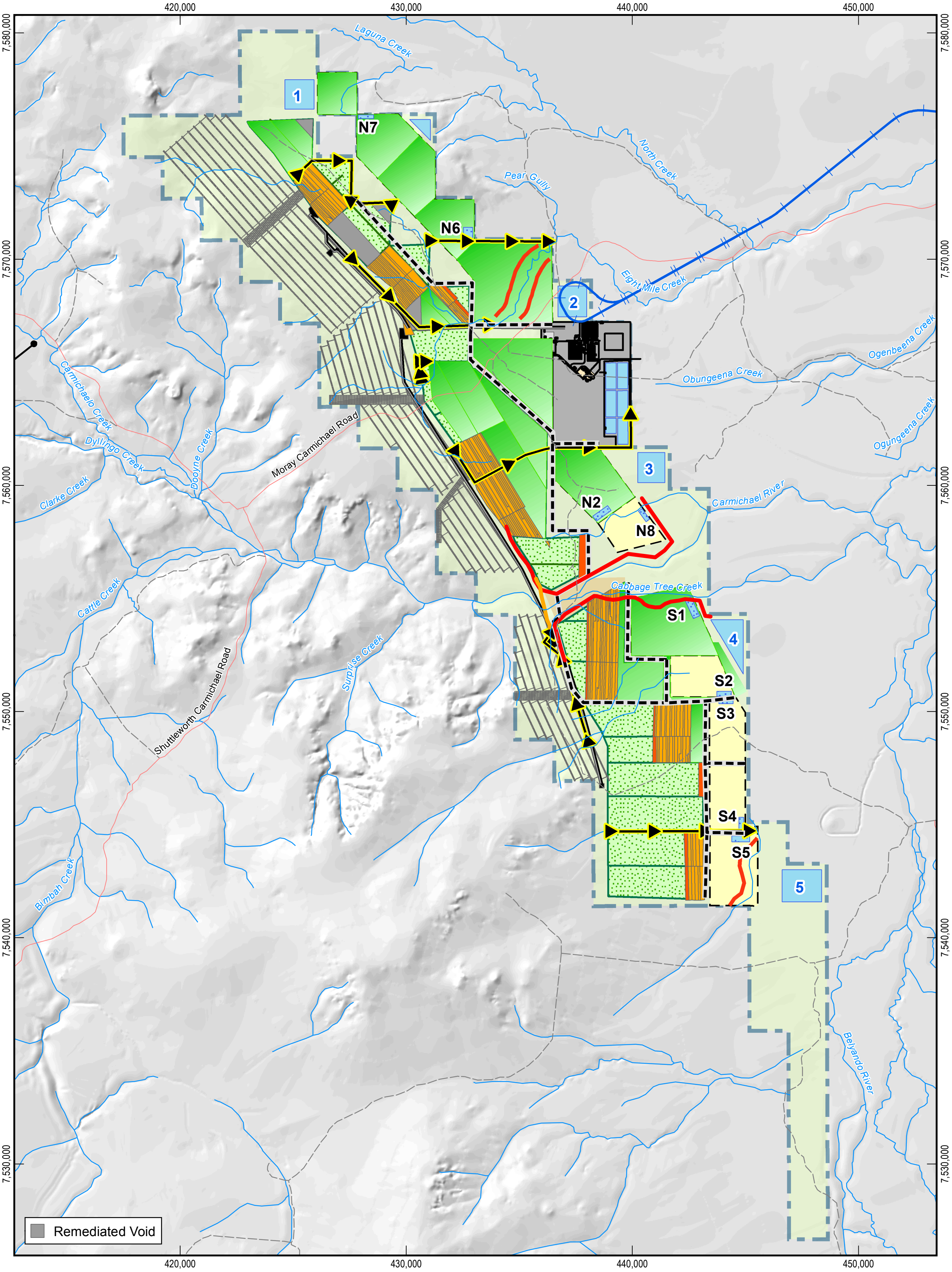

LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Haul Rd & Conveyor Crossing	Disturbed Mining Area	Out of Pit Waste Dumps
Watercourse	Levee	Water Management Dams	Area Under Rehabilitation
Overland Conveyors	Haul Road	Sediment Basins	Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2067

Job Number | 41-25215
Revision | A
Date | 03-09-2012

Figure A9

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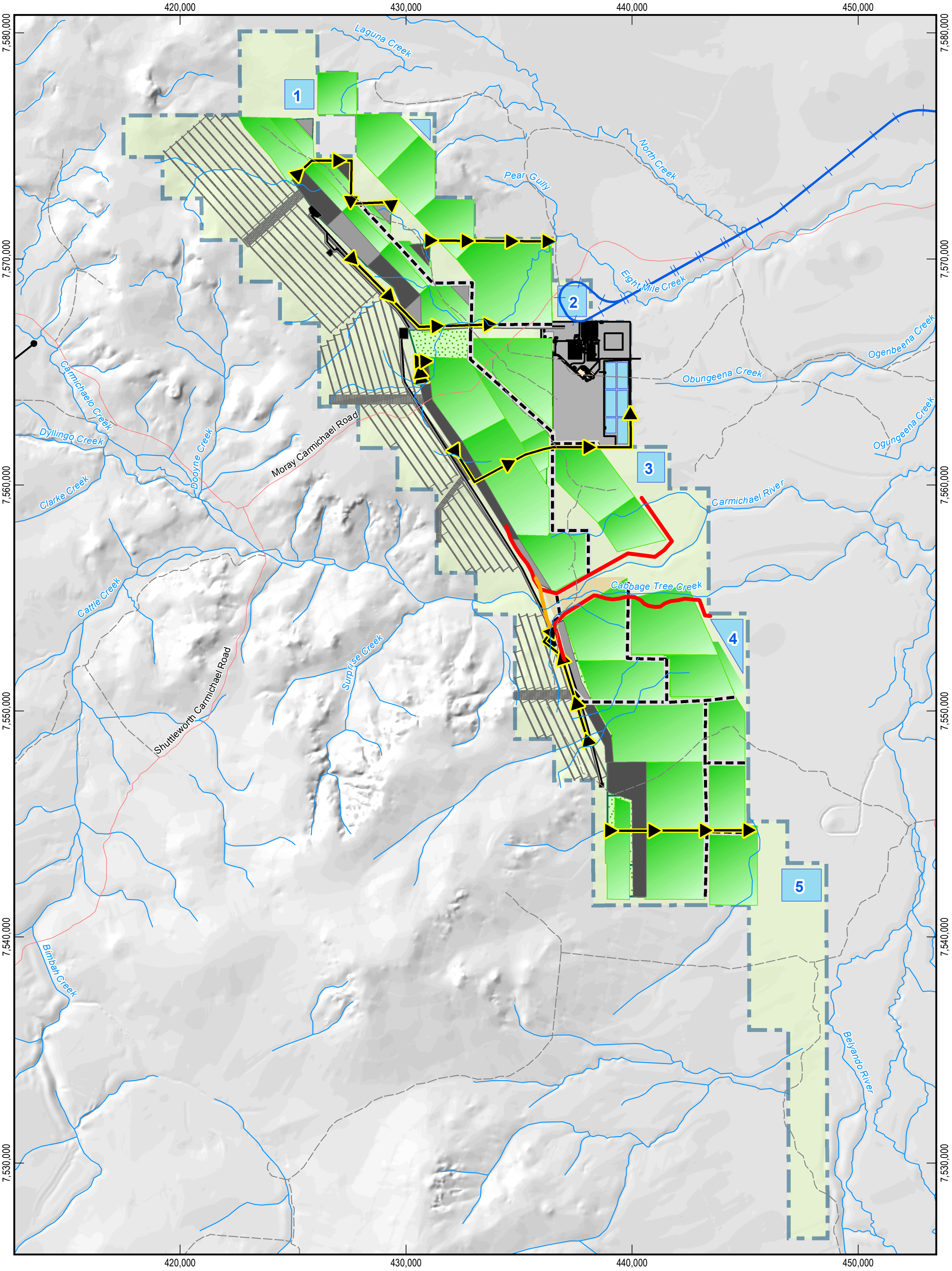

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Haul Rd & Conveyor Crossing
- Levee
- Haul Road
- Void
- Remediated Void
- Water Management Dams
- Open Cut Blocks
- Proposed Diversion
- Area Under Rehabilitation
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

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
Preliminary Water Balance

Job Number	41-25215
Revision	B
Date	03-09-2012

Plot 2103

Figure A10

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Adani: Alignment Opt9 Rev3, Mine Layout/Infrastructure (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA

Appendix B Hazard assessments

Introduction

Preliminary hazard assessments have been carried out in accordance with the ‘Manual for Assessing Hazard Categories and Hydraulic Performance of Dams’ (DERM 2012) .The manual advises that basins categorised with a significant or high hazard will require a Design Storage Allowance (DSA) in addition to the normal operating storage to prevent discharge during events with a prescribed annual exceedance probability (AEP). The storage facility (dam or pit) could fail to contain water either through discharge over the spillway, overtopping of the embankment due to high rainfall, or due to operational error and/or breakdown or due to seepage flows.

The DERM manual states “The overall hazard category for a dam, will be the highest hazard category produced by the application of Tables 1 and 2 (of the guideline i.e. Failure to Contain Scenarios and Dam Break Scenarios, respectively) under any of the failure event scenarios assessed under this section (Section 1.1). In terms of spillway design the DERM manual states “The hydraulic performance objectives are to be achieved for spillways by selecting an appropriate design AEP for flood capacity in accordance with Table 4. Table 4 provides a range of design events for spillways. A designer should select and document a conservative capacity from the nominated range based on expected dam break consequence”.

A hazard assessment has been carried out for both the sediment basins and the MAW storages. The results of the assessments are provided in the following section for both the sediment basins and the MAW storages.

Sediment basins

A hazard assessment has been conducted on the thirteen sediment basins that will treat surface runoff from the spoil areas throughout the operational period of the mine and the subsequent period of rehabilitation. DSA and Mandatory Reporting Level (MRL) design considerations only apply to dams with “significant” or “high” hazard ratings determined under the “failure to contain” scenario (section 1.1 of the DERM 2012 guideline) and the minimum hazard category (section 1.2.2 of the guideline). The DSA serves to ensure that sufficient volume is available within the dam at the commencement of the wet season to contain a volume associated with a wet season with a prescribed AEP.

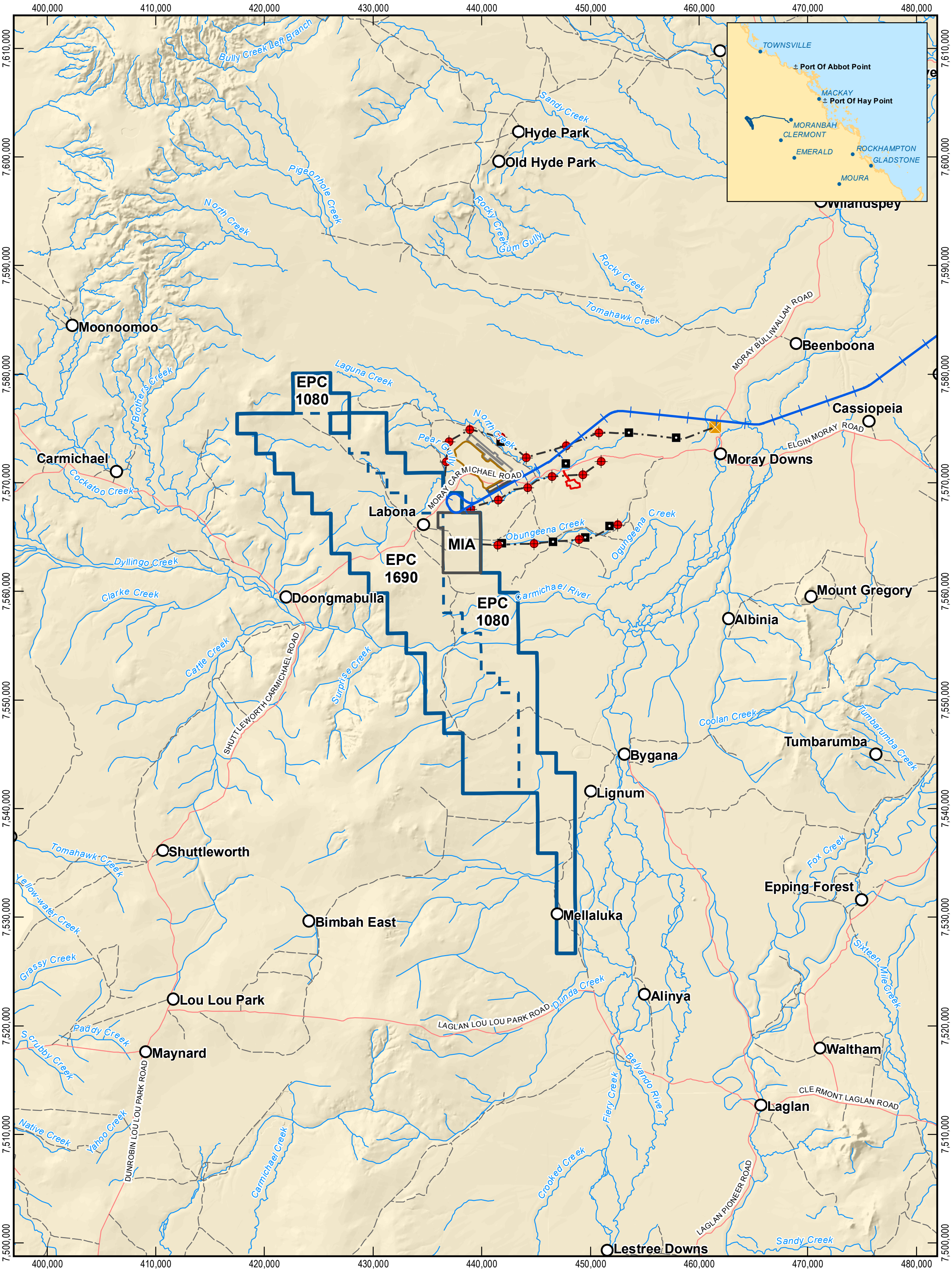
Runoff from the spoil areas is directed to sediment basins that range in volume from 95 ML to 385 ML, inclusive of the sediment storage and settlement zone volumes. Although most of the accumulated water is intended to be used for mining purposes, the basins are designed to overflow during storm rainfall to safeguard the integrity of the structure via a weir and open drain to the nearest creek tributary of the Belyando River.

Discharge water under normal circumstances meets the WQOs adopted for target pollutants in accordance with the Urban Stormwater Quality Planning Guidelines (DERM, 2010) for the Western Districts region.

Failure to contain

Thirteen basins have been assessed for the failure to contain scenario, results are detailed below:

- General environment: Based on the proposed use of the contributing catchment and the treatment and settling processes performed within the basins, the quality of stored water is not expected to exceed the threshold values of contaminant concentrations listed in Table 3 of the DERM 2012 manual.
- If an extreme rainfall event leads to overtopping, flows in the Belyando River would likely be greater by an order of magnitude and thus provide a significant measure of dilution, based on the relatively smaller storage volumes in the basins.
- In addition, the load of suspended sediment attributed to extreme storm events is also relatively small compared to the total load generated across all rainfall events. MUSIC modelling for an extended period of historical real-world rainfall, including rainfall events that lead to spills, predicts that high quantities of total suspended sediment will be removed from the runoff prior to discharge – **Low**;
- Loss or harm to humans: There are no homesteads or water supply bores along the flow path between the discharge points and the Belyando River. During a wet weather overflow, significant dilution and dissipation will occur meaning any incremental effect on water quality or water levels and velocity generated by outflows from the basin is likely to be limited – **Low**;
- Loss of stock: During wet weather there are unlikely to be stock in the creeks between the discharge points and the Belyando River. Although a dry weather spillage may encounter animals drinking within the low flow channels at seasonal billabongs, the main contaminant within the flow is suspended sediment which according to ANZECC 2000 is not considered to be a significant health risk for stock. **- Low**;
- General economic loss: There are no known third party industries or public utilities along the immediate path of outflows from the sedimentation basins, let alone those that might be affected by a potential decline in water quality. Once outflows reach the Belyando River, any potential decline in water quality is likely to be minor and therefore its potential effects on infrastructure or services are also considered minor. No significant economic loss is expected due to discharges from the basins **- Low.**



LEGEND

- Homestead
- Local Road
- Track
- Watercourse
- Rail (West)
- Mine (Onsite)
- Mine Infrastructure Area

Mine (Offsite)

- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

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

1:500,000 (at A4)

0 2.5 5 7.5 10

Kilometres

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

N

GHD adani

Adani Mining Pty Ltd

Carmichael Coal Mine and Rail Project

Location of Homesteads
Near the Study Area

Job Number	41-25215
Revision	B
Date	13-11-2012

Figure B1

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Data Source: DME: EPC 1690 (2010), EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007);
Adani: Alignment Opt9 Rev3, Mine Infrastructure Area (2012); Gassman/Hyder: Mine (Offsite) (2012). Created by: BW, CA

Dam break

Functional design of the sediment basins has not yet been undertaken. For the purposes of the dam break assessment, it is conservatively assumed that the total 3.2 m depth of the basins (1 m for sediment storage, 1 m for the permanent pool volume and 1.2 for design flow depths and freeboard) is constructed above ground, and that the embankment height is approximately 3.2 m. The peak dam break discharges in Table C-1 have been determined with DERM's simplified dam break equation which is based on the following empirical relationship between discharge and the volume and depth of storage.

$QBREACH = 2.5\ F\ V^{0.76}\ H^{0.1}$ m^3/sec Equation 1

where:

F = 1.3 = a factor to account for the simplified nature of the assessment

V = total volume of water released (in mega litres)

H = maximum depth of water in the storage (in metres) = 2.5 m

Table B-1 Sediment basin parameters

Basin	V	Q
	m3 *1000	m3/sec
N1	627.5	476
N2	542.5	426
N3	962.5	659
N4	395	335
N5	237.5	228
N6	342.5	301
N7	385	329
N8	297.5	270
S1	685	509
S2	347.5	304
S3	337.5	297
S4	365	316
S5	520	413

Based on these results, the assessment for the dam break scenario is detailed below.

- General environment: Although peak dam break discharges may seem high, dam breaks are of short duration and released water would readily spill out the small capacity low flow channels of the flat gradient receiving creeks to dissipate widely and shallowly into their broad floodplains on the way to the Belyando River. Any scour damage would be restricted to the creek beds in the immediate vicinity of the outfalls before the flows have a chance to spread out. This will be mitigated by the planned armouring of the affected reach of creek beds. The sediment basins are to be constructed offline from drainage paths, and are therefore not at risk of cascade failure. The volumes and flood levels of a wet weather dam break are small when compared to the storm events in the Belyando River. – **Low**;
- Loss or harm to humans: The diversion drains within the mine site have been designed for the 1% AEP storm event, and the Carmichael River has a defined natural floodplain. There are no known homesteads along the immediate flow path downstream of the sedimentation basins and mine site, with the closest being located approximately 27km away (refer to Figure C1). In case of overflowing, the sediment basin will add relatively little extra flow to the waterways to which it discharges. Peak flows resulting from a dam break as indicated in the table above are likely to be small when compared to the peak flows in the Carmichael River (1% AEP flows ~2500 m3/s). As a result, a dam break is unlikely to result in the inundation of land that would not otherwise flood or pose increased risk to humans **- Low**;
- Loss of stock: There is no stock between the discharge point and the natural waterways to which the sedimentation basin will be discharging and therefore loss of stock in the event of a dam break is not expected. The internal diversion drains run through the mine site for several kilometres before leaving the mine area at the Carmichael River and the nearby creeks indicated on **Figures 5-1** to **5-10** in Appendix E Carmichael Coal Mine Preliminary Flood Mitigation and Creek Diversion Design. Since the only major contaminant is sediment and because of the short duration and significant dilution of outflows, impacts to water quality in the event of a dam break are expected to be minimal – **Low**;
- General economic loss: There are no known third party industries or public utilities within the creeks between the basin outfalls and the Belyando River. Should a dry weather failure occur, it is unlikely that infrastructure along the Belyando River downstream would experience flow where it otherwise would not. The volume of the outflow compared with the much higher volume associated with natural major events makes any economic loss unlikely – **Low**.

Summary

The hazard rating is “low” for the “failure to contain” scenario and “low” for the “dam break” scenario for each of the thirteen sediment basins. Neither do the basins meet the 8 m embankment height trigger that would require the application of a Minimum Hazard Category.

Therefore, in accordance with the DERM 2012 manual all sediment basins require no DSA provision.

Spillway capacity

In the absence of any DSA or regulatory reporting requirements, the sediment basin spillways will be designed to cater for the 1% AEP storm event with the embankment height set to provide 0.5 m freeboard under peak flow conditions. These design criteria provide an appropriate level of protection to the sediment basin infrastructure and the downstream environment considering the low assessed hazard level. Rational Method calculations were undertaken to determine estimates of peak discharges from each spoil area. For the purposes of this analysis, the potential mitigating effect of temporary storage above the basins’ permanent water level has been ignored.

Design rainfall intensities were obtained from the Bureau of Meteorology for the mine site (22.125 °S, 146.375 °E). Adopted times of concentration for each catchment area were based on values determined by a weighted average of the Friend’s Equation (Equation 4.06) and the Bransby Williams’ Equation (Equation 4.10) in the Queensland Urban Drainage Manual (QUDM 2007).

Friend’s Equation Time of concentration (t_c)	$t\ (mins) = (107nL^{0.333})/S^{0.2}$
	Where L = overland sheet flow path length (m)
	n = Horton’s surface roughness factor
	Se = slope of surface (%)
Bransby Williams’ Equation	$tc\ (mins) = 58L/(A^{0.1}Se^{0.2})$
	L = length of flow path (km)
	A = catchment area (ha)
	Se = equal area slope of stream flow path (%)

Catchment areas and flow path lengths were determined from the mine plan, and in the absence of any design surface information all catchment slopes were assumed to be 0.5% with a Manning’s n value of 0.05. A summary of these calculations is included in Table B-.

Table B-2 Rational Method Calculations

Basin	Catchment Area	Time of Concentration	Rainfall Intensity for 1% AEP event
	ha	minutes	I100 mm/hr
N1	840	96	69
N2	724	80	78
N3	1285	73	82
N4	530	78	79
N5	317	66	86
N6	458	73	82
N7	515	77	80
N8	400	68	85
S1	914	93	71
S2	464	85	75
S3	450	87	74
S4	488	80	78
S5	695	85	75

The flow rates and lengths in were calculated as per the following methods in QUDM 2007 (i.e. the Rational Method as per Equation 4.02 and the Weir Equation as per Equation 7.04) and are presented in Table C-3.

Rational Method Flow Rate (Q_y) $Q_y\ (m^3/s) = C_y\,{}^tI_y A/360$

Where C_y = coefficient of discharge for the "y" year Average Recurrence Interval (ARI)

${}^tI_y$ = average rainfall intensity (mm/h) for a design duration of 't' hours for the 'y' year ARI

A = Area of Catchment

Weir Length (L) $L(m) = Q_y/1.7h^{3/2}$

Q_y = Rational Method flow rate (m^3/s)

1.77 = weir coefficient

h = flow depth (m)

Table B-3 Spillway Design Flow Rates

Basin	1% AEP Flow Rate (m3/s)	Weir Length (m)
N1	59	41
N2	58	40
N3	108	74
N4	43	30
N5	32	22
N6	39	27
N7	42	29
N8	40	27
S1	66	45
S2	36	25
S3	34	23
S4	39	27
S5	53	37

Significant energy dissipation should be provided below these weirs to prevent erosion of the basin. The maximum depth of flow over the spillway in the design event has been assumed to be 0.9m. The embankment level should be set to provide a minimum 0.5 m freeboard above the flow over the spillway.

Maintenance and monitoring requirements

The routine maintenance of the proposed infrastructure is required to minimise the potential for untreated stormwater discharging from the site and to assist in its continued satisfactory operation. To account for any uncertainty in the sediment generation capacity of the spoil areas, more frequent inspection and maintenance requirements have been proposed.

Inspection of the contaminated stormwater drainage systems will be undertaken following any rainfall event exceeding 25mm in 24 hours and at intervals not exceeding one month to identify any failures and to assess first flush capture and accumulations of contaminants. A record of these inspections will be kept as required.

Sediments basins will collect sediments after every rainfall event. These sediments will require excavation removal and offsite disposal to ensure they are not resuspended into the downstream stormwater system.

A record of all maintenance checks for all stormwater controls onsite should be kept to progressively develop an appropriate maintenance routine. The record which will also provide verification that maintenance procedures are being carried out, should include details of the following:

- The date of maintenance or inspection;
- The name of the persons performing the maintenance or inspection;
- Type of maintenance actions performed for each sediment; and
- The state of the device including an estimate of the amount of sediment captured and removed where appropriate.

Mine affected water storages

The MAW in the storages is likely to be contaminated with coal fines possible selenium. The total dissolved salts (electrical conductivity) of the co-disposal material and concentrations of selenium and salinity are not known at this stage. This assessment assumes that the selenium concentration is not high (about 0.02 mg/L or less in the liquids and 150 mg/L or less in the solids) and salinity is 5000 µS/cm or less. However, water quality is expected to exceed the threshold contaminant concentrations in Table 3 of the ‘Manual for Assessing Hazard Categories and Hydraulic Performance of Dams’ (DERM, 2012) and the MAW storages must therefore be rated with a significant or high hazard. The hazard rating may change if water quality constituent concentrations differ significantly from assumptions. The location of the homesteads receptors are shown in Figure C1.

Failure to contain

All MAW storages have been assessed for the failure to contain scenario, results are detailed below;

- General Environment: The water quality of stored water is expected to exceed the threshold values of contaminant concentrations listed in Table 3 of the DERM 2012 manual. However, areas of concern dominant vegetation are located over 25 km downstream along Belyando River. Furthermore, a comparison of the relative catchment areas of the MAW dams and receiving watercourse (Belyando River) show that flows in Belyando River during extreme events would be at least an order of magnitude greater than overflows from the dams and thus provide a significant measure of dilution. Discharge to the downstream environment through overflows or seepage could cause some environmental harm. – **Significant**;
- Loss or harm to humans: There are no known homesteads or water supply bores along the flow path between the dams and Bowen River. The nearest homestead is about 21 km from the mine site along the Belyando River, however, it is understood that the Belyando River is used for recreational purposes. Overflows from the dams will occur during extreme rainfall events and are likely to coincide with more widespread storm events resulting in elevated flows within the Belyando River. Several studies of the catchment areas indicate that flows in the Belyando River are likely to be several orders of magnitude greater than discharges from the dam. Therefore, any incremental effect on water quality or water levels and velocity generated by outflows from the dam would be limited – **Low;**
- Loss of stock: The only known water supply bores within a 20 km radius of the proposed mine are located to the north east of the mine site. Some bores of unknown use may be located along the Belyando River and are potentially within the flow path of outflows or seepage from the dam. The absence of homesteads near the mine site means that bores the along Belyando River are likely to be for livestock watering. Furthermore, overflows during extreme storm events would experience dilution by elevated flows in the Belyando River. Therefore loss to stock is not expected – **Low**; and
- General economic loss: There are no known third party industries or public utilities along the immediate path of outflows from the dams. Once outflows reach the Belyando River any incremental change in the magnitude of flow is likely to be minor and its effect on infrastructure or services, further downstream, is unlikely. Therefore, no significant economic loss is expected due to discharges from the dam **- Low.**

Dam break

Functional designs of all MAW storage dams have not yet been undertaken. For the purposes of the dam break assessment, the expected peak discharges during a break of the largest MAW storage (storage number 3) in 2016 (8,903 ML) is calculated to be around 3,800 m^3/s. Discharges have been determined with DERM's simplified dam break equation which is based on an empirical relationship between discharge and the volume and depth of storage. This assessment assumes dams are not positioned such that they would cause a cascade failure.

- General Environment: Dam break flows from the largest storage 3 would result in a high discharge of 3,800 m^3/s over a relatively short duration. This flow is less than half the 1 in 100-year flow estimate for the Belyando River. However, should a sunny day failure of the dam occur the dam break discharge would result in a substantial increase in water levels and velocity along the Belyando River which may cause damage to river banks and riparian vegetation. The impact is likely to be less at the areas of concern dominant vegetation which are some 20 km downstream of the entry point and if water levels have exceeded river banks the flood wave may have dissipated to some degree. – **Significant**;
- Loss or harm to humans: There are no known homesteads or water supply bores along the flow path between the dam and the Belyando River. The nearest homestead is about 21 km from the mine site along the Belyando River, however, it is understood that the Belyando River is used for recreational purposes. If a sunny day failure occurred at the largest dam 3 the expected discharge is likely to have a significant impact on water levels and velocity along the immediate reach of the Belyando River and it is conceivable that recreational users of the Belyando River could be at harm. However, the flood wave is likely to have dissipated to some degree by the time it reaches the first homestead and residents would be at lesser risk. - High
- Loss of stock: The only known water supply bores within a 20 km radius of the proposed mine are located to the east of the mine site, downstream of the flow path. The bores along the Belyando River are of unknown use. The volume of outflow is likely to lead to significant infiltration along its flow path especially if a sunny day failure occurred. The high discharge and velocity of outflows represents a significant threat to livestock in areas immediately downstream of the dam –**High**; and
- General economic loss: There are no known third party industries or public utilities between the dam and Belyando River. Should a 'sunny day' failure occur it is conceivable that infrastructure along Belyando River could experience elevated and faster moving flow over a relatively short period. However, the long distance (over 20 km) to areas which may contain third party industries or public utilities suggests that such an increase would not represent a high threat – **Significant**.

The hazard rating is **Significant** for the "failure to contain" scenario and **High** for the "dam break" scenario. Therefore, in accordance with DERM 2012 manual, the initial MAW dams require provision for a DSA in addition to the needs of normal operation storage requirements (refer to Appendix D). More detailed investigation in terms of potential recreational use of the Belyando River and the purpose of bores may provide evidence to adjust this assessment.

Appendix C DSA volumes

The storage capacity of dams is made up of a Normal Operating Volume (NOV) and a Design Storage Allowance (DSA).

The NOV of a dam is assessed in terms of the requirement for containment of effluent flows from mine workings to ensure continued operation and outflows from plant processes to prevent discharge to the downstream environment. The NOV is also assessed in terms of water supply requirements and the potential for reuse of MAW.

DERM has indicated that in addition to the NOV, dams that are associated with an environmentally relevant activity and are assessed as having a 'Significant' or 'High' hazard category – refer to Appendix D - (in terms of the potential environmental harm that would result from 'failure to contain' and 'dam break' scenarios), provision for a DSA must be made. The DSA is a volume that must be available in the dam on the 1st November in each year. The volume is equal to the wet season runoff (catchment and direct rainfall) at a probability of occurrence that is commensurate with the hazard category of the dam. i.e 0.01 annual exceedance probability (AEP) for high hazard and 0.05 AEP for significant hazard dams.

In the "Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM February 2012)" two approaches for the estimation of DSA are described. A simple approach involves a statistical analysis of rainfall records to determine the required frequency of wet season rainfall. The duration of wet season is obtained from Figure 1 Appendix A of the DERM 2012 manual. The DSA is then added to the NOV to obtain the overall storage requirements of the dam.

Alternatively, where transfer of contained water between storage facilities is possible, recourse to a more involved procedure is made which involves catchment rainfall-runoff models to generate inflow to storage and a water balance model to represent the operation of the mine site and water containment. In this second approach the combined storage requirement (NOV and DSA) is established by water balance modelling through inspection of the modelled frequency of spill for different storage capacities.

The PWB analysis for the proposed mine uses monthly climate data, groundwater flows and water demands representative of a 120 year period and is thus similar to the alternative and more complex method suggested by DERM. The performance of water containment for each year of record has been assessed in isolation by means of storage resetting at the beginning of each year. In the absence of estimates of NOV a storage reset level equivalent to the average storage level at the end of each year has been used which is obtained from a preliminary simulation of the water balance. The assumption has been made that the required capacity of water containment is indicated by a storage that prevents overflows during all years of the 120 year simulation. If there are no overflows during a 120 year period, this is indicative of a water containments which has a capacity equal to a 1 in a 100 year AEP. Furthermore, the derived capacity of water containment is indicative of the combined NOV and DSA requirement and the DSA may exceed design criteria specified in the 'Manual for Assessing Hazard Categories and Hydraulic Performance of Dams', DERM 2012.

Using DERM's simplified approach the DSA volumes have been estimated for reasons of completeness. Results are presented in Table C-1.

Table C-1 DSA Volumes (ML)

MAW storage dam	2013	2014	2015	2016	2017	2027	2037	2047	2067	2103
1				1,718	2,407	6,292	8,919	10,849	7,011	1,452
2	1,802	2,083	2,746	3,693	4,541	9,380	7,101	3,831	2,784	1,504
3	5,845	6,226	6,584	6,869	6,900	6,332	7,327	10,959	12,043	1,389
4							2,201	5,022	9,355	1,486
5								2,354	6,300	2,150

Appendix D Discharge Volumes

There is the potential to make controlled discharges into the Carmichael River or the Belyando River as per conditions such as those imposed for the Alpha coal mine. A simplified, rapid estimate of the amount of water able to be released into these rivers in an average year was therefore undertaken. This estimate did not include water quality aspects, other than associated with the applied release conditions (dilution factor). As there is currently no adequate historical flow data available for the Carmichael River, a rudimentary methodology has been employed to relate flows in the Belyando River (for which there is a historical record) to potential flows in the Carmichael River.

For the Belyando River, mean daily stream gauge data was obtained for Station 120301B Belyando River at Gregory Development Road (DEHP 2012). An artificial flow record was created for the Carmichael River by applying a scaling factor (see equation below) to the Belyando flows. The scaling factor is based on the ratio of peak 2-year average recurrence interval (ARI) design flow rates estimated by the Quantile Regression Technique (QRT) (Palmen and Weeks, 2009).

$$Scaling\ Factor = \frac{Q\ (2\ year\ ARI)_{\ Carmichael\ River}}{Q\ (2\ year\ ARI)_{\ Belyando\ River}}$$

$$Where\ Q\ (2\ year\ ARI) = 10^{\left[-0.915+\left(0.757 x Log_{10_{Area}}\right)+\left(1.588 x Log_{10_{i72h50y}}\right)\right]}$$

In the absence of suitable historical or calibration data for the Carmichael River this is considered a reasonable estimate of the relationship between flows in the two rivers. The QRT is a regional flood estimation method developed in and for Queensland and scales with the logarithmic transform of the catchment area. It is a more realistic method for equating the river flows than simply a linear approach, as a catchment that is ten times the size doesn't produce ten times the peak flows. This approach assumes “hydrological similarity” between the two rivers, and needs to be verified and refined when data becomes available.

The resulting scaling factor of 0.13 was adopted, based on the 35,410 km^2 Belyando catchment area contributing to the Gregory Development Road gauge and the 2,302 km^2 Carmichael River subcatchment area contributing at the proposed mine site.

The following methodology was applied to the data records to calculate potential discharges:

- The average flow for each day of the year was calculated based on the available record of 37 years. However, 2008 was excluded to obtain more conservative flows since large flooding in this year skewed the ‘average year' daily flows to be larger than what would otherwise be expected.
- For any discharges of the Carmichael Coal Mine discharge conditions will apply. The Alpha Coal Mine is located within the Galilee Basin and within the Belyando Catchment and recently received environmental approval. Within the EA release conditions are provided. In consultation with Adani it was decided to apply these releases / discharge conditions for the Carmichael Coal Mine. The conditions relate to flows for the ‘average year' to determine allowable releases, refer to the below (Appendix 3: Alpha Coal Project: Coordinator-General's Evaluation Report on the environmental impact statement).

Table D-1 Release conditions Alpha Coal Mine

Table A19: Mine Affected Water Release during Flow Events

Receiving waters	Release Point (RP)	Gauging Station[1]	Gauging Station Northing (GDA94)[1]	Gauging Station Easting (GDA94)[1]	Receiving Water Flow Recording Frequency	Receiving Water Flow Criteria for discharge (m^3/s)	Maximum release rate for all combined RP flows (m^3/s)	Electrical Conductivity and Sulfate Release Limits
Lagoon Creek	RP1 RP2 RP3 RP4 RP5 RP6 RP7 RP8 RP9 RP10				Continuous	<5 m^3/s	1 m^3/s	Maximum Electrical Conductivity: 250 µS/cm Maximum Sulfate (SO_4^{2-}): 250 mg/L
						>5 m^3/s to 10 m^3/s	1.7 m^3/s	Maximum Electrical Conductivity: 2500 µS/cm Maximum Sulfate (SO_4^{2-}): 985 mg/L
						10 m^3/s to 15 m^3/s	3.5 m^3/s	
						15 m^3/s to 20 m^3/s	5.2 m^3/s	
						20 m^3/s to 25 m^3/s	6.9 m^3/s	
						25 m^3/s to 50 m^3/s	4 m^3/s	Maximum Electrical Conductivity: 3500 µS/cm Maximum Sulfate (SO_4^{2-}): 1800 mg/L
						> 50 m^3/s	8 m^3/s	

The Alpha coal mine is much higher in the Belyando catchment than is the Carmichael Coal Mine. For this reason the catchment contributing to flows at discharge points is much smaller and the flows receiving the discharges will be smaller. The discharge conditions for the Carmichael Coal Mine will potentially reflect the larger flows lower in the catchment with the likely difference to be in the low flow discharge condition. The Alpha coal mine conditions (see attached) stipulate discharges of 1 m^3/s when in-channel flows are less than 5 m^3/s. In order to provide a conservative estimate of what the Carmichael Coal Mine discharge conditions might allow, two additional (worst case) scenarios were assessed with conditions differing as follows:

- Scenario 0: Baseline: discharges as calculated against the Alpha coal mine conditions.
- Scenario 1: Discharges equal to only 20% of the in-channel flow may be released where the in-channel flow is less than 5 m^3/s.
- Scenario 2: No discharges may be released when the in-channel flow is less than 5 m^3/s.

There should be a discussion as to which of the discharge scenarios to incorporate. Potential discharges under each of the scenarios are presented in the tables below.

Table D-2 Potential monthly discharges from Carmichael Coal Mine into the Belyando River for an 'average flow year'

	Scenario 1 (ML)	Scenario 2 (ML)	Scenario 3 (ML)
January	13176	13176	13176
February	18662	18662	18662
March	13729	13729	13729
April	9832	9832	9832
May	13522	13522	13522
June	4864	4328	3741
July	2678	872	0
August	2739	1237	147
September	2514	1367	441
October	5573	5179	4190
November	7197	7090	6333
December	12044	12044	12044
Annual (ML)	107,000	101,000	96,000

Table D-3 Potential monthly discharges from Carmichael Coal Mine into the Carmichael River for an 'average flow year'

	Scenario 1 (ML)	Scenario 2 (ML)	Scenario 3 (ML)
January	3223	2610	1322
February	6463	6429	6290
March	4510	4351	3560
April	2592	1065	0
May	3102	2005	1028
June	2592	435	0
July	2678	110	0
August	2678	152	0
September	2333	163	0
October	2678	485	0
November	2592	1003	0
December	2678	1198	0
Annual (ML)	38,000	20,000	12,000

In summary there is the potential to release an average of 38,000 ML annually into the Carmichael River with a worst-case licencing scenario of 12,000 ML annually. If greater discharges are required there is the potential to make average releases of 107,000 ML annually to the Belyando River with a worst-case licencing scenario of 96,000 Ml annually. Potential average discharges are naturally highest during the wet season.

Appendix E Preliminary Flood Mitigation and Creek Diversion Design

Adani Mining Pty Ltd

Carmichael Coal Mine

Preliminary Flood Mitigation & Creek Diversion Design

28 August 2012

Executive summary

Flood modelling of the proposed Carmichael Mine Lease Area (MLA) ML70441 was undertaken for the Carmichael River corridor and for minor waterways intersecting the MLA through the north and the south. The purpose of this study was to inform the Carmichael Coal Mine Environmental Impact Assessment (EIS) and to make recommendations for flood mitigation works based on the Runge (2011) mine design.

The Carmichael River was found to flood within a relatively narrow extent upstream of the MLA, growing in width towards the downstream boundary of the MLA where the flattening terrain allows effluent flow into the head of Cabbage Tree Creek under flood conditions. Multiple minor waterways were found to intersect the MLA from the western boundary both to the north and to the south of the Carmichael River, flooding across the proposed mine site to discharge into waterways to the east.

Based on the existing conditions results and analysis of the predicted change in hydrological conditions post-development, a conceptual staged drainage scheme was proposed for the mine site. Recommended infrastructure is presented at a preliminary design stage within this report, including the following format:

- 1 in 1000 year ARI-immune flood protection levees for the Carmichael River corridor;
- 1 in 100 year ARI-capacity local waterway diversion drains with the ability to provide 1 in 1000 year ARI flood immunity to the pits through the mine site (through the use of supplementary adjacent levees); maintaining natural flow paths and hydrology to the maximum extent practicable;
- 1 in 50 year ARI-immune haul road and conveyor crossing of the Carmichael River, comprising a bridge to pass the 1 in 50 year ARI flood level plus 500 mm freeboard while the road is at a height above the 1 in 50 year ARI flood level plus 600 mm freeboard. The bridge height was sufficient to avoid overtopping in the 1 in 100 year ARI event but scour protection must be considered due to potentially large head loss from overtopping by the 1 in 1000 year ARI event.

Subsequent modelling of the Carmichael River corridor with this proposed infrastructure in place and modelling of one of the case study diverted local waterway indicated the ability of this infrastructure in protecting the mine site from large flood events.

Afflux was found to be significant within the MLA due to the combined effect of minor increased inflows from some of the diverted waterways, also due to the reduced runoff coming from the developed mine internal areas and hydraulic constriction by the flood protection levees, haul road and conveyor crossing. Upstream of the haul road crossing afflux was modelled to peak at 0.72 m for the 1 in 100 year ARI event, but at the downstream eastern MLA boundary this had already reduced to 10 mm. It is believed that the significant reduction in afflux values over this short distance indicates that neighbouring properties are likely to experience minimal increase in flood extents both downstream and, especially, upstream of the MLA. The most significant afflux are confined within the MLA.

The concept design of the flood protection infrastructure contained within this report requires further detailed design before implementation. A number of recommendations are made as to which aspects require future analysis, and which aspects must be considered for their potential impact on the planning of the mine design. These include issues of scour and erosion control and interfaces with other infrastructure.

This report is subject to, and must be read in conjunction with, the limitations set out in Section 2.4 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Project overview

Adani Mining Pty Ltd (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 at Moranbah, and shipped through coal terminal facilities at the Port of Abbot Point and the Port of Hay Point (Dudgeon Point expansion). The Project will have an operating life of approximately 90 years.

The Carmichael Coal Mine and Rail Project (the Project) consists of three major components:

- The Project (Mine): a greenfield coal mine over EPC1690 and part of EPC1080, which includes both open cut and underground mining, on mine infrastructure and associated mine processing facilities (the Mine).
- The Project (Rail): a greenfield rail line connecting the Mine to the existing Goonyella rail system to provide for export of coal via the Port of Abbot Point and/or the Port of Hay Point (Dudgeon Point expansion).
- Off-site infrastructure such as the village and airport.

Detailed descriptions of the Project are provided in Volume 2 Section 2 Project Description (Mine) and Volume 3 Section 2 Project Description (Rail). Infrastructure of the Project (Mine) that is relevant to mine water management includes the following components:

- Open cut pit areas
- Long-wall mineshafts and services
- Out-of-pit spoil areas
- Haul road
- Product conveyor
- Mine affected water (MAW) storages (areas of Pits K and L)
- Flood protection infrastructure
- Creek diversion drains
- Industrial working area including the mine industrial area (MIA), the run of mine (ROM) coal stockpile, coal handling and preparation plant (CHPP) and the train load out (TLO) facility
- Above-ground rock waste dumps and tailings storage facilities

The Project (Mine) encompasses an area of 437 km^2 within the mine licence area (MLA) of ML70441 (herein referred to as the Project Area), and located within the exploration permits for coal (EPC) EPC1690 and EPC1080 (Figure 1-2). Of this, approximately 218 km^2 will be covered by above-ground infrastructure and facilities or open-cut mining activity. About 72 km^2 will be subject to underground mining and so experience subsidence but not significant clearing, with the balance experiencing minimal distrubance. The Carmichael River flows through ML70441, with an effluent flow path to Cabbage Tree Creek at the eastern boundary of ML70441.

The ‘Study Area’ for the purposes of this report is comprised of the following:

- The 250 km^2 Carmichael Coal MLA ML70441, a staggered strip between 5 and 10 km wide by 40 km long
- The 187 km^2 Carmichael Coal MLA EPC1080 immediately to the east of ML70441
- The broader Carmichael River catchment generally located to the west of the ML70441

LEGEND

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

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.

1:2,000,000 (at A4)

0 10 20 30 40 50

Kilometres

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

N

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

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

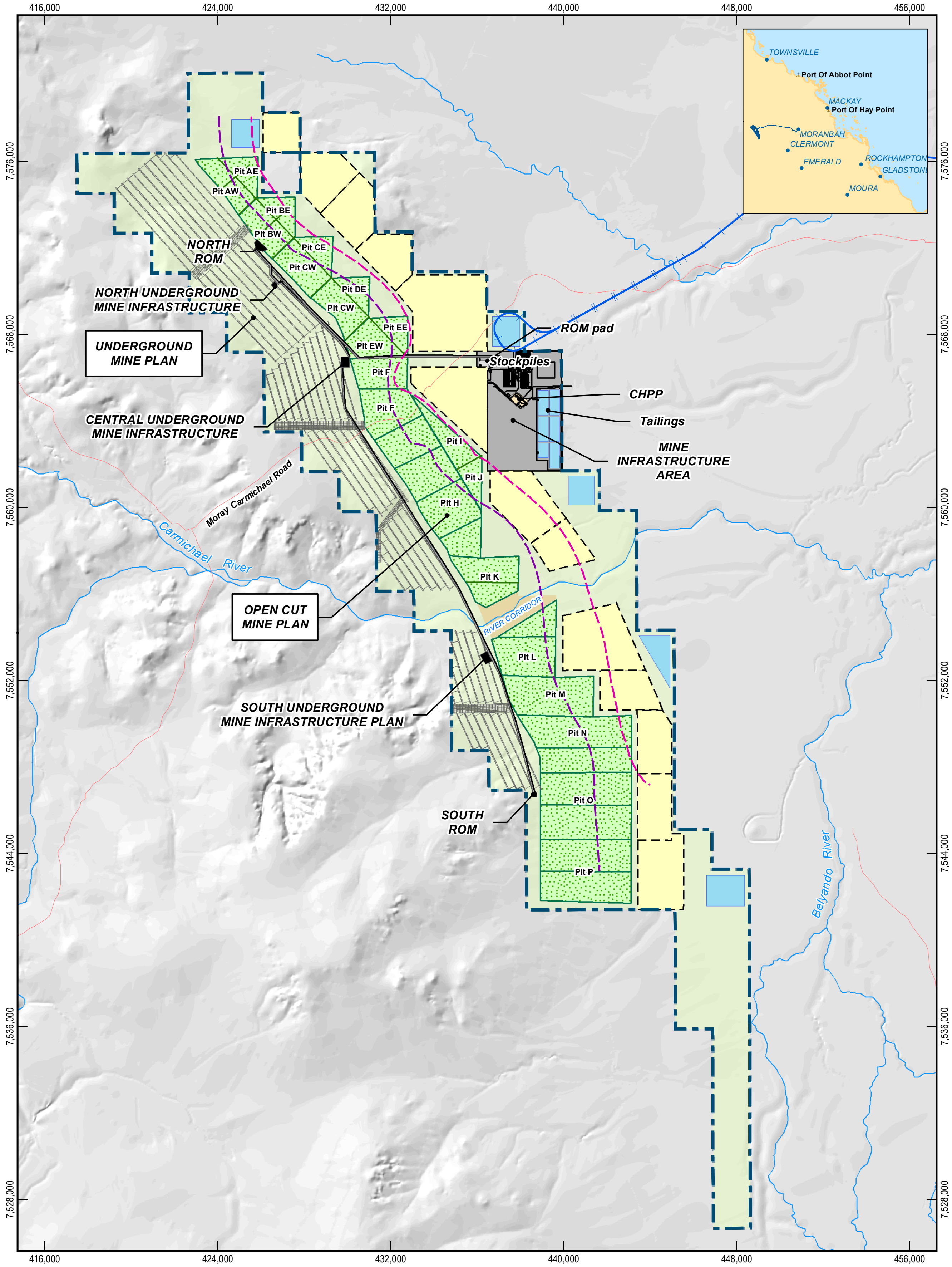
Locality Map

Figure 1-1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_562_rev_a.mxd

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: © Commonwealth of Australia (Geoscience Australia): Town, Railways, Watercourses (2007); DERM: LGA (2011); DMR: State Roads (2008); Gassman/Hyder: Mine (Offsite) (2012); DME: EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3 (SP1 & 2) (2012). Created by: BW, JVC, CA



LEGEND

- Local Road
- River / Watercourse
- AB1 Cropline
- D1 Cropline
- Project (Rail)
- Overland Conveyors
- Mine Lease Area
- Open Cut Blocks
- Out of Pit Waste Dumps
- Water Management Dams

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.

1:250,000 (at A4)

0 2 4 6 8

Kilometres

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

N

GHD adani

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

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

Project Area

Figure 1-2

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_563_rev_a.mxd

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: GA: Roads, Watercourse (2007); DME:EPC1690 (2010), EPC1080 (2011); Adani: Alignment Opt9 Rev3, Mine Layout / Infrastructure (2012). Created by: CA

1.2 Report scope

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. One component of this process is a comprehensive flood study to demonstrate that the development does not result in unacceptable risk to people or property, according to the Queensland State Planning Policy 1/03.

Adani Coal Pty Ltd (the Proponent) has also commissioned GHD to prepare this report as a tool to inform mine planning. This report is essentially a flood study and preliminary test of the flood protection infrastructure for the mine plan described in the *Carmichael Macro-Conceptual Mining Study* by Runge (2011), dealing with the design of the major flood mitigation works required to prevent uncontaminated surface runoff from entering the mine workings and thereby either (1) becoming "mine affected water" that requires treatment, or (2) flooding the mine.

The necessary flood protection infrastructure that was identified by the Proponent includes the following:

- Levees to protect the adjacent pits from the flooding of the Carmichael River
- A bridge to allow passage of haul vehicles and the conveyor from the south to the north of the mine during relatively frequent flood events
- Diversion drains to allow local waterways to pass through the site without causing flooding.

Section 2 of this report (referred to as the 'Mine Preliminary Flood Mitigation and Diversion Drain Design Report') describes the design methodology employed, the required data used to execute the design and the qualifications and limitations of the report contents. Section 3 provides assessment and modelling of the hydrology of the Carmichael River and the Project (Mine) local subcatchment under existing and developed conditions. Section 4 describes the hydrodynamic modelling undertaken to describe existing flood conditions.

Section 5 describes the conceptual scheme by which mine drainage infrastructure will be staged as required across the mine life. This includes conceptual alignments for the Carmichael River flood protection levee, the haul road and conveyor crossing and the local waterway diversion drains. Section 6 identifies preliminary designs for the Carmichael River flood protection levee with the haul road and conveyor crossing in Section 7. Section 8 demonstrates the preliminary design of a case study diversion drain as identified in the staged conceptual drainage scheme. This provides an indication of the required size and accommodation required for a diversion drain, as well as the likely requirement for erosion protection.

Section 0 demonstrates the flood scenario of the Carmichael River at the Project (Mine) site for the developed scenario once the Carmichael flood protection levee and haul road and conveyor crossing are constructed. Estimates of afflux are also included. Section 1 summarises the conceptual design of the flood protection infrastructure and diversion drains and recommends directions and considerations during the future design phases.

The assessment of flooding issues for offsite infrastructure is not included within the scope of this report, nor is the management of minor local flooding and drainage within the mine site itself.

2. Design Methodology

2.1 Overview

The Project (Mine) represents a major change to the topography. This is likely to impact the hydrology and hydraulic conditions of the waterways and river in the vicinity.

Flood modelling of the Carmichael River and local waterways under existing and developed conditions was performed in order to:

a) Aid in the design of flood protection infrastructure and diversion drains and

b) Assess hydrological impacts on the surrounding area due to the mine.

These two components were achieved as described in the following steps:

- *Develop a hydrologic (rainfall-runoff) model of the existing conditions in the Carmichael River catchment*– This model allowed estimation of critical storm durations and resulting design flow rates for the 1 in 10 year, 1 in 50 year, 1 in 100 year and 1 in 1000 year average recurrence interval (ARI) events. These events were selected to match the design criteria set by Adani.
- *Develop a hydrologic model of the developed condition in the Carmichael River catchment* – This model allowed estimation of critical storm durations and resulting design flow rates for the 1 in 10 year, 50 year, 100 year and 1000 year ARI events within the Carmichael River and within the diversion drains. It demonstrates the hydrologic impact of the proposed development on contributing catchment areas and peak flows. This model uses the existing conditions model as a starting point, which was modified to include the development changes due to the works.
- *Develop a two-dimensional (2D) hydraulic model of the Carmichael River and floodplain in the vicinity of the mine site under existing conditions* – This model was used to define existing hydraulic conditions and peak flood levels and extents for the 10 year, 50 year, 100 year and 1000 year ARI critical storm duration events.
- *Develop a one-dimensional (1D) hydraulic model of the minor watercourses within the MLA that are not draining to the Carmichael River, existing conditions* – This model allowed estimation of critical storm durations and resulting design flow rates for 10 year, 50 year, 100 year and 1000 year ARI event flooding at the northern and southern extents of the Carmichael River. The model also demonstrates the volume of flow entering the ephemeral creeks outside of the mine lease area during flood conditions;
- *Plan a conceptual Project (Mine) flood protection and creek diversion plan that progresses throughout the Project (Mine) life* – This step identifies a drainage scheme that progresses throughout the lifetime of the mine based on operational requirements. It provides a concept and alignment for preliminary sizing of flood protection infrastructure and diversion drains. This drainage scheme was based on the mine progress plots provided by Runge (2011).
- *Undertake preliminary design of a haul road & conveyor crossing at the Carmichael River* –Hydraulic analysis of the crossing and an associated bridge was undertaken to design a bridge that provided the required flood immunity to the bridge structure. Modelling was also used to determine the likely flooding of the bridge during storm events greater than the design event.
- *Undertake preliminary design of a flood protection levee containing the Carmichael River* – The levee bank alignments and heights were determined to provide 1 in 1000 year ARI

flood immunity to the internal mine areas. The alignment was chosen to minimise hydraulic impact on the Carmichael River and the effluent Cabbage Tree Creek.

- *Undertake a case study design of a proposed creek diversion drain* – One diversion drain proposed within the conceptual staged drainage plan was used as a preliminary design case study. Horizontal and vertical alignments of the drain were optimised to take flow through the mine site within allowable velocity constraints and to re-join existing natural channels. The design was undertaken with consideration of eventual subsidence on the surface above the underground mining region.
- *Develop a 2D hydraulic models to show flooding under developed conditions* – This model demonstrated the impact of the development and preliminary designs for flood protection infrastructure on the flooding of the Carmichael River. It also demonstrates the flood immunity to the mine footprint provided by the proposed infrastructure and diversion drains.

2.2 Design criteria

Design criteria for the conceptual staged drainage scheme and the preliminary flood protection infrastructure design were discussed with the Proponent. These were based on the mine plan described and suggested by the Runge (2011) mine progress plans, and reconfigured to include the EPC1080 area. The following criteria will require refinement at a later design stage but were agreed upon based on expected mine operation and environmental consideration:

2.2.1 General criteria

- All infrastructure is to be contained within the mine lease area MLA70441.
- Open cut pits are to have 1000 year ARI flood immunity provided.
- Waste rock heap areas are to have 100 year ARI flood immunity.
- Haul road crossing to have 50 year ARI immunity.
- Minimum freeboard of 600 mm is to be provided above the design immunity water level

2.2.2 Diversion drain design

- Drains to carry 100 year ARI capacity
- Drain banks to have 1 to 5 slope batter
- Channel flow velocity not to exceed 2.5 m/s for 50 year ARI flow to limit the potential for erosion.

2.2.3 Levee design

- The levee was to be placed within the proposed levee corridor of approximately 800 m width (Runge 2011) so as not to encroach on the planned underground and open cut pit areas.
- The alignment should not block the effluent flow path from the Carmichael River to Cabbage Tree Creek.
- For the purposes of this design, and without any consideration of the geotechnical engineering issues at this stage, the batter slopes on the levees have been set at 1 vertical to 5 horizontal. If depth is greater than 5-6 m, sides should be benched.
- Levee top width of 6 m.
- Levees to provide required immunity to open cut pits and waste heap areas.

2.2.4 Haul road and conveyor crossing design

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

2.3 Data collection

The following data was collected as input to the flood modelling and preliminary design:

- *Digital Elevation Model (DEM)* – A 10 m digital elevation model (DEM) was created by GHD, based on LiDAR collected by Vekta. The DEM extends just outside of the MLA.
- *Regional Elevation Model* – 10 m contour intervals of Queensland.
- *Mine Site Layout* – Rough geospatial files of the mine site layout for all mine stages were provided by Runge Pty Ltd. PDF maps were also provided in Runge (2011).
- *Aerial Photograph* – Aerial photography from Adani Mining Pty Ltd. of mine site location and extending just outside the boundary of the MLA.
- *Intensity-Frequency-Duration (IFD) Rainfall Data* – Obtained from the Bureau of Meteorology (BOM IFD 2011) for the location of the mine site. FORGE (CRC-FORGE 2000) data was also obtained for rare rainfall events.
- *Stream Gauge Data* – Daily stream flow data was provided by DERM for nearby stream gauges (DERM 2011).
- *Watercourse Locations* – Watercourse locations in the vicinity of the mine lease area were provided by DERM as geospatial files.

2.4 Consideration of risk

The design criteria outlined in Section 2.2 were selected in consultation with Adani for the purposes of this conceptual study. Notwithstanding the assumptions made as part of this conceptual design, it is necessary to consider the various surface water-related risks on a continuing basis during further planning activities, as well as during the construction, operation and decommissioning phases of the mine.

This study has presented its analyses of risk in terms of the so-called Return Period (or Average Recurrence Interval ARI) adopted in the various design criteria. The return period is the "average" number of years between successive events of the same or greater magnitude. For example, if the 100-year return period flood level is 230 m AHD at a certain location then on average, a 230 m AHD flood level or greater can be expected to occur once every 100 years. In reality this level is likely to be reached by flooding in periods more and less frequently than 100 years. It is important to note that in any 100-year period, the 100-year return period event has a 64 per cent chance of being equalled or exceeded. This means that the example 230 m AHD flood level has a better-than-even chance of being exceeded by the end of any 100-year period. If the 100-year event were to occur, then there is still a finite possibility that it could occur again soon, even in the same year, or that the 1000 year event could occur, for example, next year. Clearly if such multiple events continue unchecked then the basis for the estimate of, say, the 100 year event might then need to be questioned, but statistically this type of behaviour can be expected.

A more consistent way of considering the above (NCCOE 2004) is to include the concepts of "design life" and "encounter probability" which, when linked with the return period, provide better insight into the problem and can better assist risk management decision making. These various elements are linked by the following formula (Borgman 1963):

$$T = -N/\ln[1-p]$$

Where P = encounter probability 0-1, N = the design life (years), T = the return period (years)

This equation describes the complete continuum of risk when considering the prospect of at least one event of interest occurring. More complex equations describe other possibilities such as the risk of only two events in a given period or only one event occurring. Figure 2-1 illustrates the above equation graphically. It presents the variation in probability of at least one event occurring (the encounter probability) versus the period of time considered (the design life). The intersection of any of these chosen variables leads to a particular return period and a selection of common return periods is indicated. For example, this shows that the 200-year return period has a 40 per cent chance of being equalled or exceeded in any 100-year period.

The level of risk acceptable beyond regulatory limits is a corporate or business decision. Figure 2-1 is provided to assist in this decision making process by showing a selection of risk options. For example, accepting only a 5 per cent chance of flood inundation occurrence in a design life of 50 years means that infrastructure needs to be design for a 1 in 1000-year return period event. A similar design criteria (1 in 1000-year ARI) is required if a 1 per cent probability is an acceptable occurrence during a period of 10 years. By comparison, a 1 in 100 year return period event has a 10 per cent chance of occurrence in a 10 year period.

It is suggested that this framework is used in any further decision-making regarding flooding- and drainage- related risks for the mine. Effective risk management acknowledges that there is always some level of residual risk when developing within or adjacent to a floodplain or drainage corridor, and that flood events larger than the selected design events can occur at any time and will occur given enough time.

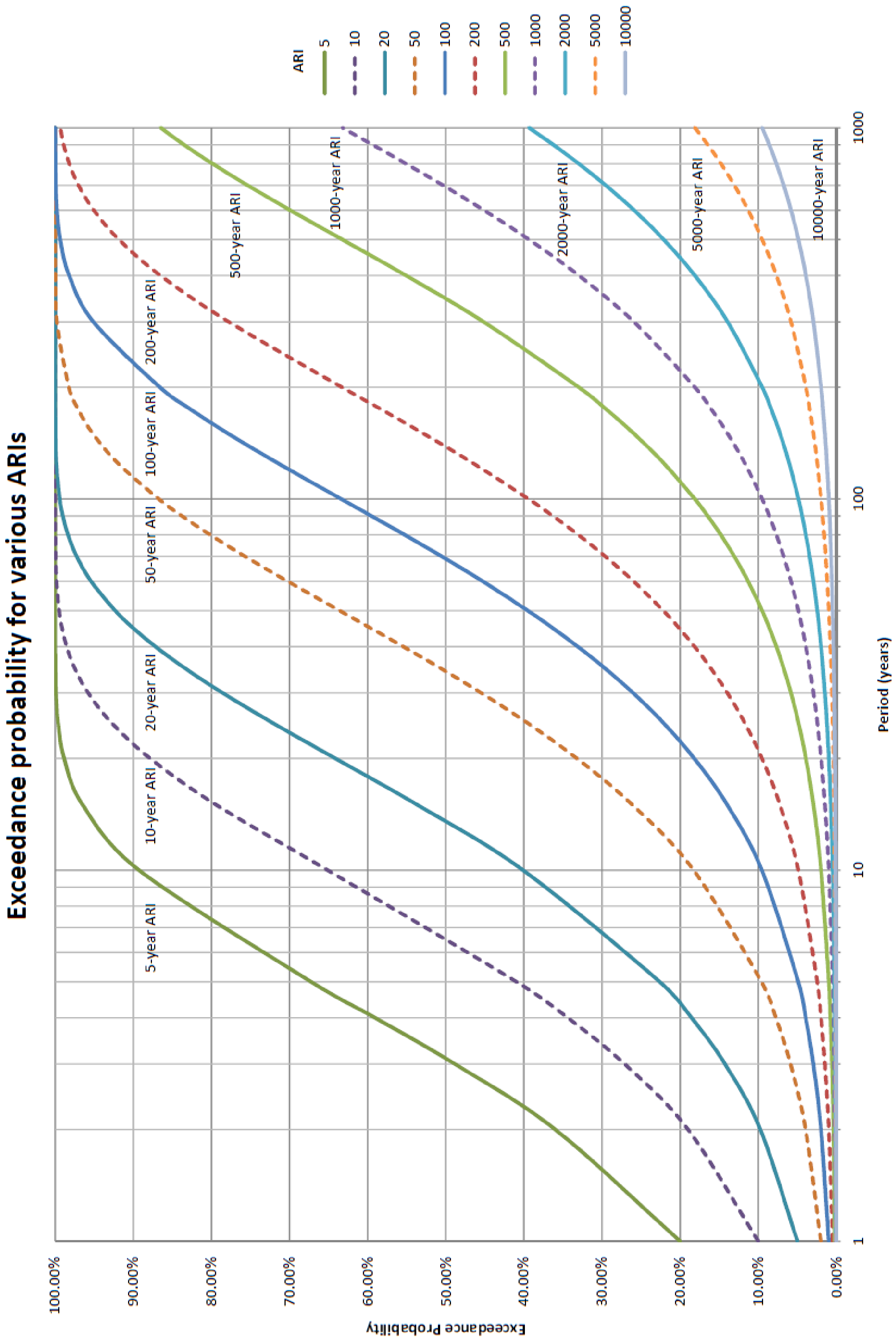


Figure 2-1 Probability Chart

3. Hydrological assessment

3.1 Existing drainage

Under existing conditions, most regions of the Project Area drain into a series of ephemeral creeks at the east of the MLA including Pear Gully and Eight Mile Creek. There are also a number of ill-defined watercourses across the northern and southern parts of the study area that drain generally in the easterly direction towards the Belyando River. The balance of the site drains overland into the Carmichael River.

The Carmichael River catchment upstream of the MLA is approximately 2000 km^2 and lies within the Burdekin Basin. Tributaries within the Carmichael River catchment include Cattle Creek, Dylingo Creek and Surprise Creek which converge into the Carmichael River just upstream of the MLA. Under normal conditions, the Carmichael River maintains a modest baseflow in the dry season. Once storm flows reach the river, it rapidly fills and overflows the channel onto the relatively flat floodplain and contributes effluent flow south east to Cabbage Tree Creek. Downstream of the Project Area the Carmichael River catchment drains into the Belyando River.

3.2 Model selection

Two hydrologic rainfall-fall models were created, one for existing catchment conditions and one for post-development catchment conditions. A comparison of the two models was required to quantify the change in flood flows in the Carmichael River due to the mine project, and provide design flows in the diversion drains. The resulting runoff hydrographs were used as input to the existing and developed conditions hydraulic flood models as described in Section 4 and Section 10.

CatchmentSIM software was used to define the regional contributing catchment, delineate subcatchments and identify stream networks. XP-RAFTS software was used to route the runoff from the contributing catchments into the Carmichael River and produce peak flows hydrographs.

CatchmentSIM software, by Catchment Simulation Solutions, automatically delineates catchments and calculates catchment properties according to a GID-based terrain analysis system. It utilises input topography data to delineates stream networks based on Horton stream ordering. It further calculates catchment properties including area, catchment slope, flow path lengths, bifurcation ratio and drainage density. Outputs include nodal link networks formatted as run files for standard hydrologic modelling software including XP-RAFTS.

XP-RAFTS hydrologic modelling software is based on the RSWM model developed by the Snowy Mountains Engineering Corporation (SMEC) and is an industry standard rainfall-runoff routing analysis package. It is capable of modelling changes due to development for both rural and urban sub-catchments and is an accepted model used to quantify flood flows from catchments as specified in Australian Rainfall & Runoff (1999).

XP-RAFTS estimates the runoff hydrograph from an individual sub-catchment based on rainfall intensities, temporal patterns and the definition of parameters describing the sub-catchment characteristics. These parameters include the sub-catchment area, slope, roughness and fraction of impervious area. Sub-catchment outflow hydrographs are routed downstream through the model via links (either lag links or routing links) that connect these sub-catchments.

3.3 Model inputs

3.3.1 Rainfall

Design rainfall coefficients are summarised in Table 1. The coefficients describe the Log-Pearson Type III distribution which generates design rainfall intensities for up to and including 100 year ARI as recommended by Book 6, Volume 1 AR&R (1998). The resulting rainfall intensities are presented in Appendix A. For the rainfall intensities of greater than 100 year ARI, the FORGE method was used for the regional hydrologic model. For the local, FORGE data was used but adjusted to remove the aerial reduction factor. FORGE method results are presented in Appendix A.

Table 1 Rainfall intensity variables for Carmichael Mine (BOM IFD 2011)

	Duration (hr)	Intensity
2 Year ARI	1	38.83
	12	6.21
	72	1.86
50 Year ARI	1	80.66
	12	12.42
	72	3.75
G (skewness) coefficient		0.050
F2 (2 year ARI) coefficient		3.98
F50 (50 year ARI) coefficient		16.40

3.3.2 Other parameters

The following model parameters were adopted as inputs to the hydrologic model:

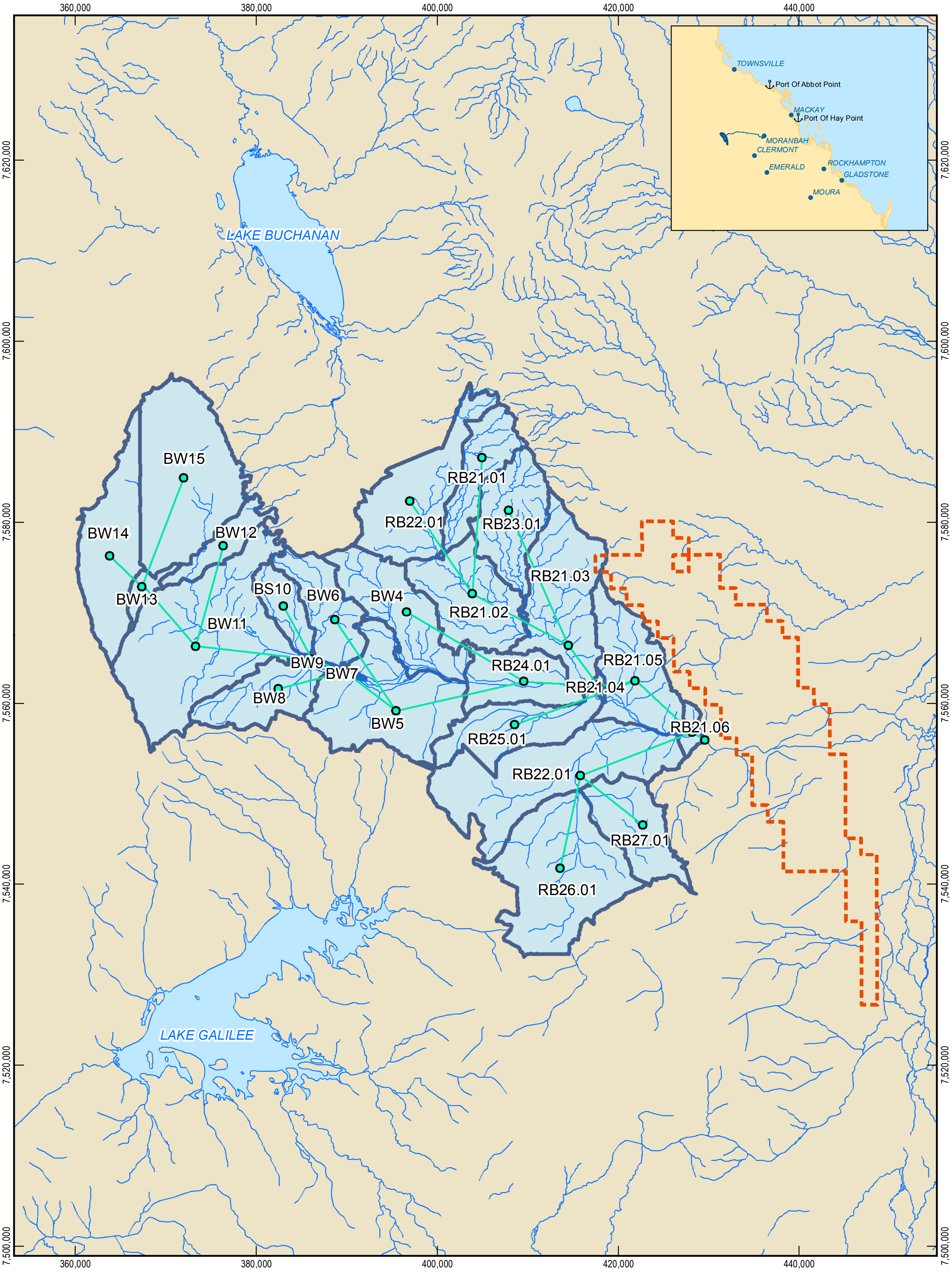
- *Design Rainfall Losses* – 25 mm initial loss and 2.5 mm continuing loss were adopted as recommended in Vol 1 AR&R 1998
- *Design Temporal Patterns* – Design temporal patterns for Zone 3 from AR&R 1989 were adopted for up to the 100 year ARI event. For the 1000 year event the GSDM and GSTMR temporal patterns were applied depending on the storm duration (BOM, 2003; BOM, 2005)
- *Manning's 'n'* – A coefficient of 0.045 for sparse vegetation was adopted for the floodplain (DERM, 2007)
- *Imperviousness* – An imperviousness of 2 per cent was chosen as an estimate for "grazing" rural surfaces
- *Lag Times* – Lag times were calculated by CatchmentSIM (Catchment Simulation Solutions 2009) using the Bransby-Williams equation on the generated subcatchments and their corresponding longest flow paths

3.3.3 Subcatchment delineation

Identification and delineation of the Carmichael River catchment was undertaken using the software CatchmentSIM. A GIS-based terrain analysis system, CatchmentSIM enables the creation of a DEM and the mapping of drainage paths from any point. From this it automatically delineates subcatchment and stream networks including hydrologic attributes such as area, equal area slope and maximum flow path length. It also generates files to input to hydrologic models including XPRAFTS.

For the Carmichael River catchment, a 20 m grid was generated in CatchmentSIM using both regional 10 m contour and the mapped regional streamlines from the Department of Environment and Resource Management (DERM). Horton Order delineation was used to generate the subcatchments using second-order streamlines.

Subcatchment areas as summarised in Appendix A (refer Figure 3-1 for the Carmichael River and Figure 3-2 for the local waterways) were identified as being contributers to the flooding of the Carmichael River within the mine site using CatchmentSIM analysis. These sub-catchments formed the basis for the hydrologic model of existing conditions.



LEGEND

- XP-RAFTS Model Node
- XP-RAFTS Model Link
- Watercourse
- State Road
- Other Rail Network
- Mine Lease Area
- Carmichael Regional Subcatchments
- Waterbody

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 5 10 15 20

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 Preliminary
Flood Mitigation and Creek Diversion Design

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

Carmichael River Hydrology - Existing — Figure 3-1

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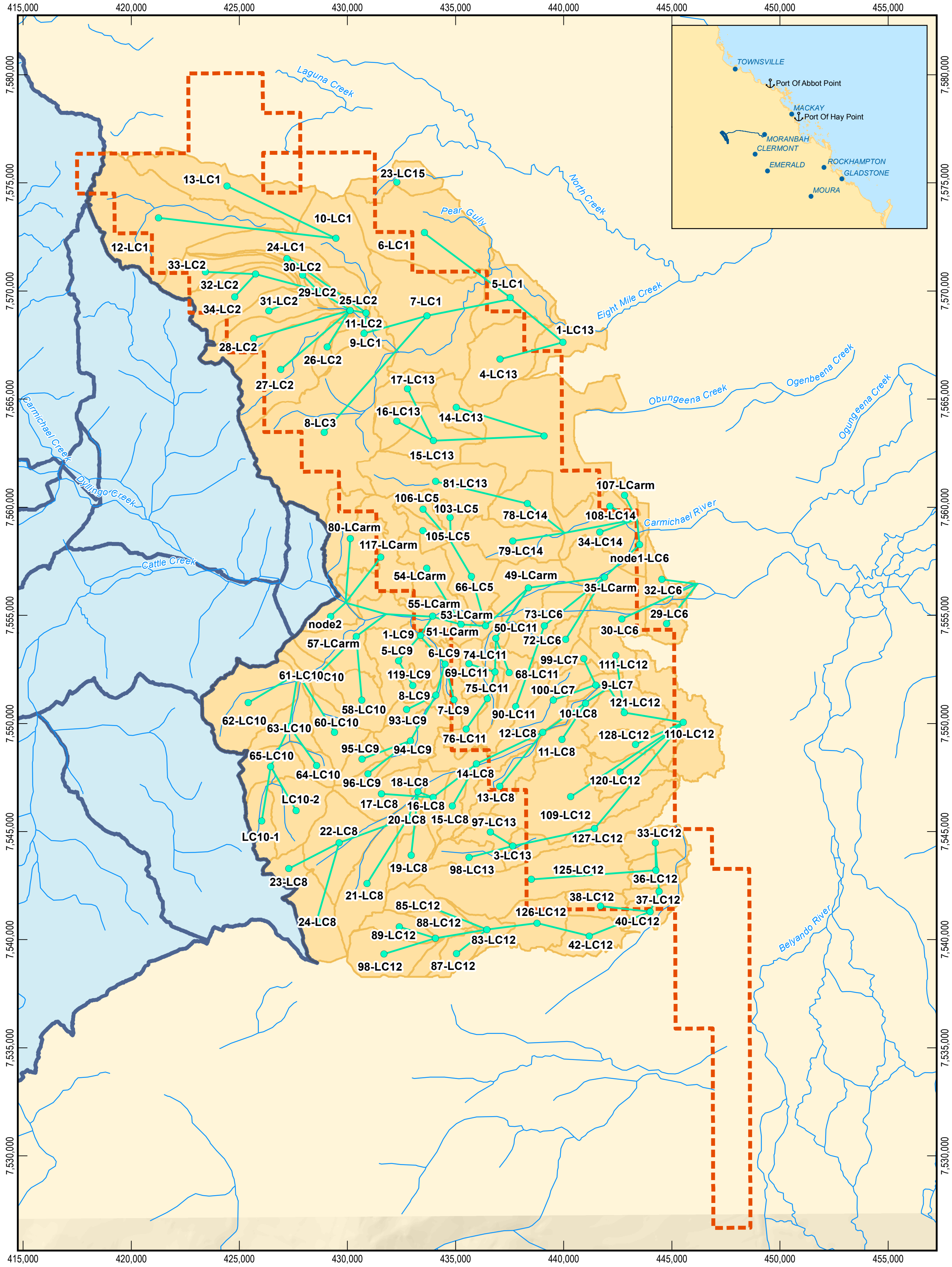
Level 4, 201 Charlotte St Brisbane QLD 4000 T +61 7 3316 3000 F +61 7 3316 3333 E bnemail@ghd.com W www.ghd.com

Data Source: DERM: State Road (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse, Waterbody (2007); GHD: Subcatchment Boundaries, XP-RAFTS Model Data (2011); Created by: BW, CA



LEGEND

- XP-RAFTS Nodes
- XP-RAFTS Links
- Watercourse
- Mine Lease Area
- Carmichael Regional Subcatchments
- Mine Local Subcatchment

1:250,000 (at A4)

0 1 2 3 4 5

Kilometres

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

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Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

Local Hydrology -
Existing

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

Figure 3-2

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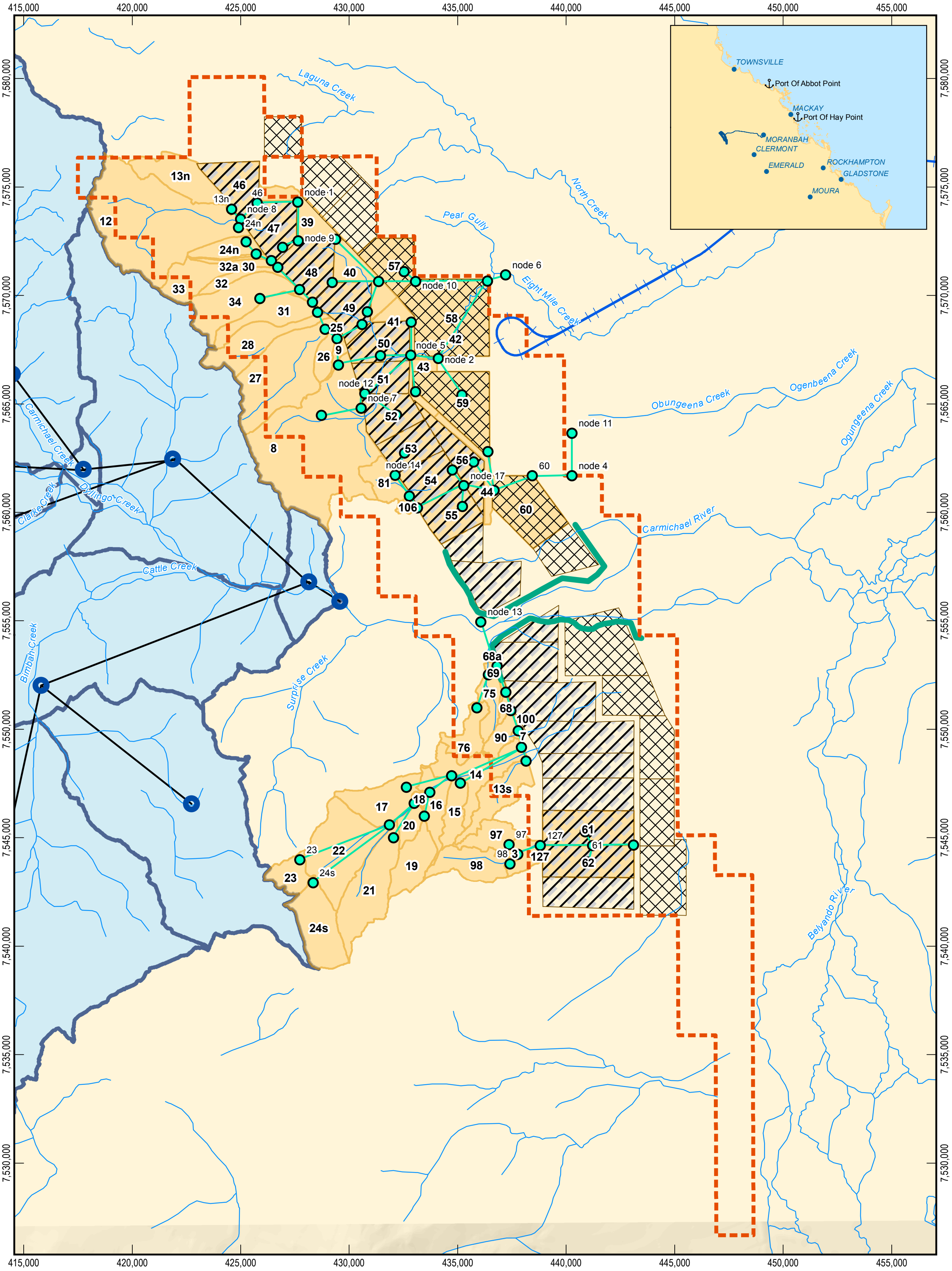
Data Source: DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Watercourse (2007); GHD: Subcatchment Boundaries, Model Data (2012); Created by: BW, CA

In order to determine the post-development hydrologic conditions, ArcGIS was used to intersect the proposed mine layout with the existing subcatchment areas. This allowed the change in subcatchment area to be calculated, taking into account the development of new terrain and diverted or collected runoff areas. In order to protect the internal mine area from receiving the runoff of subcatchments outside of the MLA, those streams currently passing through the mine area will be diverted. The post-development condition for the mine can be seen in Figure 3-3, which shows the sub-catchment areas to be diverted through the mine site at various stages of the mine operation.

For the purposes of this study, the change in subcatchment area was assumed to not impact the equal area subcatchment slope which helps define catchment response time.

Upstream of the MLA boundary, flows in the Carmichael River will be unaffected by the mine development. However, within the MLA boundary the Carmichael River will receive additional flood flows from one of the proposed diversion drains which collects local runoff along part of the western boundary of the mine, as described in Section 5. In addition, the development of the internal mine areas will change or remove a number of subcatchment areas that previously contributed to the Carmichael River.



LEGEND

- Carmichael Catchment Node
- Local XP-RAFTS Node
- Local XP-RAFTS Link
- Carmichael Catchment Link
- Watercourse
- Project (Rail)
- Proposed Carmichael River Levees
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Carmichael Regional Subcatchments
- Local Diverted Subcatchment

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0 1 2 3 4 5

Kilometres

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

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GHD adani

Adani Mining Pty Ltd
Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design
Local Hydrology -
Developed

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

Figure 3-3

Data Source: DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse(2007); Adani: Alignment Opt9 Rev3, Open Cut Areas, Waste Areas (2012); GHD: Subcatchment Boundaries, XP-RAFTS Model Data, Leveesl (2012). Created by: BW, CA

3.4 Peak flow estimates

3.4.1 Carmichael River

Storms of durations ranging from 1 hour to 72 hours were modelled in the XP-RAFTS hydrologic model. The resulting peak flow rates were analysed to determine the critical storm duration and hence the peak flow for each ARI event.

For the Carmichael River, peak flows at the location of the proposed haul road and conveyor crossing are summarised for the existing conditions in Table 2 and for the post-development conditions in Table 3. Verification of the modelled peak flows is discussed in Section 3.5.

Table 2 Peak flows in the Carmichael River at the location of the proposed haul road & conveyor crossing – existing conditions

ARI	Critical Duration	Peak Flow (m3/s)
10 year	30 hr	1187.3
50 year	18 hr	2140.5
100 year	18 hr	2604.0
1000 year	6 hr	4897.8

Table 3 Peak flows in the Carmichael River at the location of the proposed haul road & conveyor crossing – post-development conditions

ARI	Critical Duration	Peak Flow (m3/s)
10 year	30 hr	1190.8
50 year	18 hr	2157.2
100 year	18 hr	2622.9
1000 year	30 hr	4965.0

Results indicate that the contribution of the diversion drains only creates a minor increase in peak flow at the haul road crossing. This is because the time of the peak flow from the relatively small diverted catchments does not coincide with the time of peak from the larger Carmichael River and therefore the addition of their hydrographs does not increase the peak flow downstream of their confluence or the duration of storm event producing the peak flow. The following effects are observed:

- *10 Year ARI Peak Flow* – No change in critical duration, 0.3 per cent flow increase;
- *50 Year ARI Peak Flow* – No change in critical duration, 0.7 per cent flow increase;
- *100 Year ARI Peak Flow* – No change in critical duration, 0.7 per cent flow increase;
- *1000 Year ARI Peak Flow* – Critical duration increase from 6 hours to 30 hours, 1.7 per cent flow increase. The change in critical duration is likely due to slight differences in catchment response due to the diverted and intercepted local catchments near the mine.

For the waterways local to the MLA, but excluding the Carmichael River, peak flows at the downstream end of each modelled runoff path for the existing conditions are summarised in Table 8 and Table 9 and at the outlet of each diversion drain for the post-development conditions in Table 10 and Table 11. Critical durations were between 2-6 hours for these subcatchments.

3.4.2 Local waterways

Peak flows within the local waterways are summarised at various locations in Table 4. This shows peak flows under existing conditions compared to those occurring in post-development conditions when diversions will be in place (reference Section 5).

Table 5 gives the peak outflows in the proposed diversion drains. These peak flows give an indication of the likely required diversion drain dimensions and form the basis of design flows for future preliminary diversion design, as demonstrated in the case study in Section 8.

Table 4 Existing and developed conditions peak flows in local waterways.

HEC-RAS Stream	CH	Ext Flow Node	Dev Flow Node	10 year ARI (m3/s)		50 year ARI (m3/s)		100 year ARI (m3/s)		1000 year ARI (m3/s)		Average change (%)
				Exst	Dev	Exst	Dev	Exst	Dev	Exst	Dev	
N2	21147	10-LC1	40	60	87	99	159	106	192	251	462	68
N2	8262	5-LC1	node 6	242	259	386	466	419	563	905	1373	28
N2	16254	7-LC1	node 5	217	148	348	265	380	320	831	808	-19
N6	1205	25-LC2	26	100	86	173	152	192	188	446	486	-5
-	-	78-LC14/ 79-LC14	44	43	63	71	113	87	136	162	347	69
S3	1307	12-LC8	14	128	131	223	234	252	284	532	696	13
S5	6053	50-LC11	68a	30	147	56	259	65	314	147	758	388
S1	0	127-LC12	15	21	10	35	18	44	22	85	59	-45
S2	238	121-LC12 (2-LC8)	0	146	0	253	0	305	0	493	0	-100

Table 5 Peak outflows from proposed diversion drains

Diversion Drain/XP-RAFTS node		10 yr ARI	50 yr ARI	100 yr ARI	1000 yr ARI
1	node 10	95.548	172.569	208.268	497.503
2	node 2	150.864	269.906	325.809	821.308
1+2	node 6	258.783	466.191	562.952	1373.107
3	node 11	76.553	137.227	165.716	416.894
4	node 13	147.226	259.127	314.138	757.639
5	node 19	41.337	94.928	115.629	307.021

3.5 Verification of Carmichael River flow estimates

3.5.1 Comparison to 1 per cent AEP flood peaks for Queensland

It should be noted that a 1 per cent AEP corresponds to a 1 in 100 year ARI. A comparison of the 100 year ARI design flow estimate predicted by the hydrologic model against 1 per cent AEP Flood Peaks obtained for a range of catchments throughout Queensland chart (see Appendix A) shows that the 100 year ARI design flow estimate of 2,600 m^3/s, as derived using the XP-RAFTS model, lies in the lower range of the typical flows per area for Queensland rivers. Typical flows indicated by the chart lay between 2000-5000 m^3/s for an equivalent catchment size of 2,000 km^2, which is the catchment area of the Carmichael River at the ML70441 boundary. Factors such as the relatively flat terrain and the relatively low rainfall are consistent with the flow estimate falling at the lower end of the typical range.

3.5.2 Flood frequency analysis

A flow frequency analysis was undertaken on recorded data from five DERM stream gauges and scaled by ratio of catchment area to the mine site using a method given in *Hydrologic Recipes* (Grayson, 1963) to enable the estimation of a 100 year ARI design flow for the Carmichael catchment . No historical stream gauges exist on the Carmichael River but the following three DERM stream gauge data stations are in the vicinity of the Adani Mine site:

- Mistake Creek at Twin Hills, Station 120309A
- Belyando River at Gregory Development Rd., Station 120301B
- Cornish Creek at Bowen Downs, Station 003204A

The following two gauges are located further away but have been used to extract comparative data:

- Cape River at Pentlands, Station 120307
- Cape River at Taemas, Station 120302

The analysis of each record undertaken by fitting a Log-Pearson Type III distribution to an annual maximum peak series found 100 year ARI flows much lower than those generally found for the contributing catchment size according to the chart of 1 per cent AEP Flood Peaks for Queensland (excepting the gauge Cape at Pentlands, 120307). Comparatively the Carmichael River 100 year ARI peak flow calculated by the hydrologic model is high. However these gauges have low quality data according to their DERM data quality codes, with only 56 per cent of the record being considered ‘normal’ or ‘good’ on average. In addition the majority of records have been obtained during a relatively dry period and the period of data collection is relatively short (the longest record commences in 1976). This makes it difficult to extrapolate rare flood events with confidence. For this reason, the much higher flows predicted by this hydrologic study were maintained as a more likely estimate of peak design flows in the Carmichael River.

It is noted that Adani has recently installed a number of stream gauges in the vicinity of the proposed mine site, however, they have not yet produced enough data to validate the model flow predictions.

3.5.3 Comparison to the *Preliminary Railway Hydrological Investigation* report (Golders 2011)

The Golders report *Carmichael Coal Mine Project: Preliminary Railway Hydrological Investigation (*2011) created a regression model based on twenty-five stream gauge results for similar catchments near to the Belyando River and within 300 km of the Adani Railway (Golder Associates, 2011). The regression curve was then fitted to the Carmichael River catchment as a function of catchment area and annual rainfall. The Golders report estimated a 100 year ARI design flow of 1200 m^3/s for the Carmichael sub-catchment at the mine site. This is approximately half of the magnitude of the 100 year ARI design flow determined by GHD's hydrologic model.

It is believed that the design flow estimates in the Golders report have a generally low level of reliability due to the relatively large confidence limits on the regression analysis, with the confidence limits ranging from 54 per cent to 101 per cent. The wide confidence limits are likely due to the regression model being based on of poor-quality data according to DERM's quality codes and generally short flow record lengths i.e. generally less than 50 years. This is also possibly due to differences in catchment size and other physical characteristics, and differences in record length.

By comparison, the design flood estimates presented in this report are based upon a rainfall runoff model of the catchment. The design rainfall intensities are based upon longer record lengths due to the greater availability of rainfall data compared to stream gauge data. At this stage of the project it is considered prudent to use a more conservative approach, i.e. to base the designs on a higher rather than lower value.

3.6 Climate change impacts assessment for local waterways

According to the Queensland Government Scientific Advisory Group (SAG) guidelines, rainfall is likely to increase or decrease by 5 per cent per degree of global warming. The Carmichael Mine is designed to be operational until 2103. The SAG recommends adopting a 4 degree increase in temperature by 2100. This corresponds to an adopted 20 per cent increase in rainfall intensity over the mine design life. By inputting these increased intensities to the hydrologic model it is possible to estimate potential peak flow rates under climate change conditions.

The rainfall intensity data altered for climate change conditions for a 100 year ARI event can be found in Appendix A. The 20 per cent increase in rainfall intensity produces an average of 35 per cent increase in runoff.

It should be noted that the 35 per cent increase in runoff is an estimate only. Other climate change scenarios are possible which may differ from those presented in this report. The risk of climate change over the period of the mine infrastructure and operations should be considered during future mine planning and design. Potential increases in peak flow rates and the resultant impact they may have on the operation of the flood protection infrastructure are of particular risk in this regard.

4. Existing flood conditions

4.1 Model selection

Hydraulic modelling (i.e. determination of water levels from flood flows and terrain data) has been undertaken for existing (pre-development) using both one-dimensional (HEC-RAS) and two dimensional (TUFLOW) hydraulic modelling software packages. A one-dimensional hydraulic modelling approach has been used to simulate minor waterways whilst a two-dimensional modelling approach has been used to model the more complex Carmichael River floodplain. The location and extent of the 2D hydraulic models is shown in Figure 4-1.

4.1.1 TUFLOW

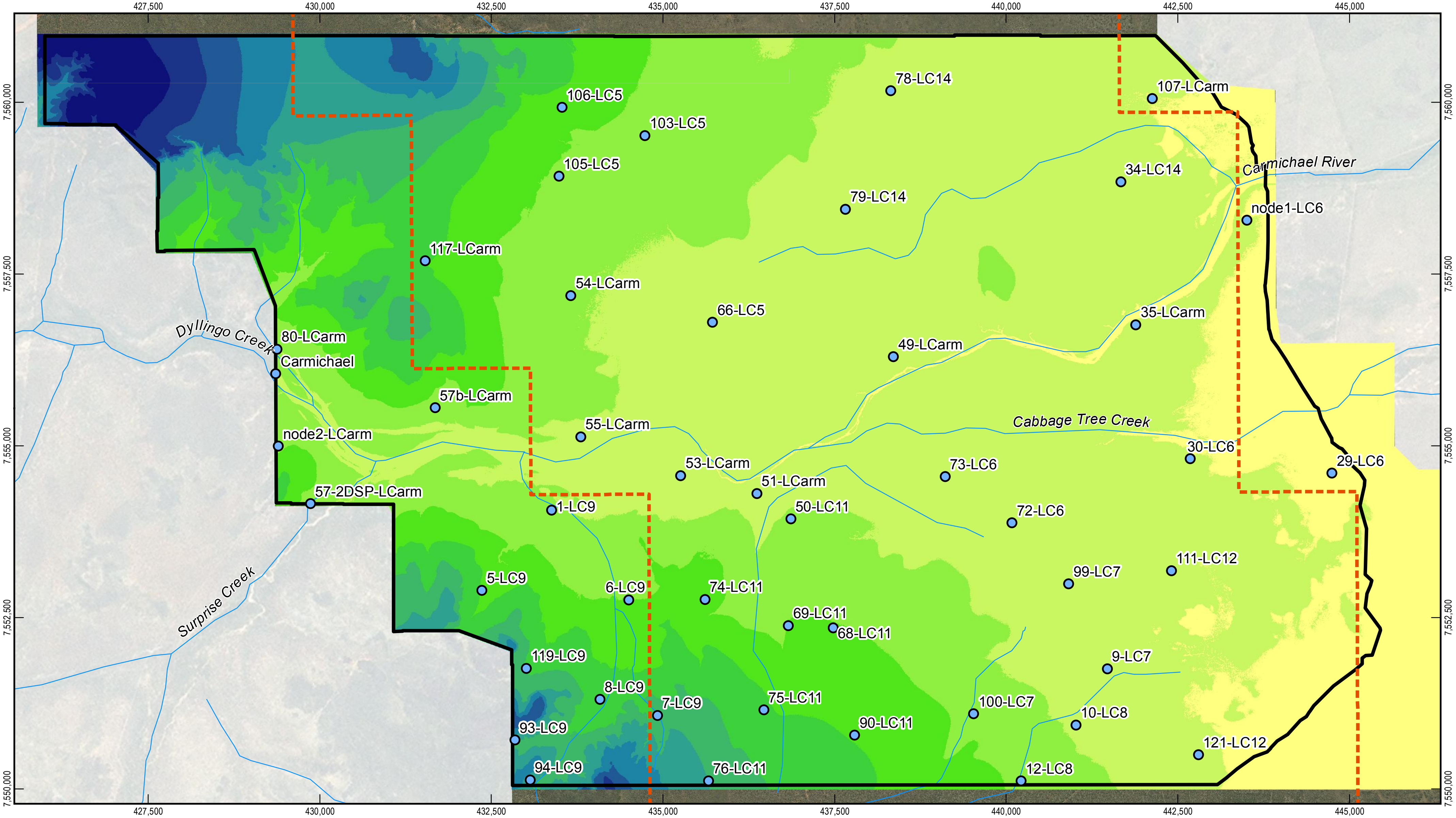
TUFLOW (WBM-BMT, 2010) is a 2D unsteady flow hydrodynamic modelling tool developed by WBM-BMT. TUFLOW is specifically oriented towards establishing flow and inundation patterns in coastal waters, rivers and floodplains as well as urban areas. TUFLOW solves the depth-averaged 2D shallow water equations for flows such as for the free-surface flows occurring from floods and tides based on the creation of an appropriate-resolution DEM, surface inflows, surface roughness and boundary conditions. TUFLOW is recognised as an industry standard 2D hydrodynamic modelling package within Australia and is well-suited to the modelling of the Carmichael River regional floodplain.

4.1.2 HECRAS

HEC-RAS was developed by the US Army Corps of Engineers Hydrologic Research Center. The software performs one-dimensional steady and unsteady flow calculations. For this study, a steady flow analysis was performed. HEC-RAS utilises cross sections to represent the geometry and conveyance capacity of the waterways and is capable of both subcritical and supercritical hydraulic analyses. This makes it suitable for analysis of existing minor watercourses and design diversion drains where a variety of slopes may create subcritical or supercritical flows.

4.2 Carmichael River hydrodynamic model

Hydraulic modelling was undertaken for the 10, 50, 100 and 1000 year ARI design events with a model time step of five seconds. All the inflow hydrographs were sourced from the hydrologic models described in Section 3.



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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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LEGEND

- Inflow Source Point
- Watercourse
- 2D Model Extent
- Mine Lease Area

m (AHD)

210 - 220	240 - 250	280 - 290
220 - 230	250 - 260	290 - 300
230 - 240	260 - 270	300 - 310
	270 - 280	310 - 320

GHD adani

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Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

Carmichael River Hydrodynamic Model - Existing

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

Figure 4-1

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Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse (2007);
GHD: Inflow Source Points, DEM (2011); Created by: BW, CA

4.2.1 Digital elevation model

In order to represent the Carmichael River floodplain in the vicinity of the mine site, a 10 m x 10 m digital elevation model was developed over an area of approximately 17,700 ha (refer Figure 4-1) using aerial survey data provided by Adani Pty Ltd.

A cell size of 10 m by 10 m was adopted to adequately represent the bathymetry and topography of the study area whilst limiting model run times to an acceptable length of time. The extent of the digital elevation model (which forms the basis of the 2D hydraulic model) was selected to:

- Accommodate the post development flood flows and levels as well as existing conditions.
- Cover likely upstream and downstream development impacts, noting that the flood extent is only known after the modelling has been done.
- Include key hydraulic controls, including significant existing upstream and downstream road and railway alignments.
- Allow for modelling of complex flow interactions.
- Enable appropriate boundary conditions to be applied.
- Reduce boundary condition effects in areas of the model where results are more important.

4.2.2 Inflow boundaries

A major inflow boundary condition was applied at the western (upstream) boundary of the hydraulic model. This boundary simulates the in-channel flow of the Carmichael River that arises from its natural catchment at that point. Additional 'source point' inflows representing runoff from the minor local sub-catchments internal to the model area were also applied. The location of these boundaries is shown in Figure 4-1.

4.2.3 Tailwater conditions

A 'free outfall' method was adopted for the tailwater conditions around the boundary of the model. The water surface profile was analysed and showed that boundary effects were localised to approximately 200 m from the edge of the model and therefore the flooding within the MLA was not significantly affected.

The existing conditions 2D hydraulic model was tested for sensitivity to tailwater conditions by simulating the 1000 year ARI flood event with various higher and lower tailwater levels. The effects of these changes were again limited to the proximity of the model boundary and did not affect flood conditions within the MLA.

4.2.4 Hydraulic roughness

Manning's roughness coefficients were determined through a field inspection of the floodplain. In addition, recent aerial photographs were used for further assessment and comparison of the assigned roughness values. It is noted that the adopted values were selected based on recognised references and engineering judgement. There are no sets of recorded flood levels for a gauged flood flow close enough to the mine site to be of use in the calibration. The gauges mentioned in Section 3 being much too far away. Verification and / or calibration of the hydraulic model is not possible.

The adopted roughness coefficient for the floodplain surface was 0.045, as recommended by industry recognised references for 'sparse vegetation'.

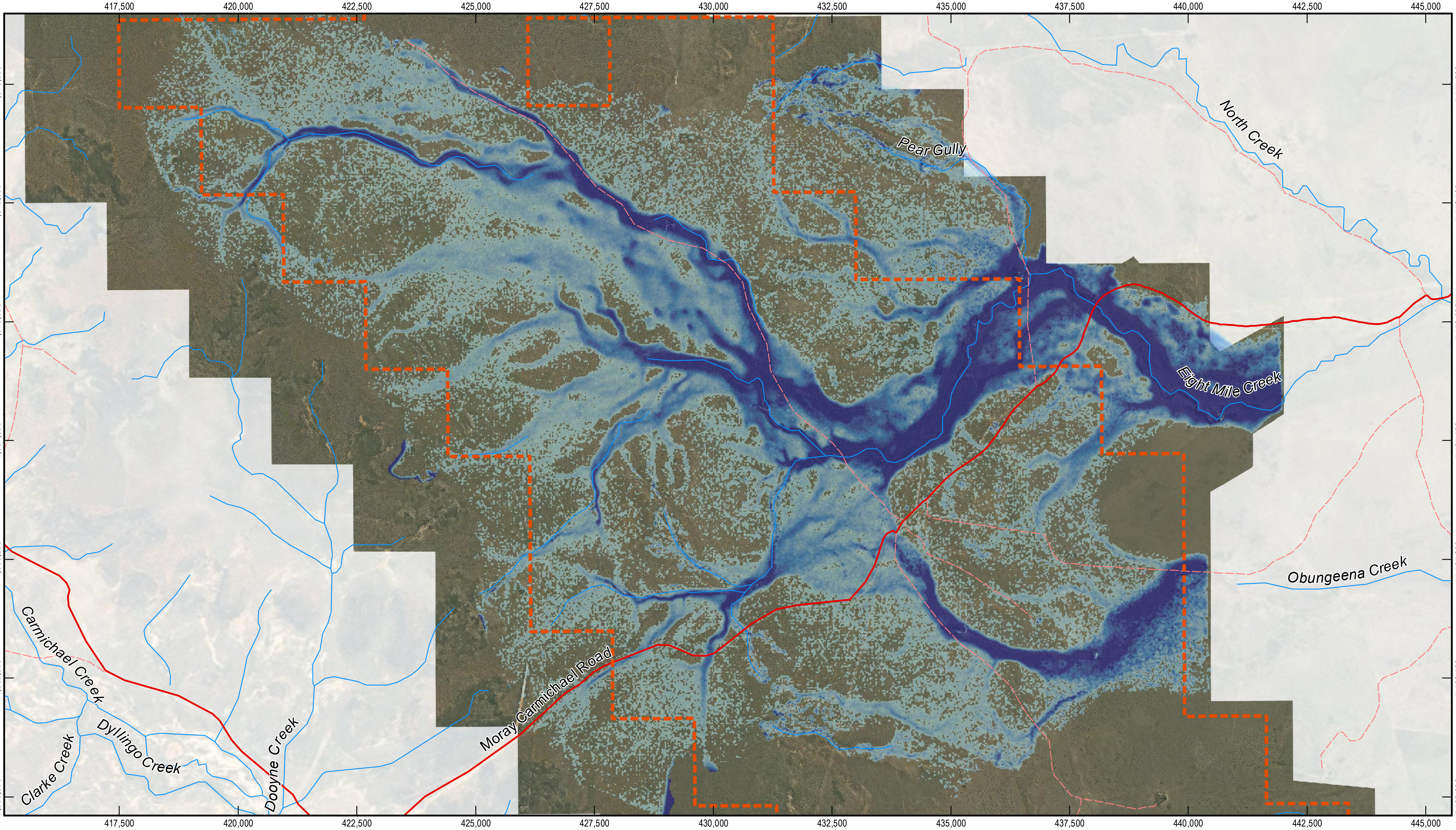
4.3 Minor waterways flood assessment

4.3.1 Topographical analysis

Some regions within the MLA have a flat topography with undefined drainage paths during major flood events. A rough “rain-on-grid” 2D hydraulic model was created to clarify the likely drainage pattern. This was run with dummy rainfall applied directly to each grid cell within the model to assess the likely patterns of flow in waterways and over open land (Figure 4-2). Results from this informed the HEC RAS modelling and also the conceptual diversion drain design as proposed in Section 5.

4.3.2 1D model overview

One dimensional hydraulic models (i.e. HEC-RAS models) were developed to determine existing flood condition water levels in waterways within the mine footprint, but not in the Carmichael River. These creeks or gullies generally traverse the mine site from west to east. One HEC-RAS model was established that included all five of the creeks or gullies that were modelled. The extent of the waterways assessed using a 1D hydraulic modelling approach and the location of the each HEC-RAS cross section is shown on the Figure 4-3.



1:110,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

LEGEND

- Watercourse
- Track
- Minor Road
- Mine Lease Area

Indicative Topographic and Hydraulic Analysis

- More Water
- Less Water

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Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

Job Number	41-25215
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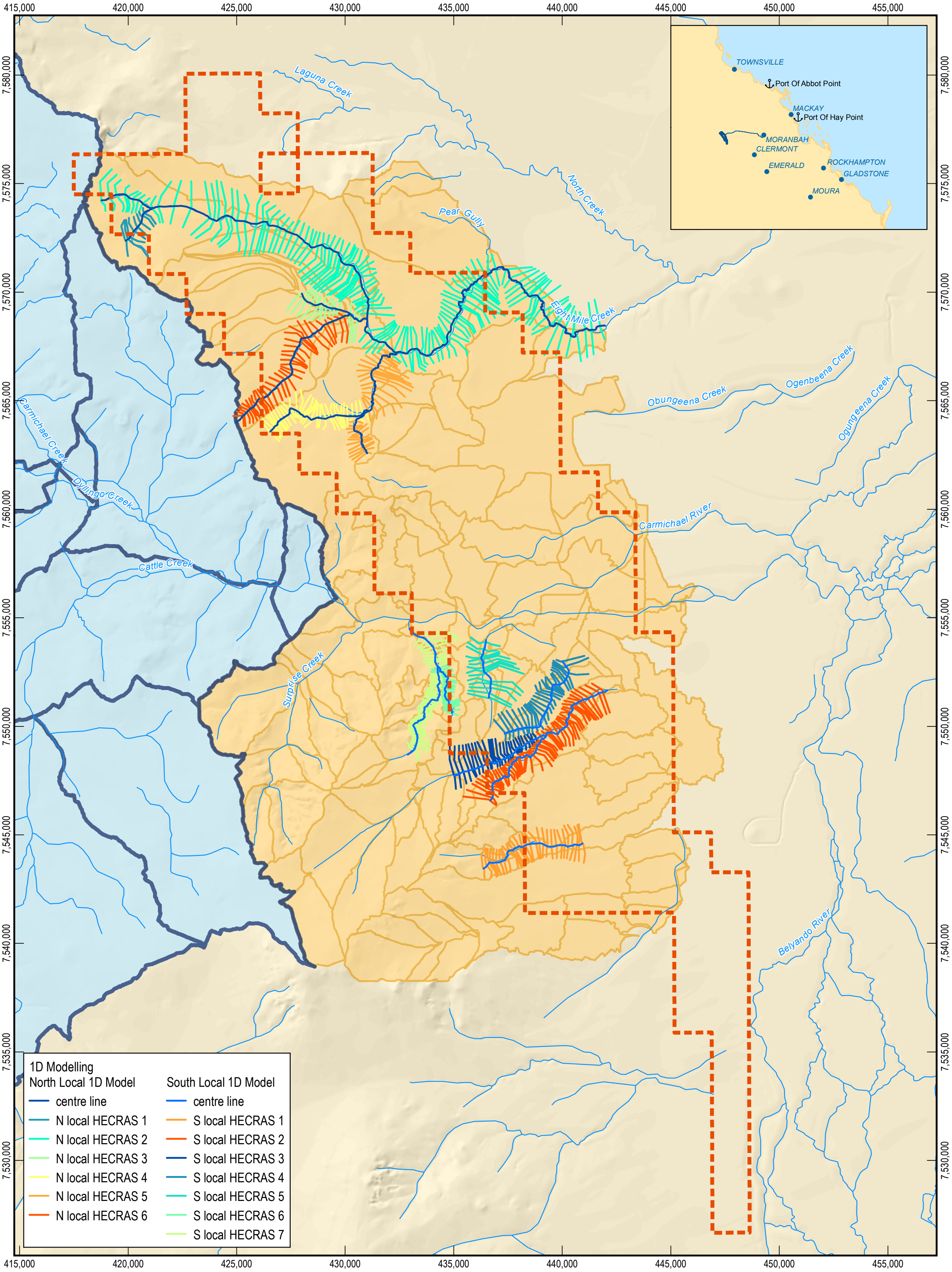
Indicative Topographic Drainage Analysis

Figure 4-2

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_559_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007);
GHD: Drainage Modelling (2012); Created by: BW, CA



LEGEND

- Watercourse
- Mine Lease Area
- Carmichael Regional Subcatchments
- Mine Local Subcatchment

1:250,000 (at A4)

0 1 2 3 4 5

Kilometres

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

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Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design
Local Waterways 1D Hydraulic Model - Existing

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

Figure 4-3

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Data Source: DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Watercourse (2007); GHD: Subcatchment Boundaries, Model Data (2012); Created by: BW, CA

4.3.4 Model parameters

In order to represent the surface roughness, a Manning's roughness coefficient of 0.045 was applied.

The boundary conditions applied to the hydraulic model include steady state peak inflows at the upstream boundary, changing along the chainage of the stream to represent inflows. A normal depth tailwater condition was adopted at the downstream extent as no other overriding hydraulic control is expected to influence these waterways during local flooding. Peak inflows are summarised in Table 6 and Table 7 as calculated by the hydrologic models described in Section 3.

Table 6 Peak flow conditions in minor waterways local to the north of the Carmichael MLA – existing conditions

		Total Q (m3/s)			
HEC-RAS Stream No	**Applied Chainage**	**10yr**	**50yr**	**100yr**	**1000yr**
S1	2053	10	16	17	40
S10	6928	9	14	15	36
S10	4269	35	56	60	144
S2	3590	36	65	71	168
S2	2337	49	88	98	229
S2	1790	53	96	107	250
S2	1571	100	173	192	446
S2	777	100	173	192	498
S2	476	113	194	214	498
S3	7573	10	16	17	41
S3	4692	20	32	34	82
S4	5510	18	28	30	72
S5	34907	10	16	17	41
S5	32245	30	48	50	121
S5	29242	48	76	81	196
S5	25497	60	99	106	51
S5	24078	60	99	106	251
S5	18254	165	266	294	638
S5	16254	217	348	380	831
S5	7033	242	386	419	905
S5	6008	242	386	417	905
S5	3463	253	401	343	930

Table 7 Peak flow conditions in minor waterways local to the south of the Carmichael MLA – existing conditions

		Total Q (m3/s)			
HEC-RAS Stream NO	**Applied Chainage**	**10yr**	**50yr**	**100yr**	**1000yr**
N1	5323	14	27	32	74
N1	3713	22	44	53	122
N1	3299	23	45	54	124
N2	9187	6	12	13	31
N2	7874	13	24	26	62
N2	5121	133	232	161	551
N2	4214	133	232	161	551
N3	4937	100	178	200	434
N3	3692	117	207	234	499
N3	1684	128	2331	252	532
N4	5464	9	15	17	40
N5	8860	15	28	33	75
N5	7325	23	43	50	113
N5	6386	30	56	65	147
N6	2614	7	14	19	40
N7	7381	31	61	74	166
N7	5082	39	77	95	208
N7	2383	40	98	118	257
N7	1450	64	122	144	318

4.4.4 1000 year ARI event

To the south of the Carmichael Mine flooding is still relatively contained to the Carmichael River corridor. However, the combined effect of incoming overland runoff over a flat plain and Carmichael River breakout flow creates flooding a distance of 3 km across proposed Pit K to the north of the main channel, much of it between 0.5 to 1.0 m deep.

To the east of the MLA, almost the entire 2D model extent is inundated to 0.5 m or more, with almost half of the proposed Pit L area experiencing depths of approximately 1.2 m. The local flooding model indicates substantial flooding across the mine site across the proposed areas of Pit N and M.

The nature of flooding of minor waterways to the north and south does not change significantly from the 10 year ARI event, however extents along the defined runoff paths typically increase by 25 m and up to 250 m in the larger flat inundated area to the east.

4.4.5 Sensitivity analysis

A sensitivity analysis was undertaken on the 1000 year ARI existing condition event by raising and lowering the applied tailwater condition. This event was selected for sensitivity testing as it has the most significant bearing on the design of the flood protection levees. Results indicate that changing the tailwater level by this plus or minus 1 m did not have a significant impact on flood levels in the vicinity of the mine site, with a maximum difference of 7 mm over the predicted flood level. Therefore it was concluded that the flood extents are relatively insensitive to the adopted tailwater conditions.

5. Conceptual staged drainage and flood protection scheme

5.1 Mine stages

Consistent with other technical reports and the EIS, the conceptual staged drainage and flood protection scheme was prepared with consideration of the selected staged mine plans. The selected stages are: 2013, 2014, 2015, 2016, 2017, 2027, 2037, 2047, 2067 and 2103.

5.2 Description of drainage scheme

The drainage scheme was designed with the intention of protecting the active mine areas from flooding while also retaining natural channels wherever practical. To achieve this, minor and major levees, diversion drains, culverts and waterway crossings are recommended.

Diversion drains will divert existing local watercourses and also receive inflow of runoff from the subsidence areas over the underground mining areas. Subsidence is expected to reach 7 m in some areas (SCT 2011).

The management of surface water, including the design of levees, diversion drains, culverts, crossings and other minor drainage features, needs to be considered during all subsequent phases of mine design, construction, operation and maintenance. The preliminary consideration of these issues presented in this report is based on staged mine plans that are separated by up to 40 years, meaning that drainage and flooding issues that occur in the intervening years cannot be identified or resolved at this time.

Summary figures are provided showing the progression of the drainage scheme across the mine life for the selected mine staged plans (references Figure 5-1 to Figure 5-10.)

5.2.1 Levees

Minor levees are suggested to protect open cuts areas from local flooding from local waterways at various stages of mine progress as follows:

- Inflows to Eight Mile Creek in the earlier stages of the mine life (see Progress Plot – Year 2014 to Year 2017).
- Either side of Eight Mile Creek inflow at the eastern edge of the MLA so as to safely pass the existing waterway between out of pit waste dump areas (see Year 2015 onwards).
- Local waterways crossing the north west corner of the MLA (see Year 2027).
- Bottom south east corner of MLA (see Year 2067).
- Other levees to protect underground mine access areas from either local or regional flooding (to be designed when the locations of these access areas are confirmed).
- Other minor levees as necessary to protect open cut pits and other infrastructure from local runoff (all years).

Major levees either side of the Carmichael River corridor are included from year 2047 (southern levee) and 2067 (northern levee). These are wrapped around active open cut pits and out-of-pit waste dump areas to protect the mine from river flooding, while allowing flows to enter the head of the Cabbage Tree Creek effluent flow path.

5.2.2 Diversion drains

Diversion drains that cater for external catchment flows have been proposed at various locations as shown on the progress plots. These have been designed with consideration given to the current mine plan and the existing topography, following existing grades to reduce the amount of excavation. At times these drains are located between open cut pit areas and so need to be considered during any subsequent design of the pits. Diversion drain alignments have been chosen with due consideration of conceptual infrastructure such as haul roads and conveyors where such information is known. However, this conceptual study has been undertaken before any detailed consideration of such infrastructure has been undertaken.

The existing watercourses have been maintained where possible. Drain discharge points have also been designed to closely mimic existing drainage paths and maintain inflows to waterways to the east of the MLA.

Acknowledging the current state of mine planning, efforts were made to optimise the locations of the diversion drains with due consideration given to the above-mentioned issued.

The preliminary conceptual design of a single diversion drain is undertaken in Section 8. This drain is required near the start of the mine development and is one of the largest of the required diversions, and as such is an appropriate demonstration of the general requirements for the other drains which will be designed at a later stage.

Other diversion drains not shown on the progress plots will be required to cater for internal and local runoff, and so will drains necessitated by the development of mine infrastructure in the intervening years between mine stages.

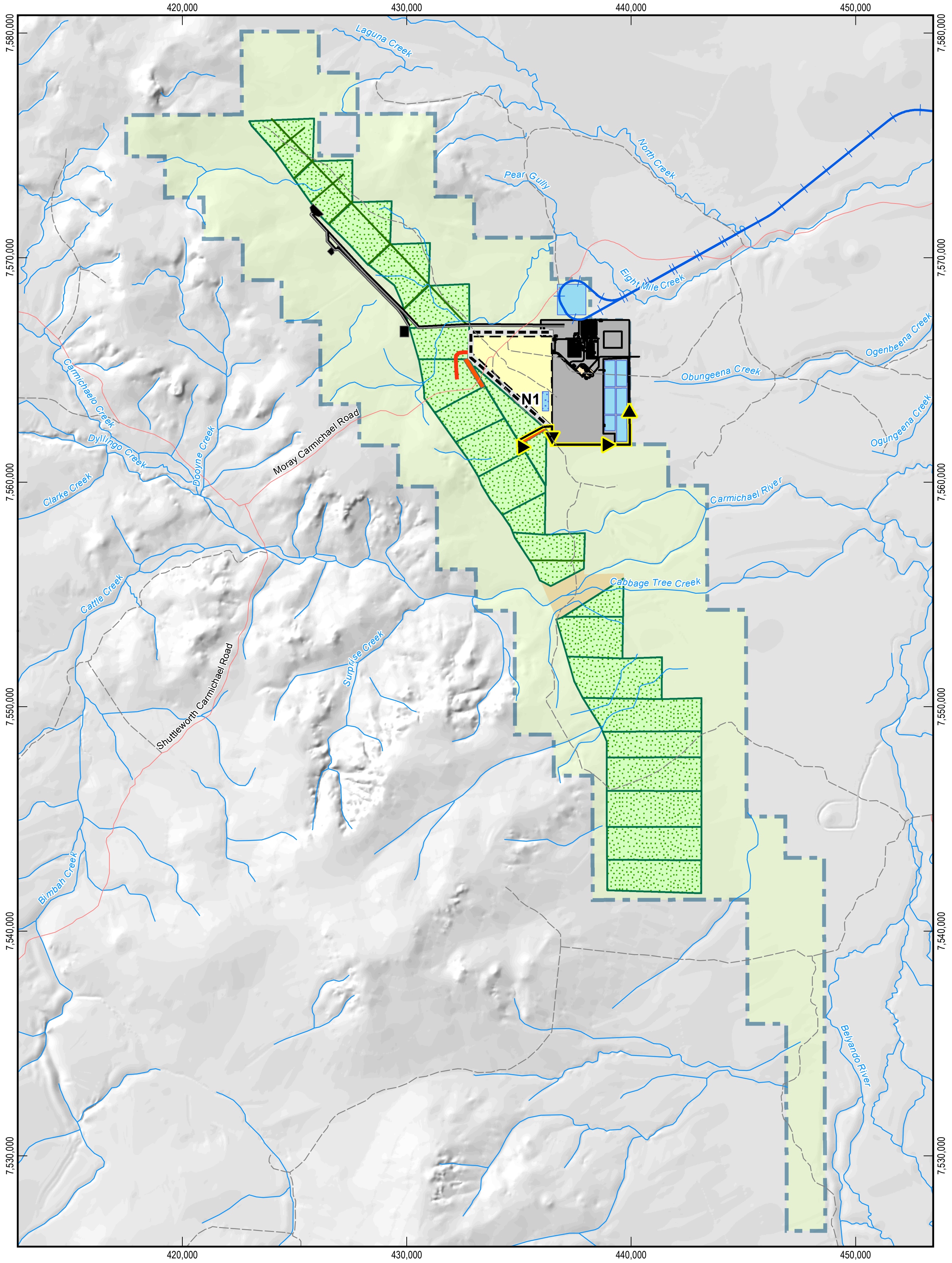
5.2.3 Culverts and crossings

Culverts and creek crossings will occur at multiple locations along the haul road and overland conveyor. Based on the location of mapped creeks and watercourses, three crossings will be needed up to year 2037 and seven from thereon after.

A bridge will be required to pass the haul road and conveyor across the Carmichael River and connect the southern mine area with the northern. This is first required in Year 2047. Preliminary design of this bridge is described in Section 7.

5.2.4 Subsidence management

Subsided areas over the underground mining area will drain into the proposed diversion drains. This local drainage will be constructed as needed across the life of the mine. To facilitate the transfer of flows from future local subsidence drainage schemes the diversion drain invert has been lowered by 7 m relative to existing levels in the expected subsidence areas. If actual subsidence is found to differ from the current assumption, it will be necessary to make appropriate adjustments to the drainage design.



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Active Mining Area
- Out of Pit Waste Dumps
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2013

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Figure A1

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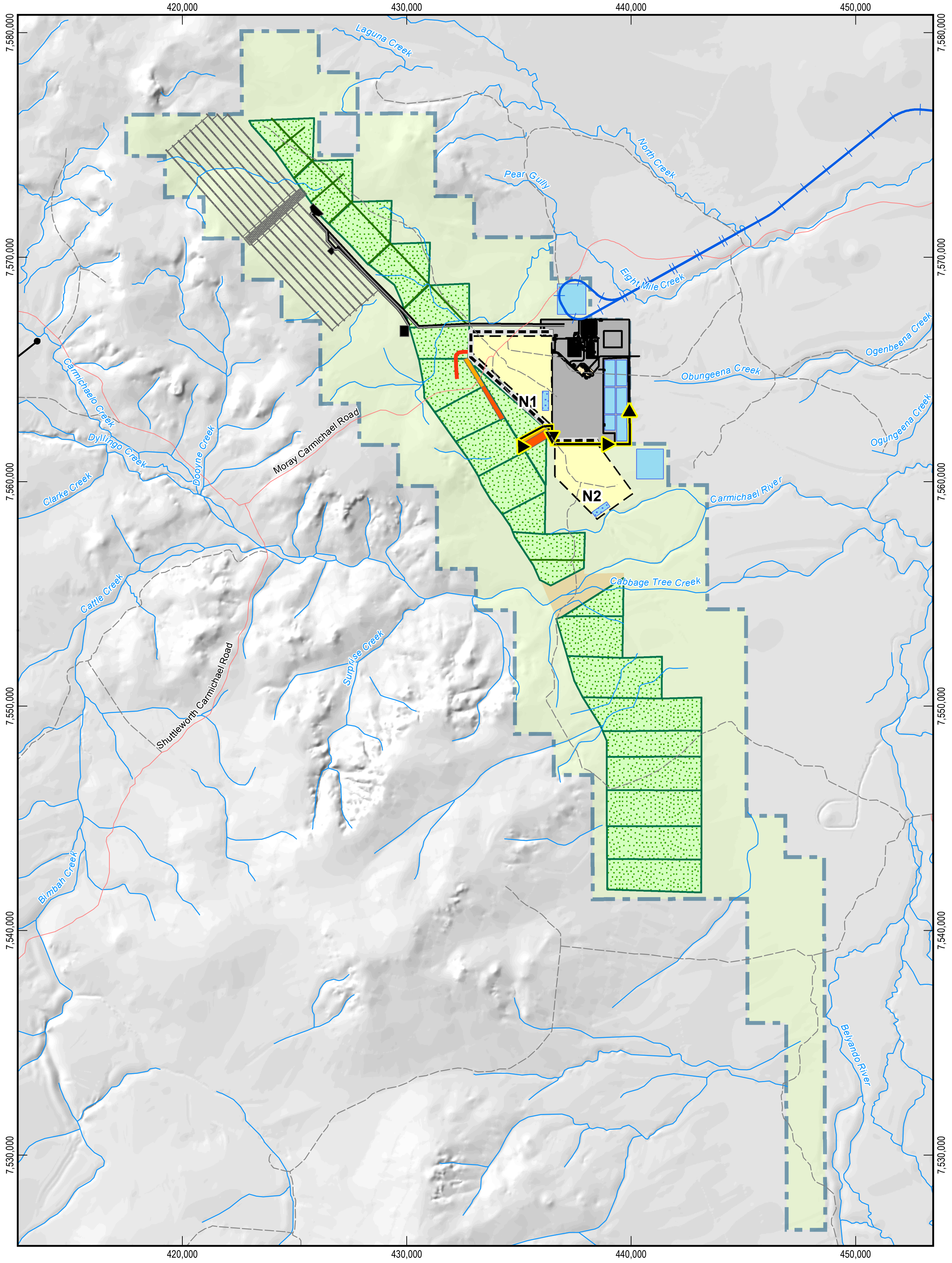
Adani: Alignment Opt9 Rev3, Mine Layout/Infrastructure (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA



LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

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Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2014

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Figure A2

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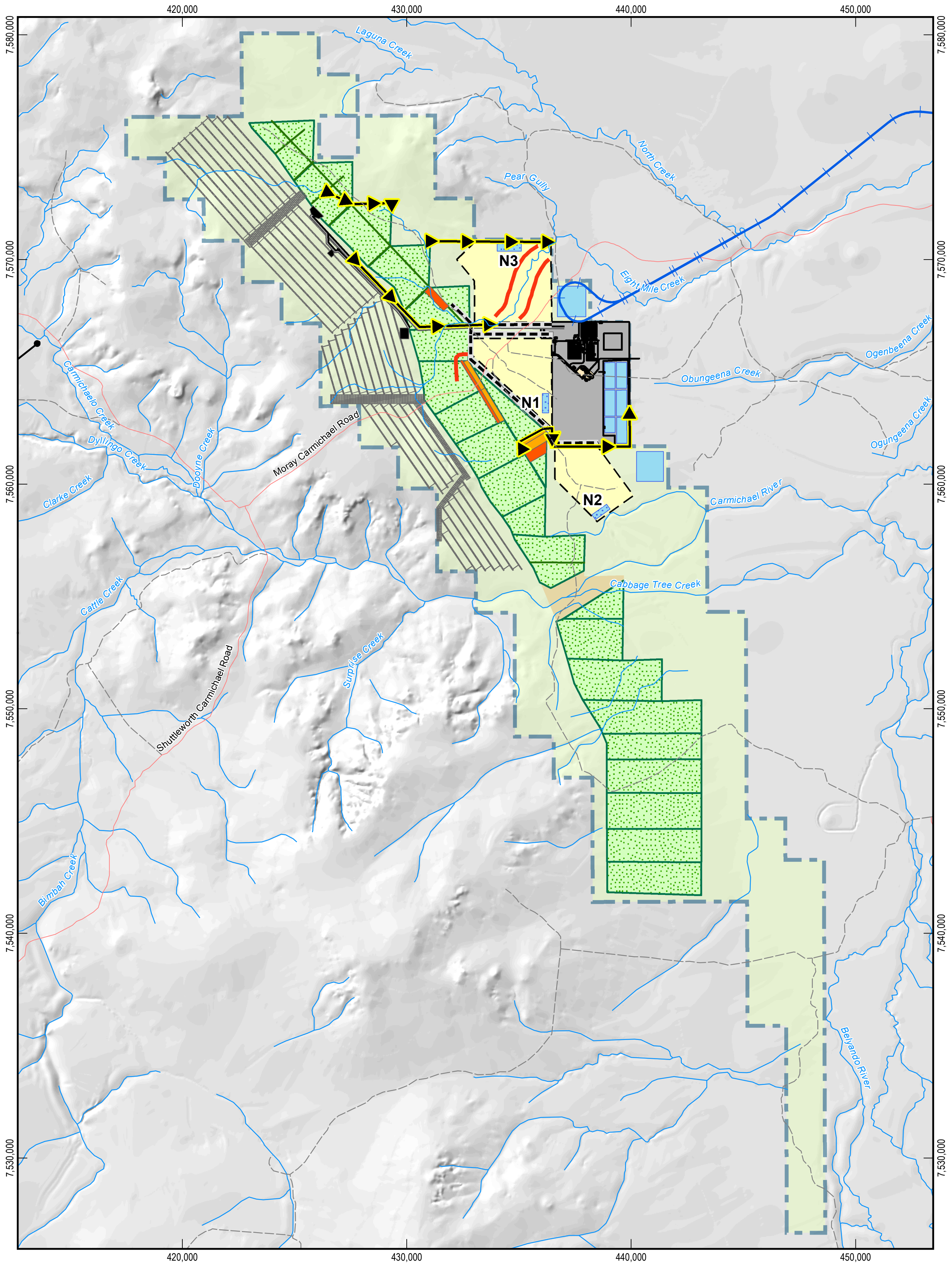

LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Levee	Disturbed Mining Area	Mine Lease Area
Watercourse	Haul Road	Water Management Dams	
Overland Conveyors	Out of Pit Waste Dumps	Sediment Basins	

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2015

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Date | 28-08-2012

Figure A3

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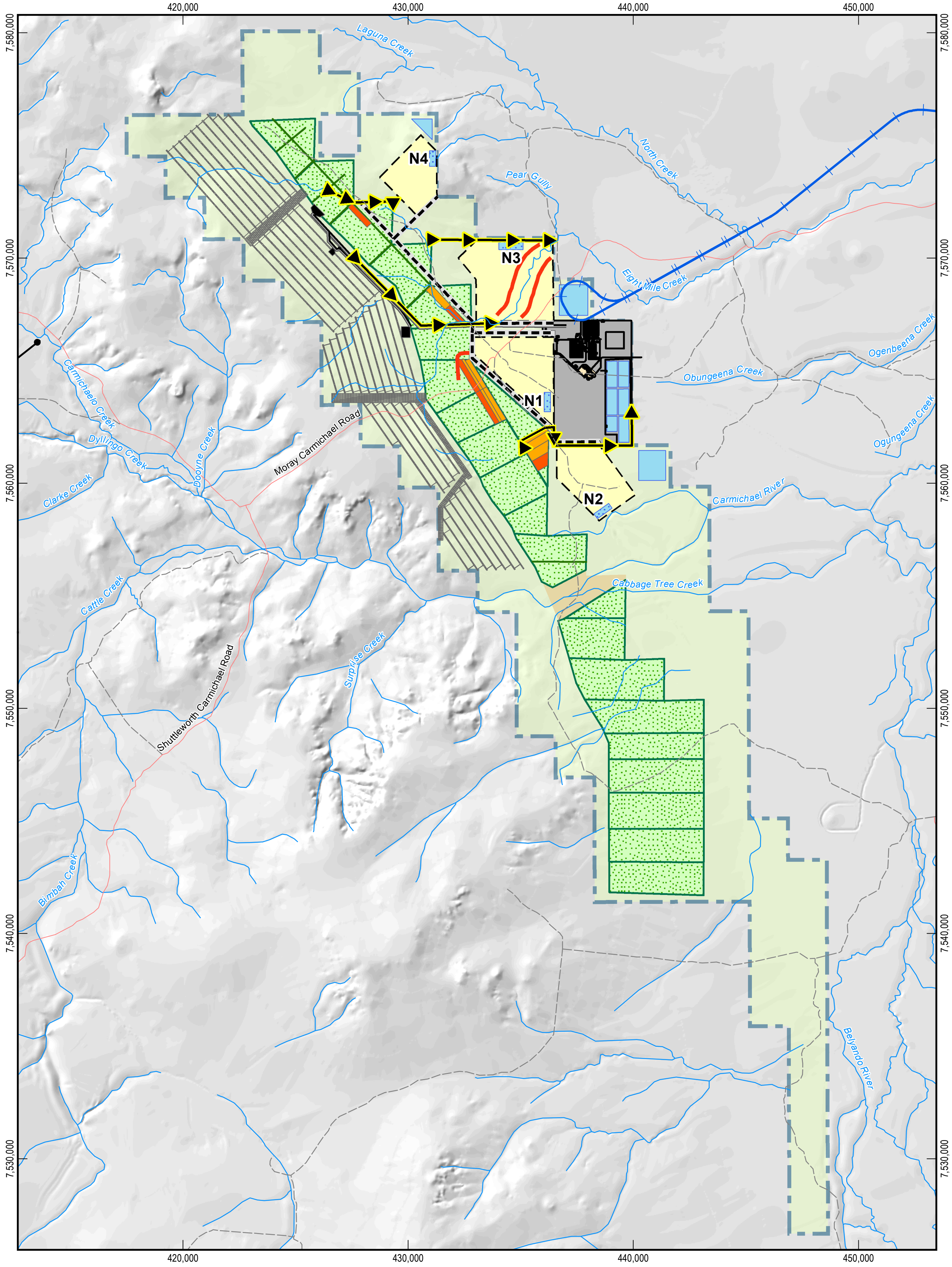

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

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
Preliminary Water Balance

Mine Layout Progress Plot - Year 2016

Job Number	41-25215
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Figure A4

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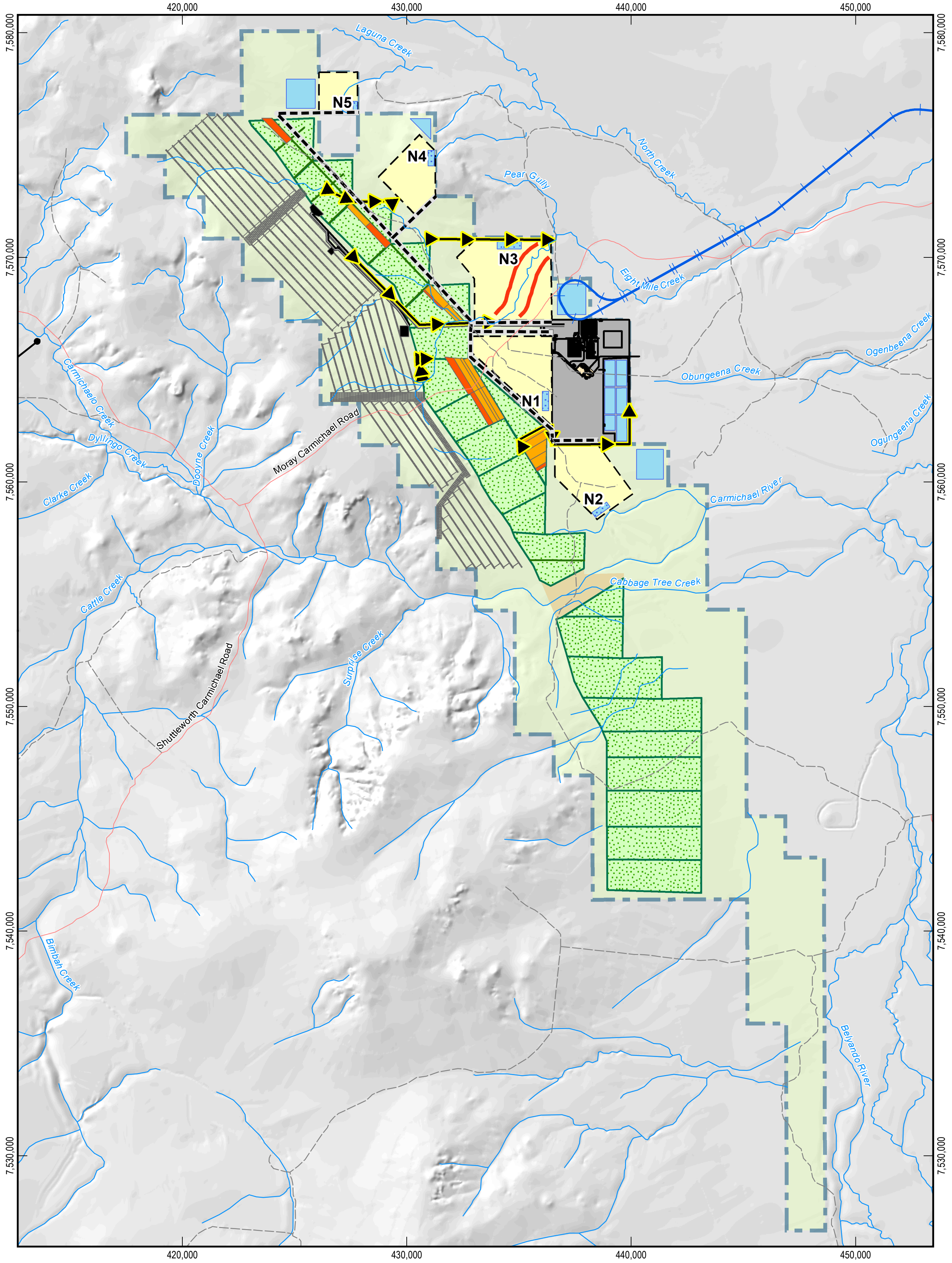

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2017

Job Number	41-25215
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Figure A5

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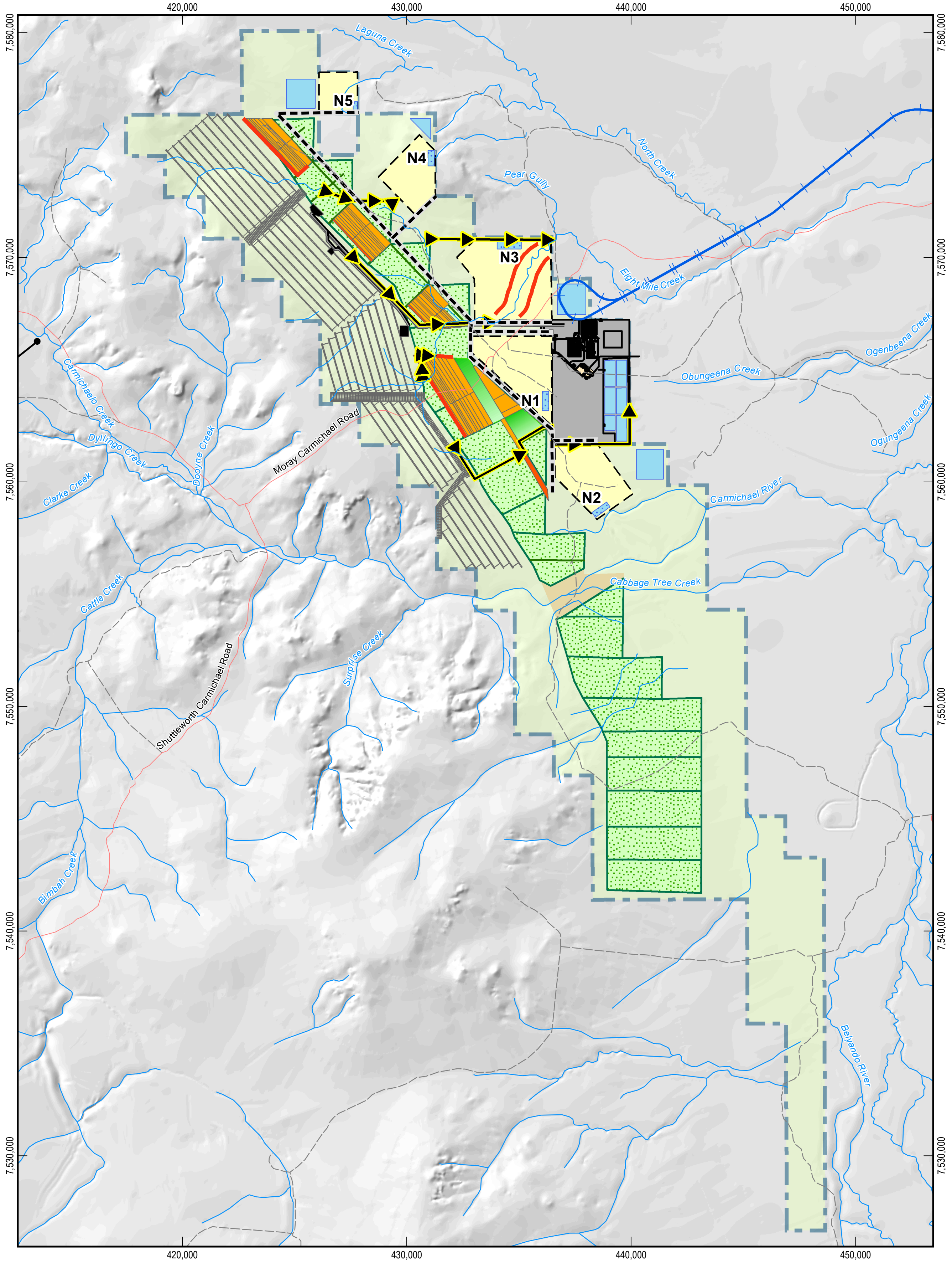

LEGEND

Local Road	Project (Rail)	Active Mining Area	Proposed Diversion
Track	Levee	Disturbed Mining Area	Area Under Rehabilitation
Watercourse	Haul Road	Sediment Basins	Mine Lease Area
Overland Conveyors	Out of Pit Waste Dumps	Water Management Dams	

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

GHD adani

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Carmichael Coal Mine
Preliminary Water Balance

Mine Layout Progress
Plot - Year 2027

Job Number	41-25215
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Figure A6

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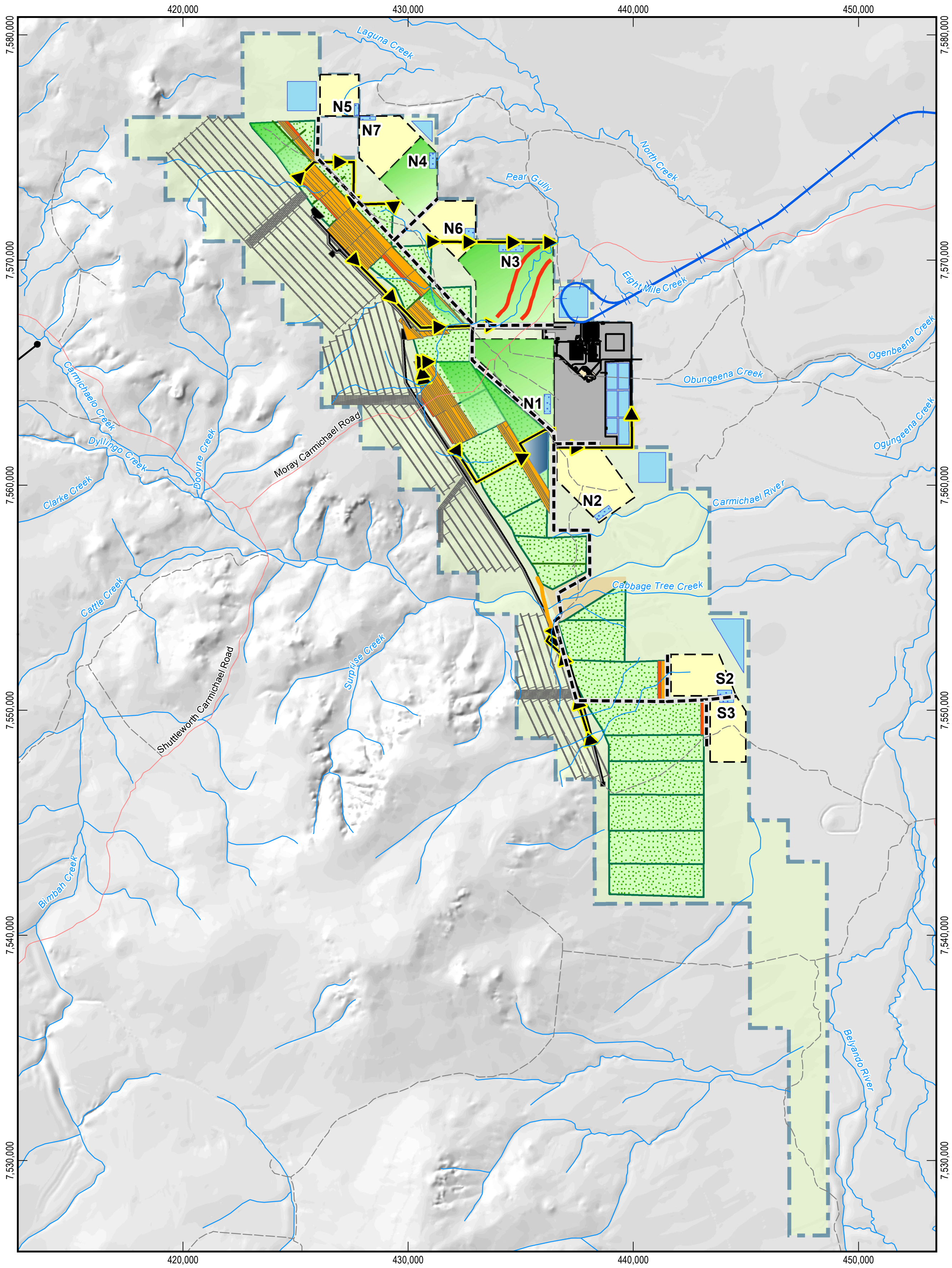

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Haul Rd & Conveyor Crossing
- Levee
- Haul Road
- Out of Pit Waste Dumps
- Active Mining Area
- Disturbed Mining Area
- Sediment Basins
- Water Management Dams
- Proposed Diversion
- Area Under Rehabilitation
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2037

Job Number | 41-25215
Revision | A
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Figure A7

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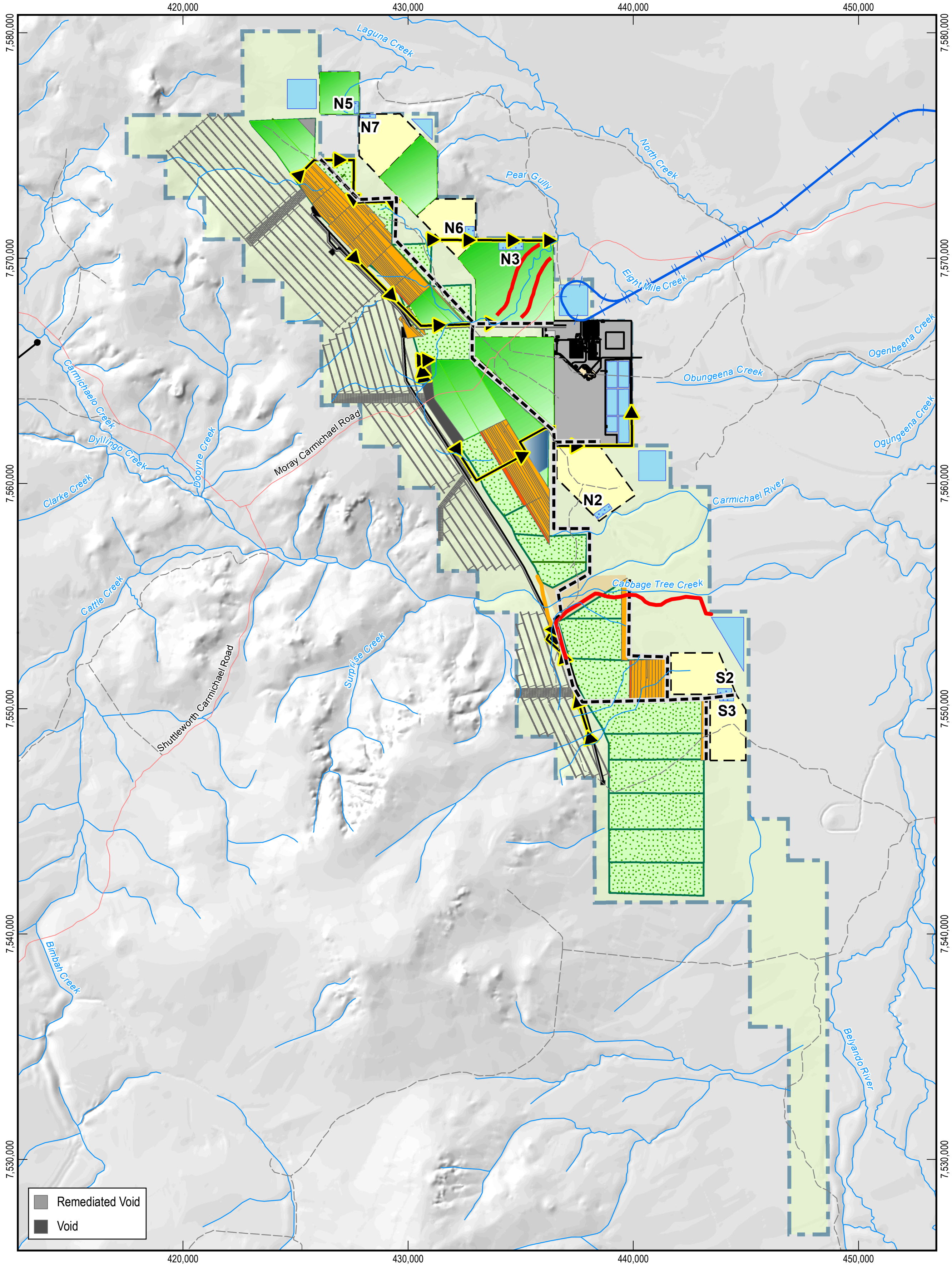

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Haul Rd & Conveyor Crossing
- Levee
- Haul Road
- Active Mining Area
- Disturbed Mining Area
- Water Management Dams
- Sediment Basins
- Proposed Diversion
- Out of Pit Waste Dumps
- Area Under Rehabilitation
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

Kilometres

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

N

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2047

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Figure A8

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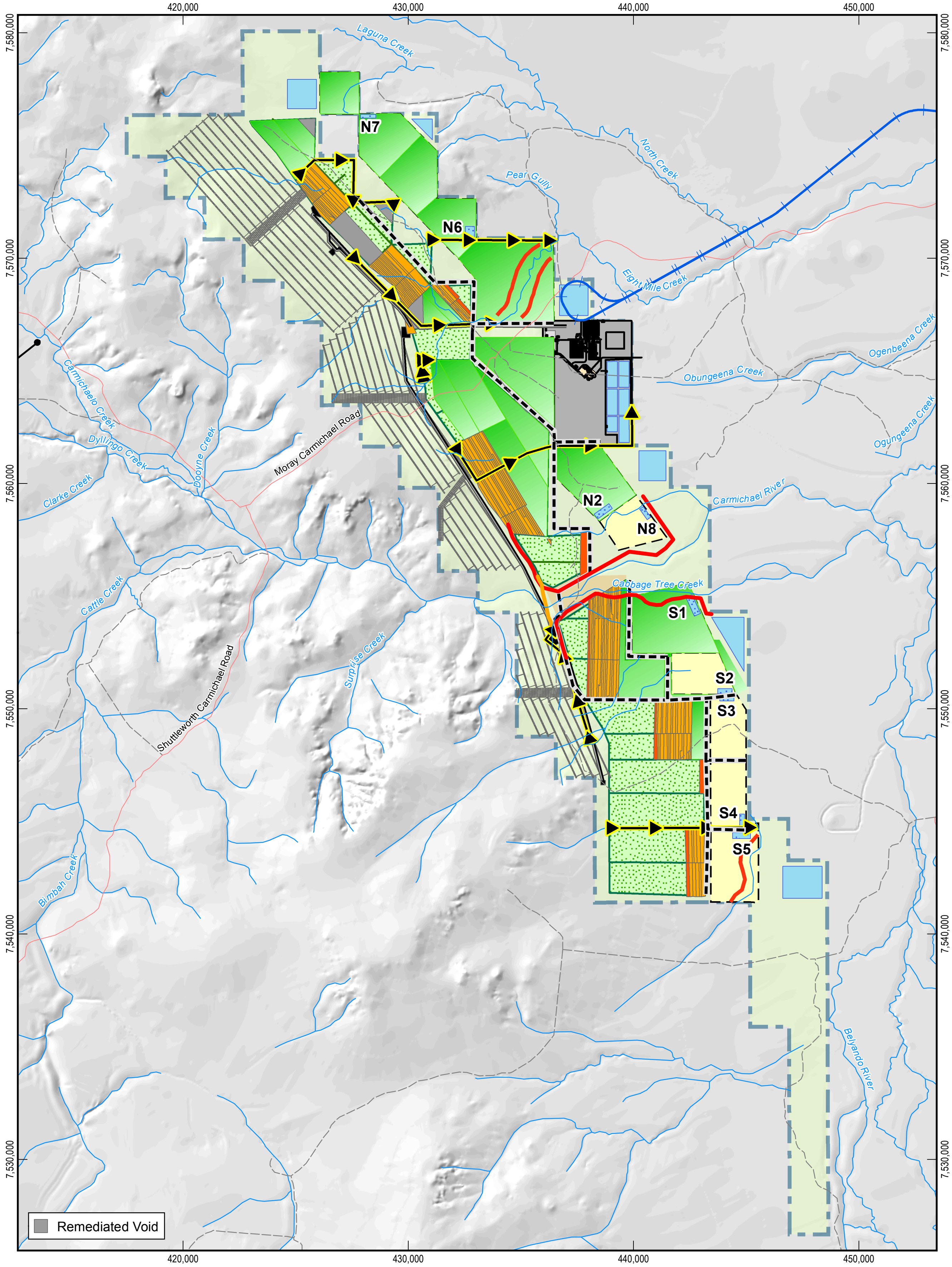

LEGEND

Local Road
Track
Watercourse
Overland Conveyors
Project (Rail)
Haul Rd & Conveyor Crossing
Levee
Haul Road
Active Mining Area
Disturbed Mining Area
Water Management Dams
Sediment Basins
Proposed Diversion
Out of Pit Waste Dumps
Area Under Rehabilitation
Mine Lease Area

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1:240,000 (at A4)
0 2 4 6 8
Kilometres
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

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Carmichael Coal Mine
Preliminary Water Balance
Mine Layout Progress
Plot - Year 2067

Job Number 41-25215
Revision A
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Figure A9

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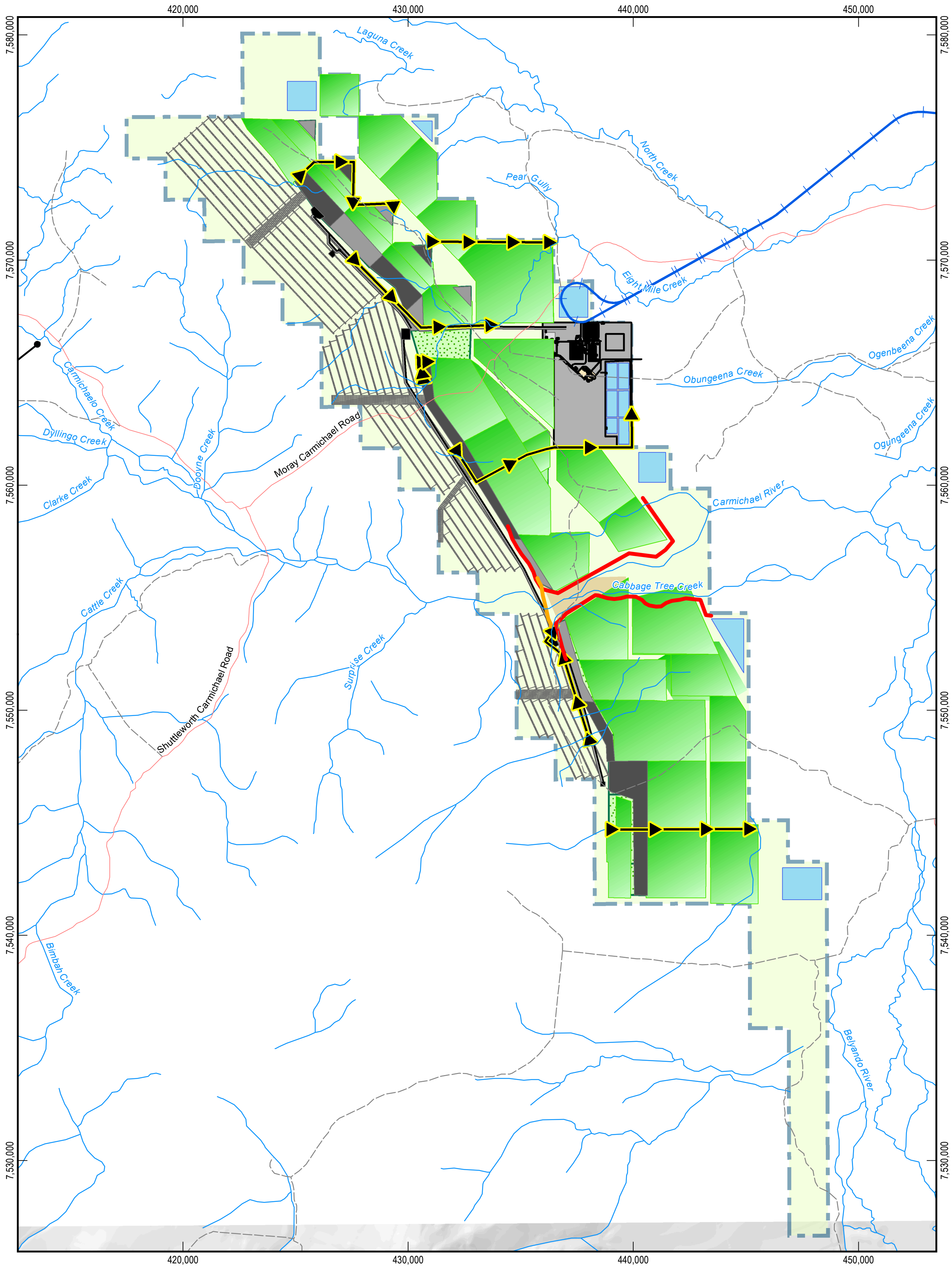

LEGEND

- Local Road
- Track
- Watercourse
- Overland Conveyors
- Project (Rail)
- Haul Rd & Conveyor Crossing
- Levee
- Void
- Remediated Void
- Area Under Rehabilitation
- Water Management Dams
- Open Cut Blocks
- Proposed Diversion
- Mine Lease Area

1:240,000 (at A4)

0 2 4 6 8

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 Preliminary
Flood Mitigation and Creek Diversion Design

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Revision | B
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Plot 2103

Figure 5-10

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Data Source: © Copyright Commonwealth of Australia - Geoscience Australia: Roads, Watercourse (2007); GHD: Levee, Conveyor Crossing (2012);
Adani: Alignment Opt9 Rev3, Mine Layout/Infrastructure (2012); DME: EPC1690 (2010), EPC1080 (2011). Created by: TH, CA

6. Preliminary levee design

6.1 Levee alignment

The levee alignment was based on that suggested by Runge (2011). The design criteria as listed in Section 2.2 required the levee to provide 1000 year ARI flood immunity to the open cut pits, and 100 year ARI immunity to the waste dump areas. The alignment was chosen to curve around the open cut pits and waste dump areas to provide protection from local overland flow as well as flooding from the Carmichael River. The alignment was also designed to allow for the effluent flow path from the Carmichael River into Cabbage Tree Creek.

The levee alignment is shown in Figure 6-1.

6.2 Levee crest height

The hydraulic model of the Carmichael River under developed conditions was used to determine the design levee height. The model was run for the 1000 year ARI design event with infinitely high levees in place. The levee height was then calculated as the 1000 year ARI water level plus freeboard. Long sections of the Carmichael River levees showing crest elevations are presented in sketches SK008 and SK010 in Appendix F.

For the northern Carmichael River levee the height of the levee above natural ground level averages approximately 2 m with a maximum height of 6.1m. The maximum height occurs in a localised area where the levee crosses a natural depression or gully.

For the southern Carmichael River levee the height of the levee above natural ground level averages at approximately 2 m with a maximum height of 3.4 m.

LEGEND

- Existing Watercourse
- Haul Rd & Conveyor Crossing
- Proposed Carmichael River Levees
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

1:60,000 (at A4)

0 500 1,000 1,500 2,000

Metres

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

N

GHD adani

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

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

Figure 6-1

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Data Source: DERM: Watercourse (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse(2007); Adani: Waste Dump, Open Cut Pits (2012); GHD: Proposed Haul Road, Levees (2012); Created by: BW, CA

7. Preliminary haul road and conveyor crossing design

7.1 Methodology

A bridge is proposed to allow passage of the haul road and conveyor over the Carmichael River (reference Figure 7-1). The bridge length was designed to allow the passage of flows within the Carmichael River main channel and maintain reasonable flood afflux levels with due consideration of the surrounding land use. The haul road was raised on an embankment above the floodplain either side of the bridge. Both the bridge height and the haul road elevation were sized to provide 50 year ARI flood immunity to the haul road across the Carmichael River, as required by Adani. In addition to the bridge, two sets of culverts were sized and included in the design to allow for the maintenance of natural flow paths within the corridor and reduce afflux due to the crossing.

A HEC-RAS model was developed to size the haul road and conveyor crossing bridge and associated culverts, based on the design flows generated by the hydrologic model as described in Section 3.4.1. Adopted design criteria were as described in Section 2.2. Output from this model can be seen in Figure 7-2.

7.2 Design summary

A drawing of the proposed haul road and conveyor crossing of the Carmichael River is provided in SK009 in Appendix F.

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

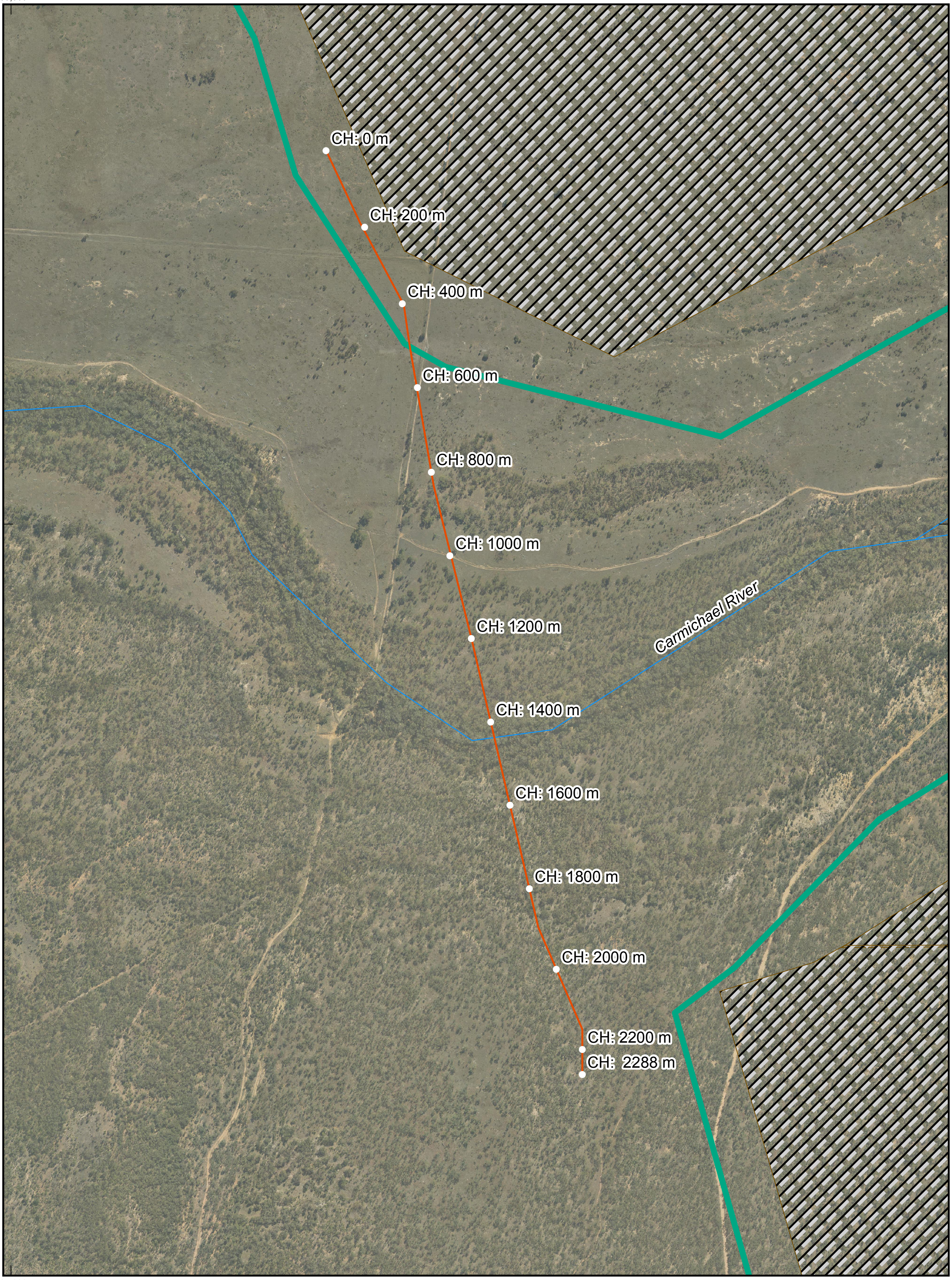
- A 180 m bridge comprising 7 x 25 m bridge spans located over the river channel
- Six cylindrical piers of 1 m diameter aligned in the direction of flow for each bridge support
- Bridge deck level of 230 m AHD
- The bridge soffit level of 228.8m AHD (i.e. a 1.2 m deep bridge deck structure). At this stage the soffit level is 0.7 m above the 50 year ARI flood level to allow for debris passage
- Four culverts of 3.1 m diameter located approximately at a low point in the floodplain approximately 250 m from the centreline of the Carmichael River (refer to Figure 7-2)
- Four culverts of 2.75 m diameter located at approximately 175 m from the centreline of the Carmichael River.
- Riprap placement at and just downstream of the bridge to minimise scour potential and protect the abutments and piers due to high velocities through the bridge.
- Haul road has a maximum longitudinal gradient of 10 per cent

Table 8 Summary hydraulic analysis of proposed design (from 2D results)

ARI (Yrs)	Q (m3/s)	U/S WL (m AHD)	Headwater Afflux (m)	Tailwater Afflux (m)	Velocity Through Bridge (m/s)
10	1230	227.20	0.13	0.03	2.39
50	2204	228.24	0.52	0.17	3.18
100	2684	228.66	0.72	0.24	3.57
1000	5553	230.33	1.63	0.64	4.08

For a detailed analysis of the afflux created by the proposed design, please see Section 10.2.

435,000



435,000

LEGEND

- Existing Watercourse
- Haul Rd & Conveyor Crossing
- Proposed Carmichael River Levees
- Mine (Onsite)
- Open Cut Mining Area

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1:13,000 (at A4)

0 100 200 300 400 500

Metres

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

Carmichael River Haul Road & Conveyor Crossing Alignment

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

Figure 7-1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_553_rev_a.mxd 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

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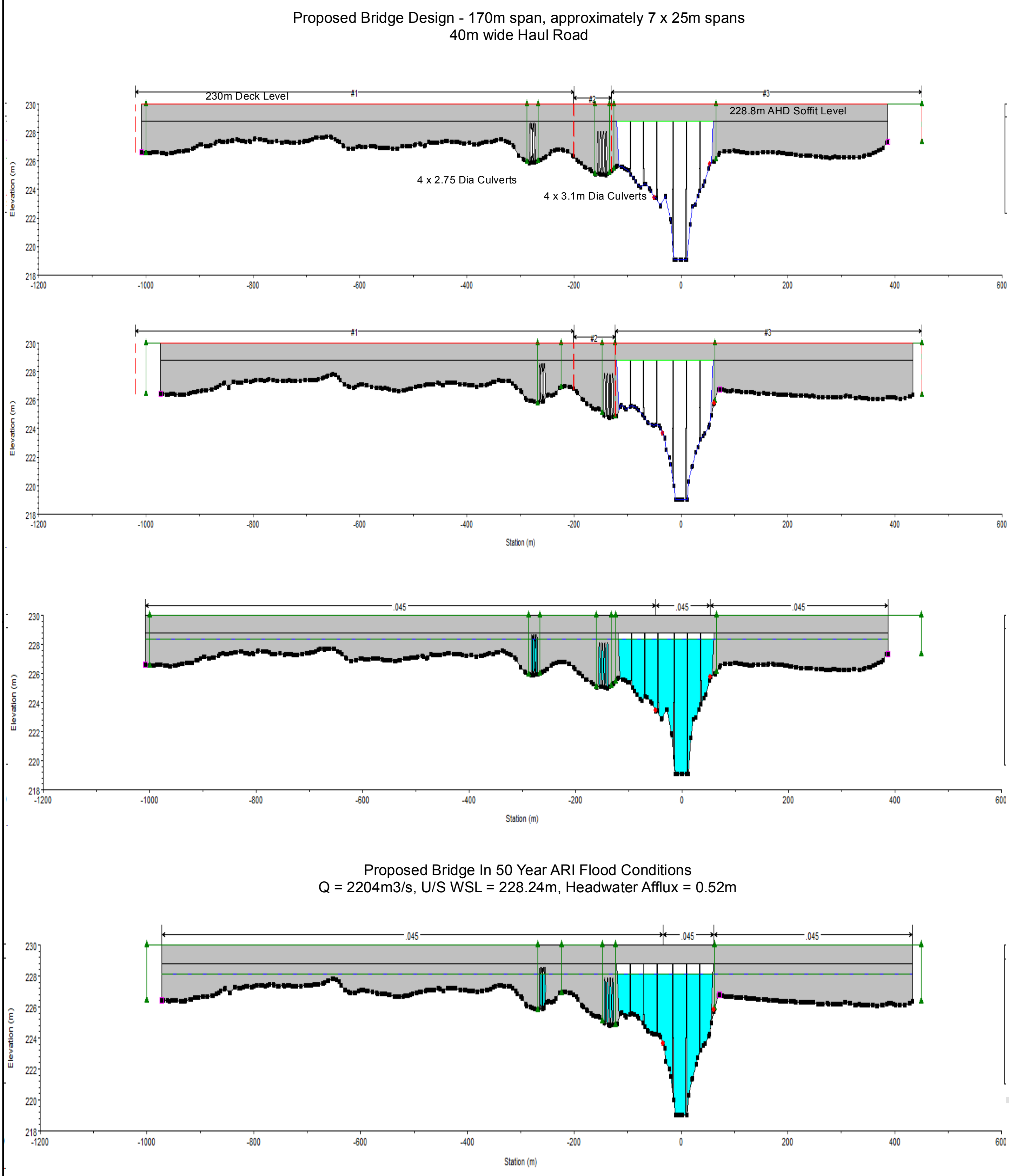

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Carmichael Coal Mine and Rail Project

Job Number	41-25215
Revision	A
Date	28 Aug 2012

1D Hydraulic Model Results of Proposed Haul Road & Conveyor Crossing

Figure 7-2

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G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_560_rev_a.mxd

Data source: GHD, Proposed Haul Road And Conveyor Crossing Conceptual Design (2012), Haul Road Crossing 1D HEC-RAS Results (2012).

8. Case study of a diversion drain design

8.1 Methodology

This section outlines the preliminary hydraulic design of a single diversion drain that forms part of the conceptual surface water management system described in Section 5. This drain was selected as it is required early in the mine life, is one of the largest of the required diversions, and can be used as an example of the typical requirements for other drains to be designed and constructed throughout the mine's life. Further detailed design of this drain will be required at a later stage.

The hydraulic design was dominated by the need to limit 50 year ARI flow velocities to 2.5 m/s as per the DERM (2011) guidelines for erosion and scour control. This preliminary design includes two localised areas where velocities marginally exceed 2.5 m/s, which occur where the channel base width widens. It is expected that this issue could be managed by the incorporation of scour protection or energy dissipation measures. Alternatively, minor channel redesign may become possible when the design of other infrastructure is progressed sufficiently to enable refinement of the hydraulic modelling.

Full hydraulic results of 1D HEC-RAS modelling of these channels for 10 year, 50 year, 100 year and 1000 year ARI can be found in Appendix E.

8.1.1 Determining flows

Flows were sourced from the hydrologic model described in Section 3.4.2. Table 9 describes the relevant inflows along the proposed diversion drain for each of the design ARIs.

Table 9 Design flows in subcatchments diverted by the case study diversion drain

Subcatch No (XP RAFTS node)	HECRAS station	Diversion Drain Chainage (m)	50 yr Total Flow (m3/s)	100 yr Total Flow (m3/s)	1000 yr Total Flow (m3/s)
31	22641	0	93	114	297
28	20844	1800	113	138	360
27	20244	2400	145	179	461
26	19644	3000	152	188	486
9	19044	3600	155	191	494
node 5	15644	7000	265	320	808
node 2	14525	8120	270	326	821
58	9196	-	466	563	1373

8.1.2 Diversion alignment

The diversion drain was aligned to collect runoff from part of the subsidence area over the underground mining area as well as some external catchment runoff. The drain skirts the edge of pits CW, EW, EE and F.

The diversion drain outlet rejoins the existing natural watercourse within the MLA, where it will be bounded on either side by waste rock heaps. The preliminary design includes a recommendation for the minimum waterway corridor width through the spoil heap, with protection levees to be constructed outside this corridor.

8.2 1D hydraulic model

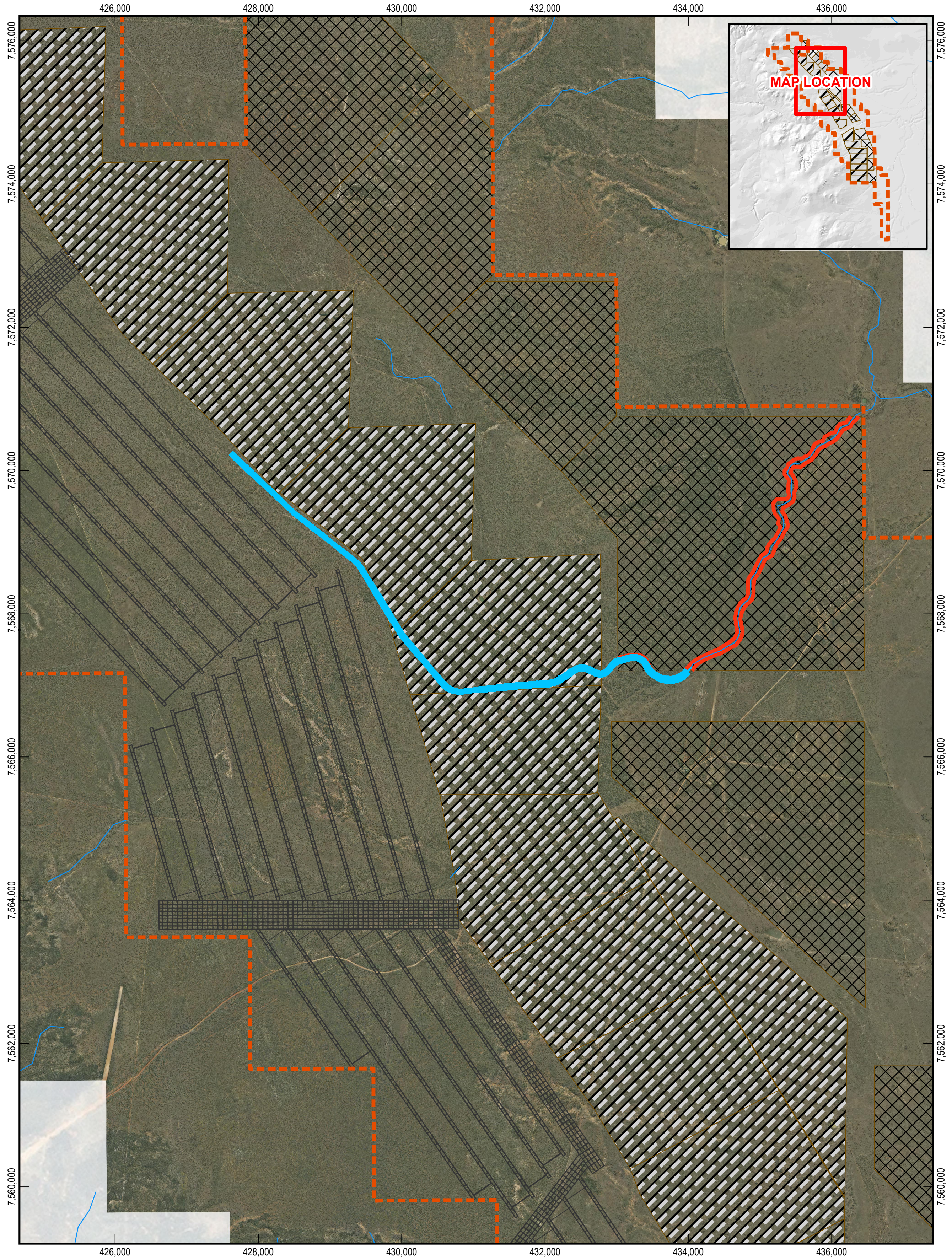
Model inflows were sourced from the post-development hydrologic model as shown in Table 9;

- The model geometry now represents the single diversion drain selected as a typical example of those described in Section 5.2.
- The cross-section locations for the 1D diversion drain models were taken approximately every 200 m
- The downstream reaches of the 1D hydraulic model taken from the model for existing conditions described in Section 4.3.

8.3 Design summary

The drain alignment can be seen in Figure 8-1. Longitudinal and a cross sectional profiles of the case study diversion drain are provided in Drawings SK004 to SK005 in Appendix F.

Table 10 indicates selected drain characteristics and flow results at key locations for the 50 year ARI design flow. This event has been reported for comparison against DERM diversion design guideline velocity limits (DERM 2011), which reference the 50 year ARI design flow. The drain has also been designed with a conveyance capacity equivalent to a 1 in 100-year ARI event and a minimum 600 mm freeboard (refer to Table 11).



LEGEND

- Existing Watercourse
- Diversion Drain
- Levee
- Underground Mine Plan
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

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1:75,000 (at A4)

0 500 1,000 1,500 2,000

Metres

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

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Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

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

Case Study Diversion Drain

Figure 8-1

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Data Source: DERM: Watercourse (2010); DME: EPC1690 (2010), EPC1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Locality, Rail, Watercourse(2007); Adani: Underground Mine Plan Waste Dump, Open Cut Pits (2012); GHD: Diversion Drain, Levees (2012); Created by: BW, CA

Table 10 Characteristics of proposed diversion channel for 50 Year ARI flows

HECRAS station	Diversion Drain Chainage (m)	Channel Base Width (m)	Q50 (m3/s)	Slope	Flow Depth (m)	Channel Velocity (m/s)
22641	0	1	93	1:450	2.89	1.98
20844	1800	1	113	1:450	3.15	2.01
20244	2400	1	145	1:450	3.40	2.22
19644	3000	1	152	1:460	3.45	2.26
19133	3490	1	152	1:460	3.10	2.72
19044	3600	3.6	155	1:460	2.98	2.67
18844	3790	8	155	1:460	2.94	2.22
17044	5600	8	155	1:460	2.71	2.57
16444	6200	24	155	1:460	2.33	1.96
15644	7000	24	265	1:460	3.02	2.30
14525	8120	24	270	1:810	2.98	2.02

Table 11 Characteristics of proposed diversion channel for 100 Year ARI flows

HECRAS station	Diversion Drain Chainage (m)	Channel Base Width (m)	Q100 (m3/s)	Water Level (m AHD)	Flow Depth (m)	Freeboard (m)
22641	0	1	114	252.48	3.11	3.02
20844	1800	1	138	248.79	3.41	0.79
20244	2400	1	179	247.73	3.68	2.50
19644	3000	1	188	246.45	3.73	3.62
19133	3490	1	188	244.96	3.35	3.72
19044	3600	3.6	191	244.66	3.25	3.78
18844	3790	8	191	244.20	3.22	3.68
17044	5600	8	191	240.00	2.95	1.05
16444	6200	24	191	238.34	2.60	1.41
15644	7000	24	320	237.27	3.27	0.73
14525	8120	24	326	235.69	3.24	0.76

Diversion drain cross-sections can be found in Drawing SK005 in Appendix F, showing a typical deep-cut cross section, a typical shallow-cut cross section with fill required for the channel embankments, and two typical cross-sections through the waste dump waterway corridor. The drain varies in depth from 4 – 7 m, and in top width from approximately 50 – 70 m.

A check was also undertaken for 1000-year ARI design flows to assess the general requirements for open cut pit protection levees where they are required adjacent to this drain. It was found that, on average, 1000-year ARI water levels were 1.2 – 1.8 m higher than 100-year ARI levels. Thus, to meet the design criteria of 600 mm freeboard in the 1000-year event, pit protection levees will be required with a height of up to 1.8 m adjacent to the diversion drain. Further design of these levees will occur as the design of other nearby infrastructure, such as haul roads and overland conveyors, progresses.

Tables, longitudinal profiles and cross-sections indicating hydraulic characteristics including peak flood levels, depths and velocities for the 10, 50, 100 and 1000 year ARI design events in the diversion drains are given in Appendix E.

The extent of excavation required for the drain is primarily due to two factors:

- The alignment of the drain. The open cut pits are located on low-lying land intercepting the natural watercourses, meaning that drains along the edges of these pits must cut through higher ground.
- The allowance for up to 7 m of subsidence at the upstream end of the drain.

Drawings SK004 in Appendix F includes provision for a preliminary channel grading that does not account for any subsidence. Such a profile could be constructed initially, with a deeper re-grading only necessitated once subsidence occurs above the underground mining areas.

Where the diversion drain requires fill embankments to contain the 100-year ARI design flows, special consideration will be required for local drainage and other inflows.

The preliminary hydraulic modelling has indicated that a minimum waterway corridor width of 75 m is required through the waste dump at the downstream end of the drain to manage afflux (reference Figure 8-1). Levees to protect the waste dumps should be located outside of this 75 m corridor, and should be constructed to a height equal to or exceeding the 100-year ARI flood level plus 600 mm.

9. Post-development flooding conditions

9.1 Post-development hydrodynamic model

In order to determine the impact of the proposed development, or Project (Mine) as it is referred to in the EIS, hydraulic modelling has been undertaken for post-development conditions which includes proposed mine infrastructure.

9.1.1 DEM

The terrain was raised to represent the proposed levees adjacent to the Carmichael River, in accordance with the preliminary levee design (refer Section 6).

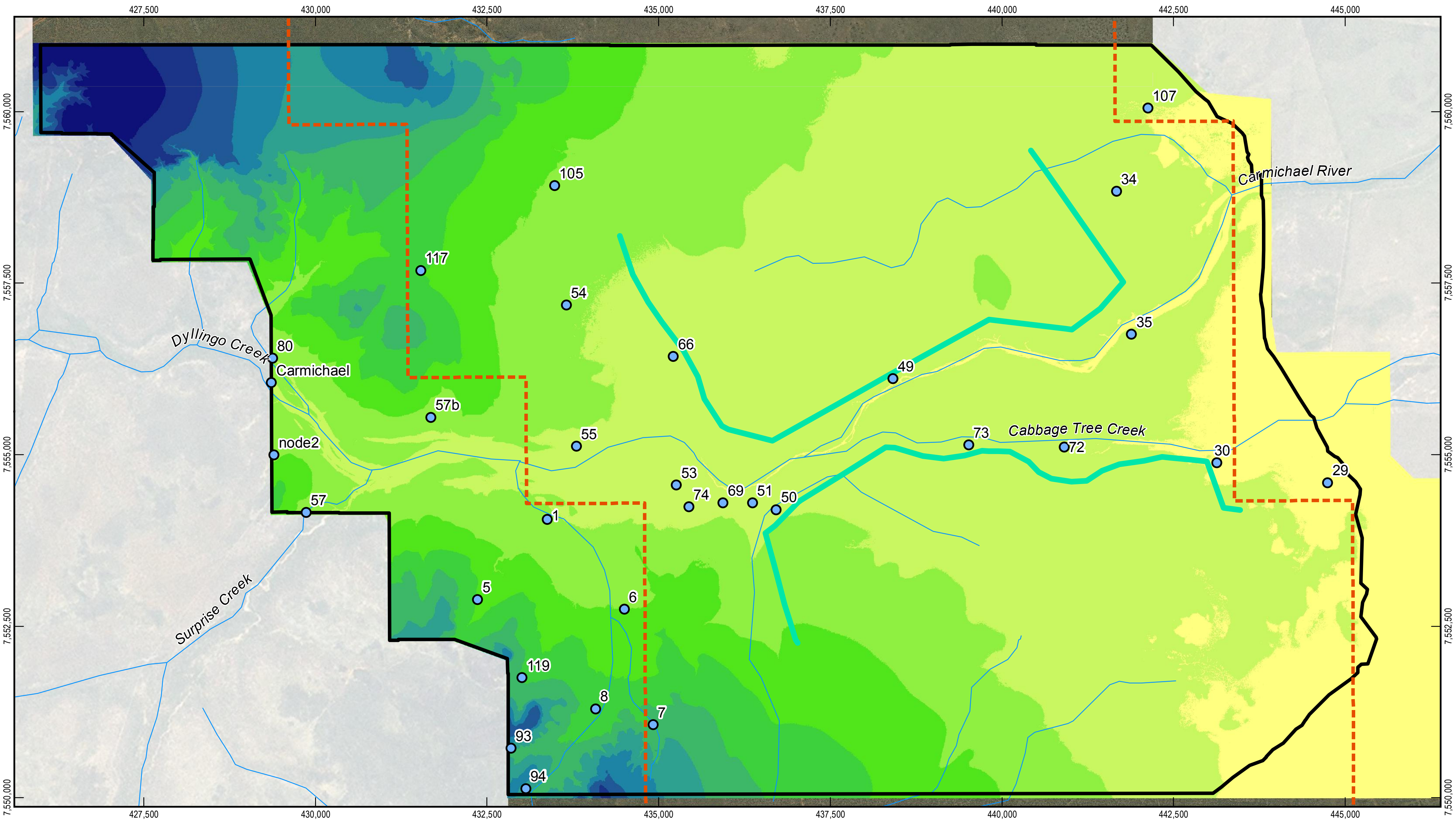
Terrain modification and a layered 2D flow bridge structure were incorporated to represented the proposed haul road and conveyor crossing of the Carmichael River, in accordance with the preliminary design (refer Section 7).

9.1.2 Inflow boundaries

Model inflows were sourced from the post-development hydrologic model (i.e. with the external diversion drain in place) as described in Section 3.

9.1.3 Tailwater conditions

No change was made to tailwater conditions of the hydraulic model.



1:75,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Inflow Source Point
- Watercourse
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area

m (AHD)

- 210 - 220
- 220 - 230
- 230 - 240
- 240 - 250
- 250 - 260
- 260 - 270
- 270 - 280
- 280 - 290
- 290 - 300
- 300 - 310
- 310 - 320

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Flood Mitigation and Creek Diversion Design

Carmichael River Hydrodynamic Model - Post Development

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

Figure 9-1

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Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse (2007);
GHD: Inflow Source Points, Levees, DEM (2011); Created by: BW, CA

9.2 Flooding results

Flood inundation maps indicating the depth of flooding and the predicted change in flood level (afflux) for the 10, 50, 100 and 1000 year ARI design events under post development site conditions are provided in Appendix D.

9.2.1 General Observations

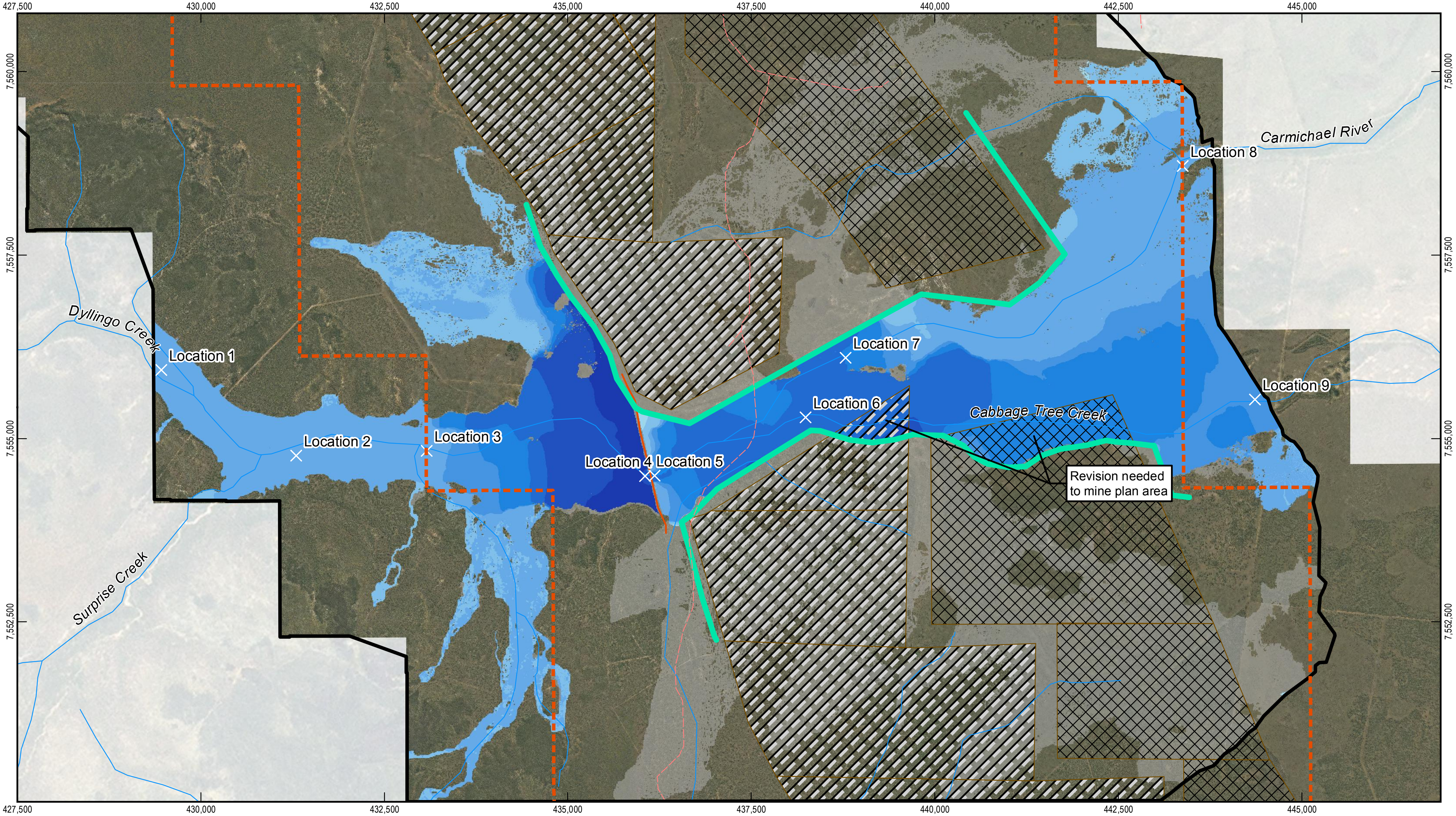
With the establishment of the mine site and accompanying flood mitigation infrastructure, the Carmichael River is now confined to the corridor between the flood levees with no runoff being received from the area internal to the MLA, excepting the new contribution of the diversion channel. The contraction of the floodplain causes an insignificant increase in flood extent upstream of the MLA for any of the simulated flood events. This outcome reflects the relative distance of the contraction from the western MLA boundary.

The proposed levees successfully prevent flooding of either the underground mining area or the open cut pit areas. The haul road crossing bridge is immune to the 10 year or 50 year ARI events, but is overtopped by the 100 year and 1000 year events. As discussed elsewhere the water level difference across the crossing for the current design is substantial (more than 1 m) and this leads to potentially a substantial risk of scour in floods larger than the 50 year ARI flood.

Figure 15 shows the afflux value at a range of locations of interest within the study area for comparative purposes, as summarised in Table 12 and below.

Table 12 Afflux due to proposed development, at locations of interest

Location	Description	Afflux (m) For ARI			
		10 year	50 year	100 year	1000 year
1	Carmichael River Model Inflow Boundary	0	0	0	0.01
2	2km Downstream of Carmichael River Model Inflow	0	0	0.01	0.04
3	Midway through MLA	0.01	0.13	0.19	0.51
4	Upstream of Haul Road Crossing	0.13	0.52	0.72	1.63
5	Downstream of Haul Road Crossing	0.03	0.17	0.24	0.64
6	Upstream Cabbage Tree Creek	0.04	0.19	0.25	0.63
7	Eastern MLA Boundary	0	0	0.01	0.07
8	Western MLA Boundary	0.02	0.02	0.03	0.2
9	Downstream Cabbage Tree Creek	0.01	0.07	0.09	0.15



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Flood Extent Change

Afflux (m)

- -37.3 - -0.4
- -0.4 - -0.2
- -0.2 - 0.0
- 0.0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.2

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Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

Afflux with Points of Interest, 100 Year ARI Event

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

Figure 9-2

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Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA

9.2.2 10 Year ARI

The 10 year ARI flood does not reach along the length of the levee, with only marginal increases in flood levels immediately upstream of the haul road. Afflux is negligible at the western boundary of the MLA, and nil at the eastern boundary. Through the corridor bounded by the levees, there are no significant increases in flood levels.

9.2.3 50 Year ARI

Increases of more than 0.5m in flood levels are predicted immediately upstream of the haul road, however the impacts at the western MLA boundary are expected to be negligible. Through the levee corridor, moderate increases in flood level of 0.1 – 0.2m are expected, dropping away to nil at the eastern boundary in the Carmichael River. Flood levels in Cabbage Tree Creek at the eastern MLA boundary are increased by approximately 0.07m by virtue of the levee redirecting some water that would have otherwise left the creek as overland flow to the south.

9.2.4 100 Year ARI

As expected, the impacts expected for the 50-year ARI event are marginally worsened in the 100-year ARI event. The haul road causes localised afflux of more than 0.7m. A minor 0.03m increase in flood level is predicted at the western MLA boundary, which drops to nil 2 kilometres further upstream. Increases in the range of 0.2 – 0.3m are indicated through the levee corridor. Moving further downstream, there is no significant increase in flood level in the Carmichael River at the eastern MLA boundary, although Cabbage Tree Creek levels are increased by approximately 0.1m.

9.2.5 1000 Year ARI

More significant impacts are indicated for the 1000-year ARI event as the haul road is overtopped. Afflux of 1.5 – 2.0m is expected at the haul road, decreasing to 0.2m at the western MLA boundary, and then to 0.03 m by 2 km upstream of the boundary. A negligible 0.01 m increase is predicted at the upstream model boundary, which is approximately 4 km upstream of the MLA. Through the levee corridor, flood levels are increased by 0.5 to 0.7 m on average. At the eastern MLA boundary, Carmichael River and Cabbage Tree creek levels are increased by 0.07 and 0.2 m respectively.

9.3 Discussion

The 1D modelling results of the proposed diversion drain show successful diversion of the relevant minor waterways currently intersecting the open cut pits. The preliminary design of this drain serves as a template for the later design of other diversion drains and surface water management infrastructure. The drains will accommodate drainage from subsided ground over the underground mining areas, and will safely convey flood flows up to the design event through the mine and into the existing natural watercourses downstream.

Compared to the existing condition flood conditions in the Carmichael River corridor under developed conditions shows an increase in flood level arising from two sources: an increase in flood flow and hydraulic constraints. The flood flow increases at all locations downstream of the MLA western boundary due to (1) the diversion of some runoff from local catchments to the south of the river, (2) the reduction in floodplain storage due to the Carmichael River levees, and (3) the interception of flow otherwise lost to flooding to the south of the Cabbage Tree Creek effluent flow path. This increase in flood flow persists to the eastern boundary of the model.

The following observations apply:

- The proposed flood protection levees successfully prevent flooding of the underground mining and open cut pit areas for all ARI events modelled.
- The potential for external “clean” surface water flows into mine affected areas is minimised, with diversion drains to convey that runoff through the mine site and to the downstream receiving waters.
- Post-subsidence surface flooding in areas proposed for underground mining will be minimised through the ability to convey surface runoff into the diversion drains.
- Levees will be required adjacent to diversion drains within the mine site to protect open cut pits.
- The haul road and bridge crossing remains flood-free for the 10 year, 50 year and 100 year ARI events, being overtopped by the 1000 year ARI event.
- At the eastern MLA boundary the afflux varies from 0.00-0.07 m depending on the event simulated.
- At the western extremity of the 2D model, which is located approximately 4.2 km upstream of the western MLA boundary, the afflux varies from 0.00 to 0.01 m depending on the event ARI.
- Afflux just upstream of the crossing varies between 0.13 to 1.63 m depending on the event ARI.
- The difference in water level between the upstream and downstream side of the haul road crossing is considerable for the 50, 100 and 1000 year ARI events, indicating a substantial potential for scour. This is especially true for those lower parts of the crossing that may be overtopped in floods marginally larger than the 100 year ARI design flood.

9.3.1 Sensitivity Analysis

A peak flow sensitivity analysis was undertaken for the Carmichael River levees using the 2D hydraulic model. The sensitivity analysis event was the 1000 year ARI event with a 20 per cent increase in rainfall intensity (refer to Section 3.6). The results showed that the southern levee will overtop upstream of the haul road and conveyor crossing but not downstream, thereby keeping the open cut pit areas dry. On the northern side, overtopping occurs along the first two-thirds (from the east) of the levee alignment. Overtopping ceases downstream of the natural hill in the topography at approximately eight kilometres chainage.

10. Conclusions

10.1 Summary of existing flood conditions

As summarised in Section 3.3, peak flow estimates in the Carmichael River coinciding with the location of the MLA were determined to be as follows, based on an XP-RAFTS hydrologic model:

- 10 year ARI event - 1187 m3/s
- 50 year ARI event - 2140 m3/s
- 100 year ARI event - 2604 m3/s
- 1000 year ARI event - 4897 m3/s

Multiple minor waterways were found to intersect the MLA from the western boundary, with flows generally ranging between 20-253 m^3/s for the 10 year ARI event, 32-401 m^3/s for the 50 year ARI event, 42-343 m^3/s for the 100 year ARI event and 82- 930 m^3/s for the 5-1000 year ARI event.

A simplified climate change impact assessment predicted these flows to increase by about 50 per cent over the next 100 years.

It was found that the Carmichael River flood extent was relatively narrow, until the latter part of the MLA where it widens out over the flat terrain that conveys flood water into an effluent flow path contributing to Cabbage Tree Creek. To the north and south of the Carmichael River corridor, the flooding of local waterways was similarly contained up until the region proposed for open cut mining. In this region the flatter terrain caused quite wide-spread overland flooding.

10.2 Summary of conceptual staged drainage scheme

A conceptual drainage scheme was proposed for selected mine stages. This scheme was designed with the intention of protecting the active mine areas from flooding while also retaining natural channels wherever practical. To achieve this, minor and major levees, diversion drains, culverts and waterway crossings are recommended. The existing watercourses have been maintained where possible and drainage outflow points have also been designed to closely mimic existing drainage paths and maintain inflows to waterways to the east of the MLA.

The management of surface water, including the design of levees, diversion drains, culverts, crossings and other minor drainage features, needs to be further considered during all subsequent phases of mine design, construction, operation and maintenance. The preliminary consideration of these issues presented in this report is based on staged mine plans that are separated by up to 40 years, meaning that drainage and flooding issues that occur in the intervening years cannot be identified or resolved at this time. Furthermore, the reliance on constructed drainage measures to manage surface water and local flooding within the mine site will necessitate careful consideration of drainage design, construction, monitoring and maintenance issues throughout the mine’s life.

10.2.1 Levee design

The proposed flood protection levees either side of the Carmichael River have been substantially modified from those proposed in Runge (2011). This was to accommodate the added EPC1080 area and the associated changes in mine layout. The required levees were found to have an average height of 2 m with maximum height of 6.1 m on the northern levee and 3.43 m for the southern levee, based on the 1000 year ARI flood level plus 600 mm freeboard. See SK008 and SK010 in Appendix F for design long sections.

10.2.2 Case study diversion drain

The case study diversion drain was sized and modelled as an example of the approach to be taken in the design of diversions during a conceptual drainage design phase. The main design constraint for this drain was the 2.5 m/s maximum velocity guideline from DERM (2011). The drain invert was lowered by 7 m in order to allow for the possibility of subsidence as predicted by SCT (2011). The proposed design is aligned from east to west between open cut pit areas and discharges occur into existing waterways, thereby maintaining the natural hydrology as far as possible. The existing waterway passes through a proposed waste rock dump area. In order to cause minimal disruption to the natural hydrology, minor levees are proposed either side of the existing channel to safely pass flows to the western boundary of the mine site.

The drain size designed to carry the 100 year ARI peak flow is summarised in SK002 in Appendix F. In some regions, minor levees are required around the diversion drain to meet the design flood immunity.

10.2.3 Haul road and conveyor crossing

The Runge (2011) concept design of a causeway crossing with culverts was quickly dismissed by 1D modelling analysis due to capacity, afflux and velocity issues and replaced by a 180 m-span bridge structure over the Carmichael River channel with a soffit level of 228.8 m AHD. The height of the haul road was set by the 50 year ARI event flood level plus 600 mm freeboard.

Two sets of culverts to the north of the bridge are recommended in order to allow some continuity of the existing flow path and reduce the likely afflux due to the dam-like effect of the haul road level. See SK009 for the long section of the proposed haul road and conveyor crossing structure.

10.3 Impact of the proposed development

2D modelling of the Carmichael River corridor with the proposed drainage, road and flood mitigation infrastructure in place and 1D modelling case study of one of the proposed diversion drains indicated the success of this infrastructure in protecting the mine site from extreme flood events. Analysis of the post-development conditions with 2D modelling also indicated likely hydrologic or hydraulic impacts of the proposed development. Hydrologic impacts on the Carmichael River corridor were found to be minimal, as listed:

- *10 year ARI event* - 0.3 per cent flow increase;
- *50 year ARI event* - 0.7 per cent flow increase;
- *100 year ARI event* - 0.7 per cent flow increase;
- *1000 year ARI event* - 1.7 per cent flow increase.

The proposed diversion drains from west to east aim to imitate the natural hydrology of minor waterways across the mine site and so are not expected to cause significant reductions of inflow to the catchments east of the MLA.

The flood flow increases at all locations downstream of the MLA western boundary due to (1) the diversion of some runoff from local catchments to the south of the river, (2) the reduction in floodplain storage due to the Carmichael River levees, and (3) the reduction in flow lost to flooding to the south of the Cabbage Tree Creek effluent flow path. This increase in flood flow persists to the eastern boundary of the model.

Afflux due to the combined effect of slightly increased flows from the diversion drain discharging to the Carmichael River, reduced runoff from the developed mine internal areas and hydraulic constriction by the flood protection levees and haul road and conveyor crossing is summarised in the Table 12 in Section 9.2. While the afflux within the levee corridor is large, up to 1.63 m for the 1000 year ARI event, at the upper and lower limits of the modelled Carmichael River the afflux has been attenuated by the terrain such that upstream land is not likely to experience greatly increased flood extents. The velocities through the haul road and conveyor crossing were found to be somewhat high, reaching 3.18 m/s for the 50 year ARI event and 4.08 m/s for the 1000 year ARI event.

10.4 Recommendations

In general, the various requirements for the management of surface water, flooding and drainage need to be considered during all mine planning, design, construction, operation, maintenance and decommissioning activities. These issues have the potential to influence or dictate the design of other infrastructure. It is suggested the following areas especially require attention in the next stage of the design of the levees:

- *Interfaces with Other Infrastructure* – Further design of the levee and other infrastructure needs to consider how these elements interface;
- *Levees to Protect Underground Mine Access Area* – The requirement for levees to protect underground mine access areas from local and regional flooding needs to be determined once the location of these areas has been determined;
- *Adjustment to the Conceptual Waste Dump Areas* – In order to fit the combined width of the proposed flood protection levees and the creek diversion channels within the MLA, Figure 10 and Figure 11 should be used as a reference to design minor shifts of the waste dumps areas;
- *Detailed Design Consideration of Side Slope Stability* – The adopted 1 vertical to 5 horizontal side slopes on the proposed levees will require design refinement based upon knowledge of the geological data and the construction material when it is available.
- *Detailed Analysis of Velocities* – The requirement for protection of the levee face from scour due to the velocity of flood waters needs to be investigated based upon knowledge of the geological data and the construction material when it is available.

It is suggested the following areas require attention during the design of the diversion drains:

- *Importance of Drainage Issues to Mine Safety* - The reliance on constructed drainage measures to manage surface water and local flooding within the mine site will necessitate careful consideration of drainage design, construction, monitoring and maintenance issues throughout the mine's life.
- *Interfaces with Other Infrastructure* – Further design of the diversion drains and other infrastructure needs to consider how these elements interface;
- *Design of Inlets into the Diversion Drains* – The management of drainage, scour and erosion at the inlets to the diversion drains requires on-going attention as the mine design progresses;
- *Design of Waterway Crossings and Culverts* – The design of all waterway crossings and culverts requires on-going attention as the mine design progresses;
- *Calculation of Appropriate Channel Side Slope* – As yet no geotechnical data has been provided for the region underlying the proposed diversion drains. The assumed channel side slopes of 1 vertical to 5 horizontal must not be used without a full geotechnical analysis of a stable slope angle both with respect to slumping and scour protection placement capability;
- *Benching of Large Cuts*- The proposed design is based on an assumed channel side slope of 1 vertical to 5 horizontal with no benches. Further developments to the design should include benching of deeper cuts. As for the analysis of appropriate channel side slope, a full geotechnical analysis of appropriate benching must be undertaken upon the provision of geotechnical data;

- *Potential Erosion at Outlet Gully* – Detailed consideration of the flow velocities at the outlets into the existing natural minor waterway is required, including the need for any erosion protection measures if needed;
- *Lining of the Drain* – At this stage the nature of the lining of the drain has not been considered. This aspect will require further attention in the next stage of the design.
- *Energy Dissipation Structures* – There are a few locations along the case study diversion drain where energy dissipation is required in order to reduce the 50 year ARI in-channel velocity to the acceptable maximum of 2.5 m/s. Methods of energy dissipation in these areas could include rip-rap lining or rock chutes.
- *Gully Intersections* - Where the channel intercepts a natural inflow gully or other area of concentrated flow protection, it is necessary to prevent erosion of the drain bank. A flattening of side slope, rock lining or other energy dissipation options are likely required to prevent erosion of the channel bank.
- *Detailed Design in Accordance with* Watercourse Diversions Guidelines – Central Queensland Mining Industry *(DERM, 2011)* – these guidelines include further design criteria which include:
  - Incorporation of features that mimic the natural stream characteristics to create 'dynamic equilibrium';
  - Providing a corridor of suitable width to accommodate potential channel meanders;
  - Consideration of channel vegetation implementation to stabilise channel banks, terraces and floodplain drainage paths;
  - Consideration of the need for fish movement within the channel, or a fish movement exemption notice application

For the haul road and conveyor crossing the following should be considered:

- There is a substantial head drop across the structure which may cause scour, particularly in combination with the relatively high velocities through the bridge. Particular care should be taken for those parts of the haul road that can be overtopped in the floods marginally bigger than the 100 year ARI flood.
- The waterway openings presented in the design are considered at the lower bound and design refinements may lead to a larger waterway design to reduce the risk of scour damage in a flood.

11. References

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Appendices

A. Hydrologic Data

Local subcatchment parameters – existing conditions

Peak flow in minor waterway subcatchments to the north of the Carmichael River – existing

Local subcatchment parameters – post-development conditions

Carmichael catchment rainfall intensity data

Plot of 1 per cent AEP Flood Peaks in Cumecs/SQ.KM (for Queensland)

Local subcatchment parameters - existing conditions

Sub-catchment Label	Total Area (km^2)	Catchment Slope (%)
RB21.06	9.55	0.47
RB28.02	184.89	0.10
RB21.05	98.24	0.16
RB27.01	83.26	0.15
RB21.04	3.14	0.22
RB24.03	68.86	0.13
RB21.03	127.55	0.20
RB23.01	87.92	0.27
RB21.02	102.87	0.17
RB29.01	76.31	0.35
RB28.01	182.14	0.20
RB21.01	61.68	0.40
RB22.01	120.86	0.31
CC1.10	0.00	0.00
BW5	155.80	0.17
BW6	67.87	0.23
BW7	1.46	0.13
BW8	70.49	0.28
BW9	1.95	0.11
BW10	36.17	0.40
BW11	243.19	0.33
BW12	34.44	0.26
BW13	13.29	0.34
BW14	115.96	0.33
BW15	185.04	0.25
57-2DSP-LCarm	4.64	0.32
12-LC8	0.38	0.61
12-LC8	0.38	0.61
94-LC9	6.35	1.26
93-LC9	1.50	1.55

Sub-catchment Label	Total Area (km^2)	Catchment Slope (%)
80-LCarm	8.61	0.75
Node2-Lcarm	2.46	0.32
5-LC9	7.14	0.28
6-LC9	1.37	0.63
8-LC9	1.05	0.94
7-LC9	2.28	0.98
50-LC11	1.15	0.97
119-LC9	1.17	0.28
75-LC11	2.24	1.02
90-LC11	4.12	0.99
68-LC11	2.73	0.28
69-C11	0.67	0.70
76-LC11	2.95	0.75
74-LC11	2.58	0.45
100-LC7	5.60	0.36
10-LC8	1.45	0.32
9-LC7	1.44	0.13
110-LC12	10.57	0.30
121-LC12	6.47	0.30
72-LC6	2.98	0.24
29-LC6	2.89	0.06
30-LC6	4.11	0.06
99-LC7	1.59	0.14
111-LC12	3.47	0.30
73-LC6	6.03	0.21
49-LCarm	8.22	0.17
35-LCarm	7.59	0.68
79-LC14	7.08	0.14
103-LC5	1.56	0.28

Sub-catchment Label	Total Area (km^2)	Catchment Slope (%)
78-LC14	6.03	0.13
Node1-LC6	1.81	0.10
34-LC14	6.34	0.15
107-LCarm	1.15	0.10
54-LCarm	4.97	0.45
51-LCarm	1.04	0.55
106-LC5	2.03	0.58
105-LC5	1.95	0.48
117-LCarm	8.94	0.75
53-LCarm	1.59	0.56
55-LCarm	3.70	0.39
57b-LCarm	4.64	0.32
1-LC9	0.64	0.49

Peak flows in minor waterway subcatchments to the north of the Carmichael River - Existing

	ARI	10 yr	50 yr	100 yr	1000 yr
	Critical Duration	6 hr	3 hr	2 hr	2 hr
Subcatchment Label	12-LC1	29.543	47.612	50.456	121.358
	13-LC1	18.1	28.809	30.964	74.262
	10-LC1	60.244	98.796	105.798	251.217
	9-LC1	164.851	266.08	293.816	637.857
	7-LC1	216.67	347.717	380.34	830.877
	5-LC1	241.581	385.77	419.011	905.102
	4-LC13	13.011	20.805	22.182	52.529
	1-LC10	252.654	401.043	434.074	930.161
	27-LC2	19.731	31.857	34.276	81.656
	32-LC2	35.877	64.671	71.384	167.924
	29-LC2	49.176	87.813	98.157	228.824
	30-LC2	4.151	7.863	8.748	20.939
	25-LC2	100.267	173.237	191.882	445.91
	11-LC2	112.868	193.881	214.024	497.65
	8-LC3	35.351	55.687	59.592	143.739
	6-LC1	23.508	37.915	40.808	96.055

Peak flows in minor waterway subcatchments to the south of the Carmichael River - Existing

	ARI	10 yr	50 yr	100 yr	1000 yr
	Critical Duration	6 hr	3 hr	2 hr	2 hr
Subcatchment Label	15-LC8	8.813	17.349	21.588	48.529
	16-LC8	99.639	177.523	199.624	433.521
	14-LC8	117.371	207.463	234.489	499.05
	12-LC8	127.635	223.051	251.824	532.175
	13-LC8	12.79	23.76	26.495	62.258
	11-LC8	3.525	5.757	6.178	14.834
	10-LC8	133.124	231.601	160.975	551.369
	100-LC	9.372	15.455	16.535	40.433
	94-LC9	30.965	61.128	74.206	165.814
	8-LC9	39.265	77.157	94.502	208.342
	6-LC9	50.363	97.847	117.839	256.686
	1-LC9	64.01	122.368	144.475	317.543
	7-LC9	7.198	14.254	17.268	39.856
	75-LC11	14.798	28.314	32.914	74.558
	69-LC11	22.551	42.817	49.51	112.886
	50-LC11	29.96	56.06	65.07	147.13
	98-LC13	13.608	26.968	32.266	74.148
	97-LC13	8.888	17.465	20.936	47.975
	3-LC13	22.756	44.959	53.96	123.765

Local subcatchment parameters - post-development conditions

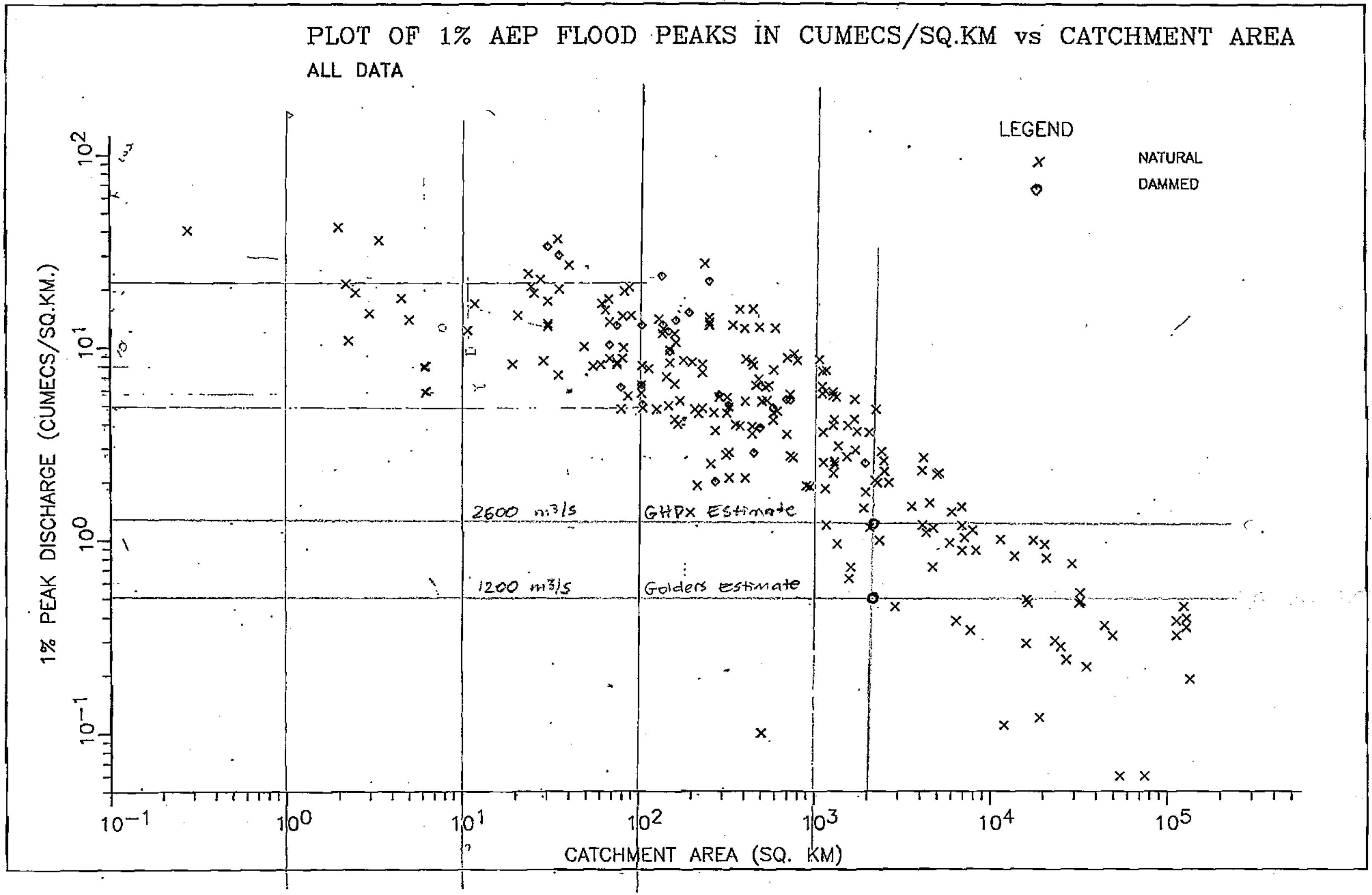
Subcatchment Number	Total Area (ha)	Catchment Slope (%)	Peak Total Flow (m3/s)			
			10 year ARI	50 year ARI	100 year ARI	1000 year ARI
3	9.0	1.2	24.7	45.1	54.5	124.1
8	2637.3	0.4	34.5	61.6	76.0	145.9
9	67.2	0.3	87.6	154.9	191.3	401.2
12	2283.0	0.4	30.5	55.5	68.6	129.5
14	577.9	0.7	131.0	234.1	283.5	577.4
15	260.7	1.2	9.7	17.6	21.7	48.9
16	323.7	1.1	101.2	181.9	220.4	453.6
17	530.4	0.9	14.2	26.4	32.2	70.3
18	34.8	0.9	79.1	142.4	172.7	353.9
19	420.0	1.3	14.4	26.1	31.5	72.5
20	150.4	1.3	67.3	118.8	145.8	301.8
21	820.5	1.0	21.3	39.7	48.1	103.6
22	1002.9	0.7	44.1	77.1	95.4	200.9
23	249.9	0.6	6.4	11.9	14.6	31.3
25	1.8	0.4	0.1	0.2	0.2	0.5
26	172.3	0.5	86.0	152.1	187.8	394.0
27	1211.9	0.5	81.8	144.6	178.5	374.2
28	535.7	0.6	62.5	112.8	138.5	292.9
30	24.8	0.5	6.0	11.0	13.5	29.3
31	438.2	0.6	51.0	92.6	113.9	241.7
32	181.4	0.4	40.7	74.1	91.2	194.1
33	469.5	0.7	18.9	35.1	42.8	92.2
34	713.0	0.8	17.5	32.0	39.8	83.5
39	382.1	0.4	63.1	115.8	140.9	277.3
40	408.2	0.2	87.3	158.7	192.3	378.8
41	168.7	0.5	4.4	8.3	10.1	22.1
43	152.6	0.2	2.8	5.2	6.3	12.5
44	185.4	0.5	63.1	112.6	136.0	284.1
46	454.0	0.5	47.2	88.4	107.9	208.4
47	501.6	0.5	10.3	18.6	22.4	46.6

48	515.1	0.5	10.5	19.1	22.9	47.4
49	483.9	0.5	10.0	18.1	21.9	45.6
50	467.3	0.5	96.9	170.9	210.0	439.4
51	356.6	0.5	8.0	14.2	17.7	37.2
52	467.2	0.5	9.8	17.5	21.4	44.6
53	402.0	0.5	8.7	15.5	19.3	40.6
54	425.2	0.5	9.1	16.2	20.2	42.0
55	477.1	0.5	9.9	17.9	21.7	45.2
56	422.9	0.5	9.1	16.2	20.1	41.9
57	466.4	0.5	9.7	17.5	21.4	44.6
58	1284.1	0.2	258.8	466.2	563.0	1122.3
59	839.8	0.5	15.2	27.9	33.8	66.5
60	724.0	0.5	76.6	137.2	165.7	340.6
61	673.5	0.5	12.9	23.5	28.3	56.4
62	619.9	0.5	12.1	22.1	26.6	53.4
68	52.2	0.3	136.1	242.2	293.5	596.4
69	57.8	0.7	147.2	259.0	314.0	631.2
75	224.1	1.0	16.0	29.1	35.3	79.7
76	294.5	0.8	8.3	15.6	19.0	42.2
81	279.1	0.4	14.5	25.9	31.8	66.7
90	175.5	0.4	135.0	240.6	291.4	592.6
97	293.2	1.0	9.5	17.5	21.2	48.3
98	444.7	1.2	14.9	27.1	32.7	74.8
100	18.1	0.4	131.4	234.6	284.2	578.6
106	50.1	0.6	15.8	28.1	34.8	74.2
127	188.5	0.3	28.2	52.1	63.1	142.6
13n	544.8	0.4	9.7	18.0	21.8	43.1
13s	439.2	0.8	11.8	22.3	26.9	58.5
24n	243.0	0.4	5.3	9.5	11.8	24.8
24s	651.9	0.9	16.5	30.3	37.5	79.7
32a	46.1	0.4	7.4	13.7	16.7	36.8
68a	6.4	0.3	147.2	259.1	314.1	631.4
node1	0.0	0.0	47.2	88.4	107.9	208.4

node10	0.0	0.0	95.5	172.6	208.3	409.4
node11	0.0	0.0	76.6	137.2	165.7	340.6
node12	0.0	0.0	41.9	77.1	94.1	179.9
node13	0.0	0.0	147.2	259.1	314.1	631.4
node14	0.0	0.0	8.7	15.5	19.3	40.6
node15	0.0	0.0	51.3	94.9	115.6	250.9
node16	0.0	0.0	51.3	94.9	115.6	250.9
node17	0.0	0.0	34.7	61.5	74.8	158.2
node19	0.0	0.0	51.3	94.9	115.6	250.9
node2	0.0	0.0	150.9	269.9	325.8	668.6
node3	0.0	0.0	519.0	916.8	1102.6	2209.9
node4	0.0	0.0	76.6	137.2	165.7	340.6
node5	0.0	0.0	148.1	264.9	319.8	657.3
node6	0.0	0.0	258.8	466.2	563.0	1122.3
node7	0.0	0.0	34.5	61.6	76.0	145.9
node8	0.0	0.0	38.9	73.1	89.7	169.7
node9	0.0	0.0	56.5	104.0	126.7	247.6

Return Period (yrs)	Duration (hrs)	Rainfall (mm)	Areal Rainfall (mm)	Intensity (mm/hr)
		IFD Rainfall Data		
10	0.25	28.900	28.900	**115.6**
10	0.5	41.900	41.900	**83.8**
10	0.75	51.225	51.225	**68.3**
10	1	58.700	58.700	**58.7**
10	1.5	65.549	65.549	**43.7**
10	2	70.601	70.601	**35.3**
10	3	78.000	78.000	**26**
10	6	92.401	92.401	**15.4**
10	12	110.399	110.399	**9.2**
10	18	127.804	127.804	**7.1**
10	24	141.603	141.603	**5.9**
50	0.25	40.434	40.434	**161.735**
50	0.5	58.489	58.489	**116.978**
50	0.75	71.304	71.304	**95.072**
50	1	81.557	81.557	**81.557**
50	1.5	90.863	90.863	**60.576**
50	2	97.677	97.677	**48.838**
50	3	107.784	107.784	**35.928**
50	6	127.261	127.261	**21.21**
50	12	150.623	150.623	**12.552**
50	18	175.163	175.163	**9.731**
50	24	194.5	194.5	**8.104**
100	0.25	45.577	45.577	**182.31**
100	0.5	65.856	65.856	**131.712**
100	0.75	80.229	80.229	**106.972**
100	1	91.717	91.717	**91.717**
100	1.5	102.098	102.098	**68.066**
100	2	109.688	109.688	**54.844**
100	3	120.934	120.934	**40.311**
100	6	142.579	142.579	**23.763**
100	12	168.507	168.507	**14.042**
100	18	196.006	196.006	**10.889**
100	24	217.681	217.681	**9.07**
		FORGE Rainfall*		
1000	1	142.5878474		**142.5878474**
1000	1.5	183.7570964		**122.5047309**
1000	2	204.8432289		**102.4216145**
1000	3	186.7661445		**62.25538151**
1000	4.5	222.3447189		**49.40993754**
1000	6	219.318574		**36.55309566**
1000	9	261.2742787		**29.03047541**
1000	12	258.094262		**21.50785516**
1000	18	300.5628726		**16.69793737**
1000	24	334.004339		**13.91684746**

*Note that the ARF (0.877) that is incorporated into the FORGE results
(based on the Carmichael River catchment area) has been removed
for the local catchment hydrology.



PLOT OF 1% AEP FLOOD PEAKS IN CUMECS/SQ.KM vs CATCHMENT AREA
ALL DATA
LEGEND
NATURAL
DAMMED
1% PEAK DISCHARGE (CUMECS/SQ.KM.)
2600 m3/s
GHPx Estimate
1200 m3/s
Golders Estimate
CATCHMENT AREA (SQ. KM)

FIGURE 1

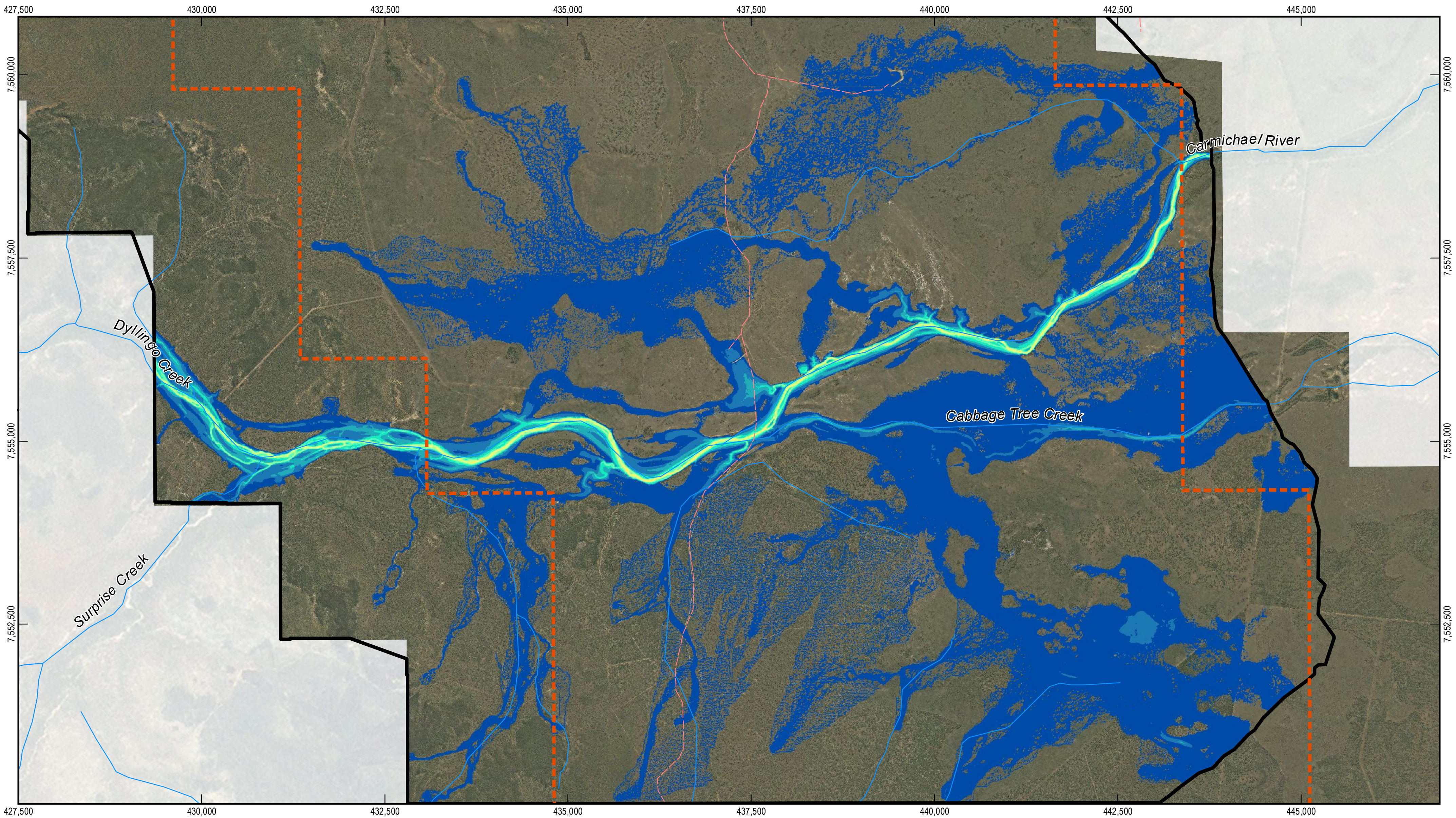
B. Carmichael River Model Results – Existing Conditions

Figure B1: 10 Year ARI Design Flood Map, Existing Conditions

Figure B2: 50 Year ARI Design Flood Map, Existing Conditions

Figure B3: 100 Year ARI Design Flood Map, Existing Conditions

Figure B4: 1000 Year ARI Design Flood Map, Existing Conditions



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine Lease Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

GHD adani

Adani Mining Pty Ltd

Carmichael Coal Mine Preliminary
Flood Mitigation and Creek Diversion Design

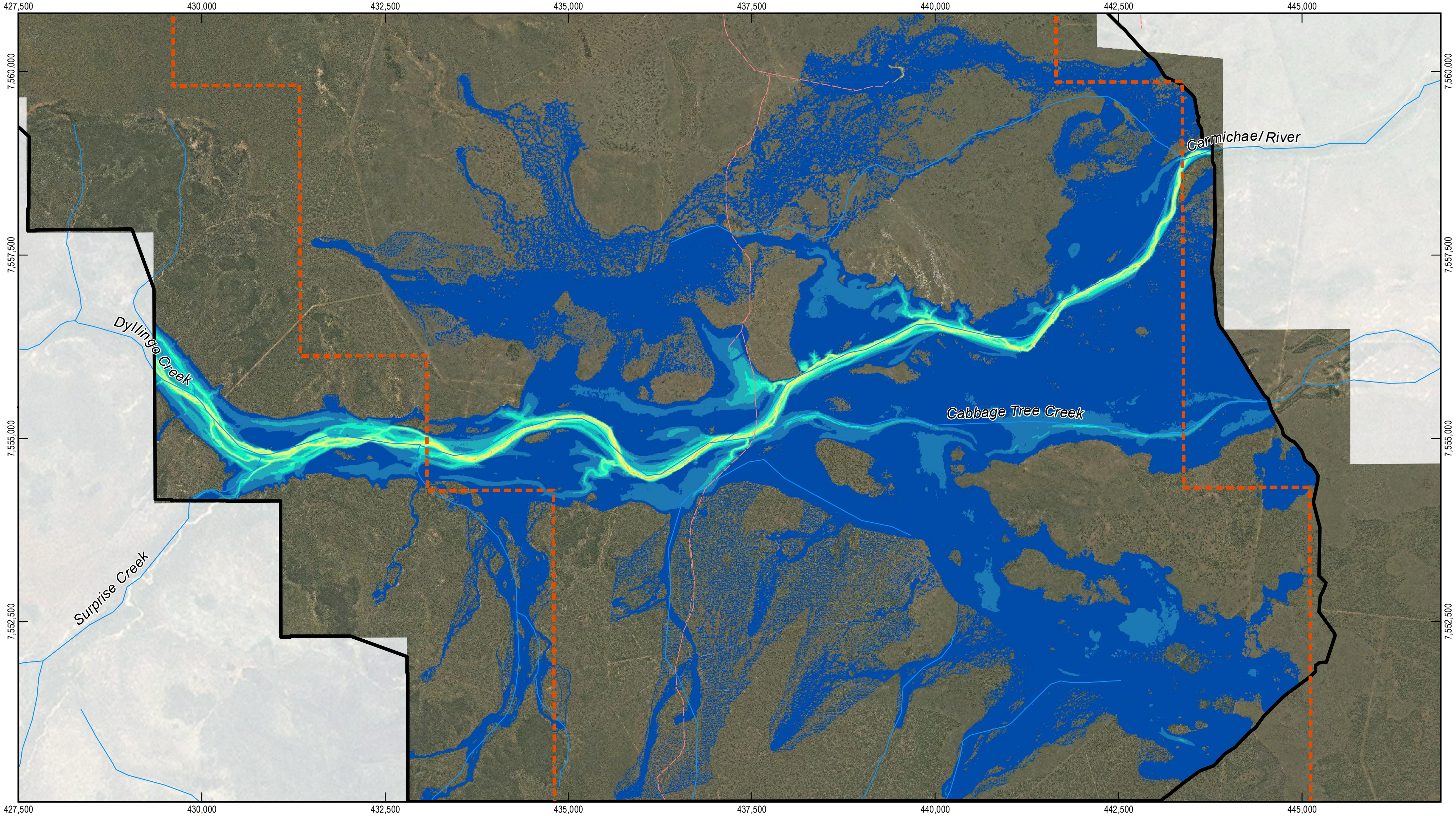
10 Year ARI Design Flood
Existing Conditions - Depth

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

Figure B1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_556-01_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Modelling (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine Lease Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

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

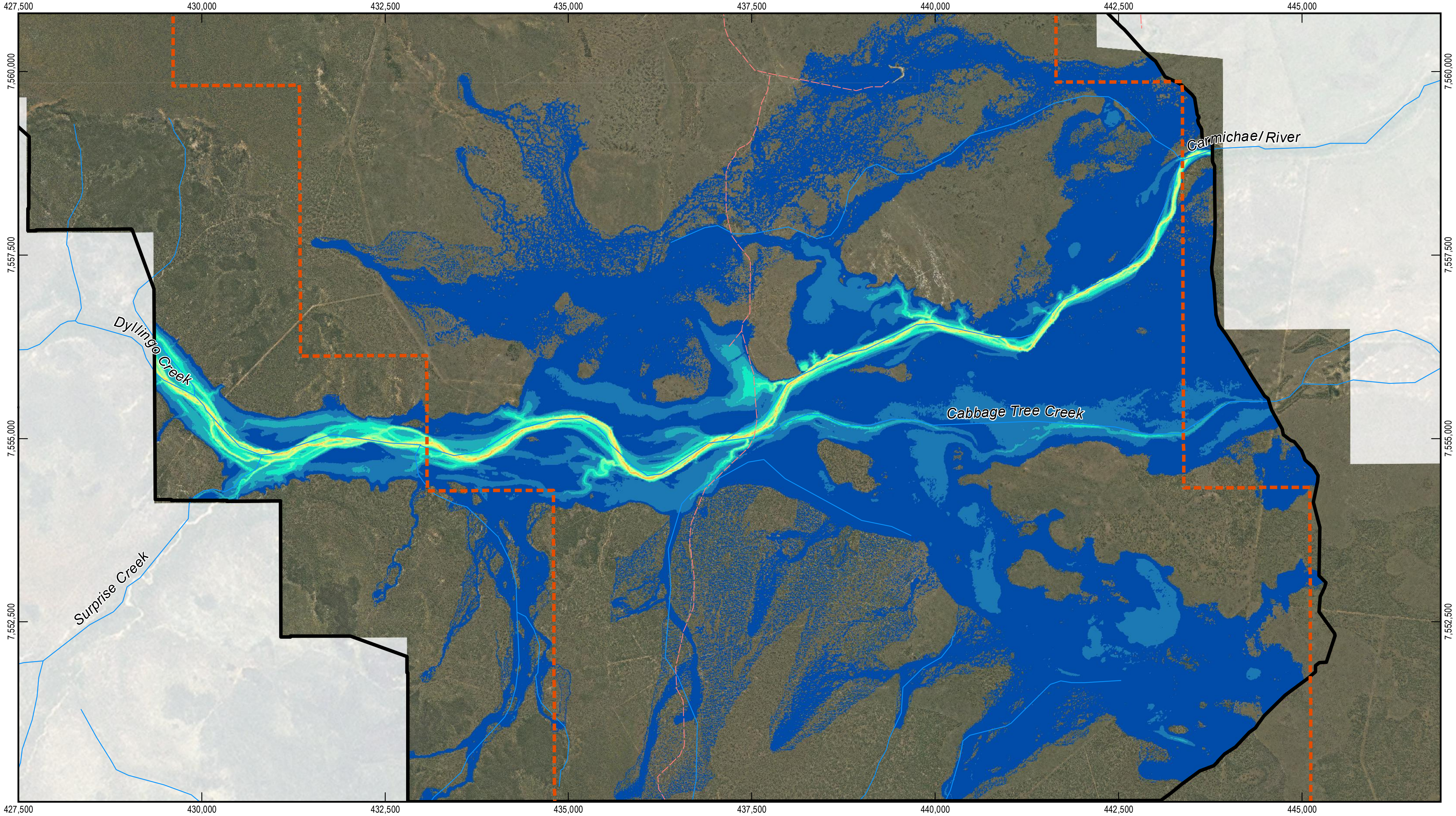
50 Year ARI Design Flood
Existing Conditions - Depth

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

Figure B2

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_556-02_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Modelling (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine Lease Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

GHD adani

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

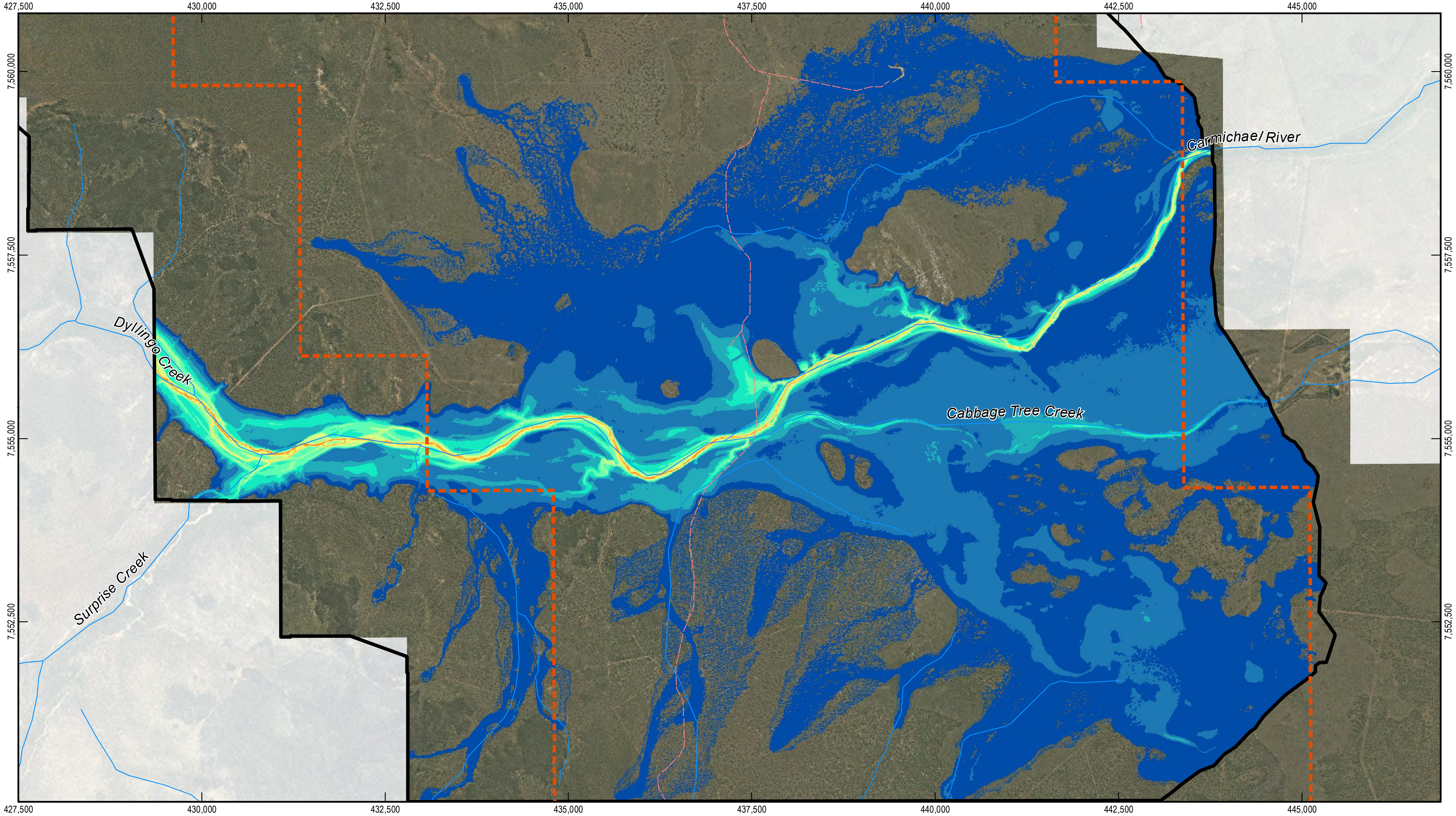
100 Year ARI Design Flood
Existing Conditions - Depth

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

Figure B3

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_556-03_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Modelling (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- 2D Model Extent
- Mine Lease Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 10.44

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

1000 Year ARI Design Flood
Existing Conditions - Depth

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

Figure B4

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_556-04_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Watercourse, Trails, Tracks (2007);
GHD: Modelling (2012); Created by: BW, CA

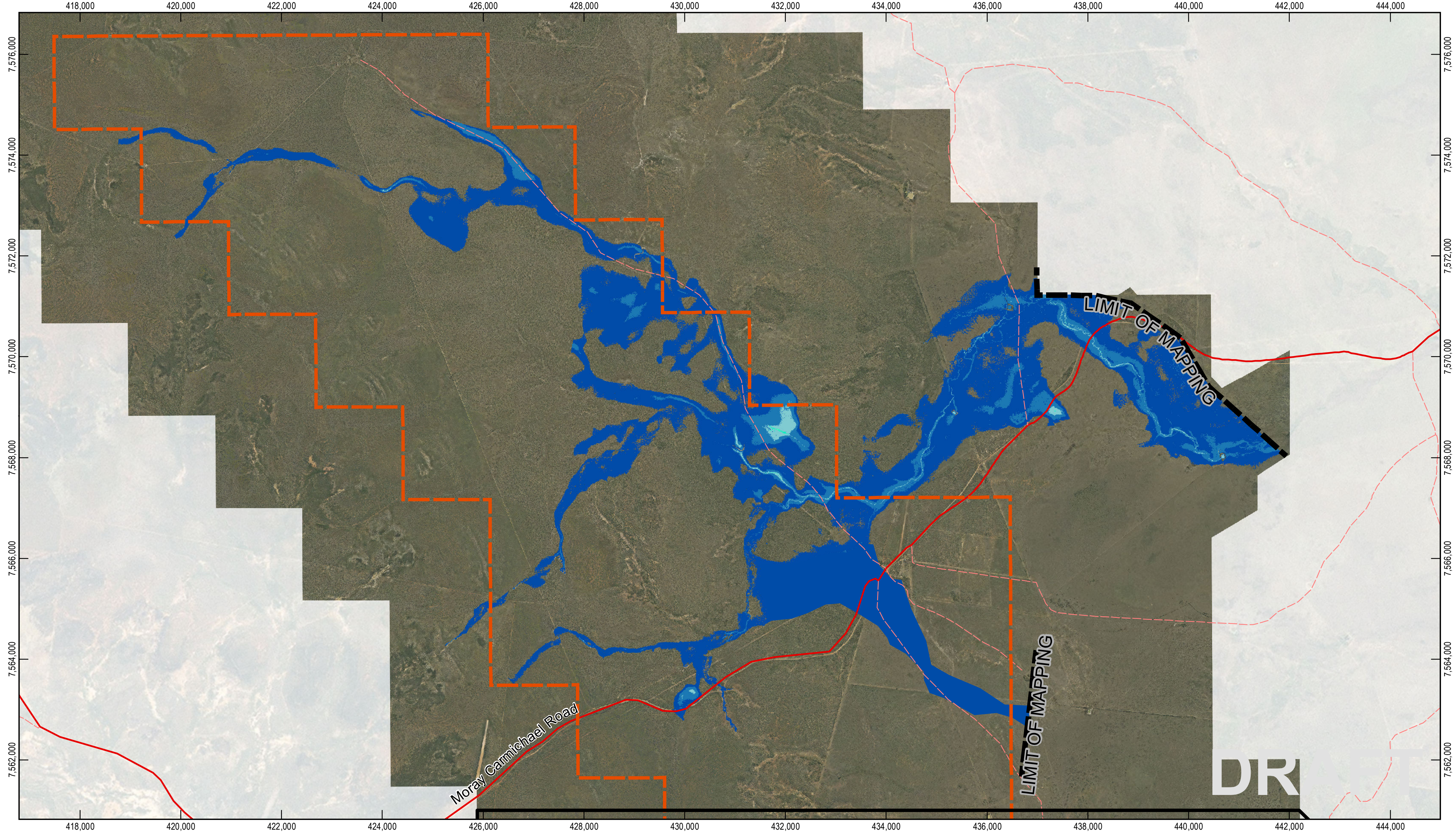
C. Local Waterway Model Results – Existing Conditions

Table of HEC-RAS Flow, Velocity, and Level Results

Figure C1: 100 Year ARI Design Flood, Minor Waterways Intersection the MLA, North

Figure C2: 100 Year ARI Design Flood, Minor Waterways Intersection the MLA, South

*Map of other events to be supplied upon request.



1:100,000 @ A4

0 1,000 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Track
Minor Road
2D Model Extent
Mining Lease Boundary

Depth (m)
0.05 - 1
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 4.7

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Adani Pty Ltd
Preliminary Flood Mitigation
& Creek Diversion Design

Job Number 41-24415
Revision A
Date 22 Aug 2012

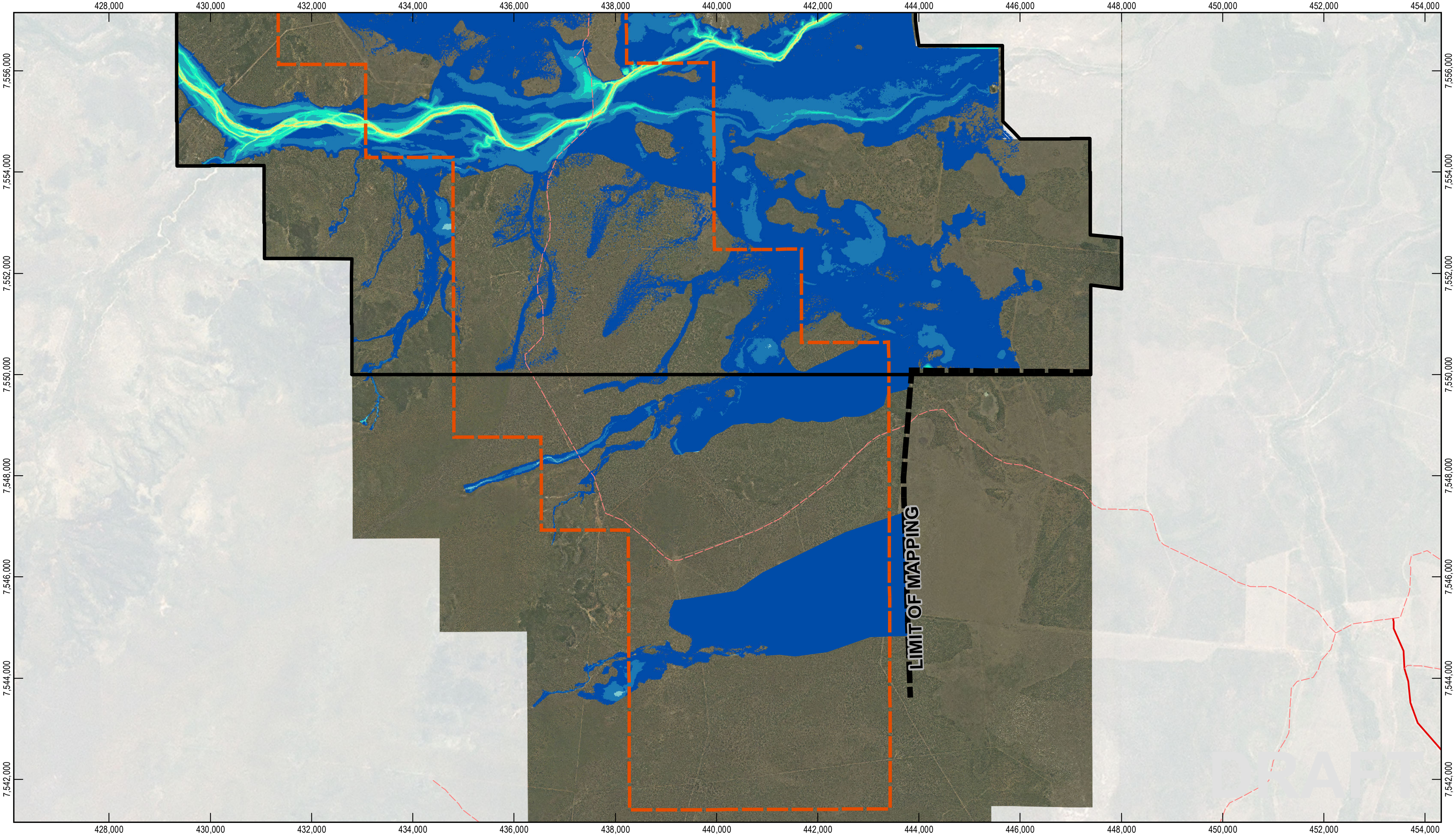
100 Year ARI Flood Event, North
Existing Waterways Intersecting The MLA

Figure C-1

G:\41\24415\GIS\Maps\MXD\4124415_037_rev_a.mxd

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

Data source: Adani Pty Ltd, Mine Lease Boundary/ML70441/2011, Waste Dump/2011, Open Cut Pits/2011. DERM, Waterways/2011, Tracks & Roads/2011. GHD, 2D Model Boundary/2011, Flood Surface/2011, Proposed Levee/2011, Proposed Haul Road Crossing/2011, Proposed Diversion Drain/2011.



1:100,000@ A4

0 1,000 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Track
Minor Road
2D Model Extent
Mining Lease Boundary

Depth (m)
0.05 - 1
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 4.7

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ADANI

Adani Pty Ltd
Preliminary Flood Mitigation
& Creek Diversion Design

Job Number	41-24415
Revision	A
Date	22 Aug 2012

100 Year ARI Flood Event, South
Existing Waterways Intersecting The MLA

Figure C-2

Data source: Adani Pty Ltd, Mine Lease Boundary/ML70441/2011, Waste Dump/2010, Open Cut Pits/2010. DERM, Waterways/2011, Tracks & Roads/2011. GHD, 2D Model Boundary/2011, Flood Surface/2011.

Existing Local Waterways 1D MODEL RESULTS

			10 year ARI					50 year ARI					100 year ARI					1000 year ARI				
Waterway	**Chainage**	**Channel Base**	Q Total	W.S. Elev	nergy Slop	Vel Chnl	Froude #	Q Total	W.S. Elev	nergy Slop	Vel Chnl	Froude #	Q Total	W.S. Elev	nergy Slop	Vel Chnl	Froude #	Q Total	W.S. Elev	nergy Slop	Vel Chnl	Froude #
		Elevation																				
	(m)	(m) AHD	(m3/s)	(m) AHD	(m/m)	(m/s)		(m3/s)	(m) AHD	(m/m)	(m/s)		(m3/s)	(m) AHD	(m/m)	(m/s)		(m3/s)	(m) AHD	(m/m)	(m/s)	
1	446.13	292.89	9.85	294.08	0.001	0.5	0.21	15.87	294.38	0.001001	0.5	0.21	16.82	294.4	0.001001	0.51	0.21	40.45	294.89	0.001001	0.52	0.21
1	635.38	295.38	9.85	295.6	0.037965	0.82	0.91	15.87	295.62	0.047069	1.03	1.05	16.82	295.62	0.048277	1.06	1.06	40.45	295.71	0.033423	1.32	0.98
1	951.62	296.95	9.85	297.31	0.002068	0.37	0.25	15.87	297.38	0.00202	0.44	0.26	16.82	297.39	0.002015	0.44	0.26	40.45	297.41	0.002116	0.47	0.27
1	1200.16	297.93	9.85	298.24	0.009244	0.72	0.52	15.87	298.31	0.009388	0.85	0.55	16.82	298.31	0.009616	0.88	0.55	40.45	298.45	0.015103	1.34	0.73
1	1465.85	299.29	9.85	299.63	0.00329	0.45	0.31	15.87	299.7	0.003211	0.53	0.32	16.82	299.71	0.003178	0.53	0.32	40.45	299.95	0.00271	0.66	0.32
1	1781.47	300.98	9.85	301.36	0.011444	0.85	0.59	15.87	301.43	0.011941	0.99	0.62	16.82	301.44	0.012165	1.02	0.63	40.45	301.61	0.016069	1.43	0.76
1	1908.17	301.95	9.85	302.24	0.004407	0.48	0.36	15.87	302.31	0.004135	0.55	0.36	16.82	302.32	0.004218	0.56	0.36	40.45	302.52	0.003507	0.69	0.36
1	2052.97	302.86	9.85	303.18	0.01089	0.76	0.56	15.87	303.24	0.012085	0.92	0.61	16.82	303.25	0.011561	0.92	0.6	40.45	303.4	0.015196	1.28	0.72
10	591.19	237.1	35.35	239	0.000348	0.3	0.12	55.68	239.23	0.000339	0.34	0.12	59.59	239.28	0.000325	0.34	0.12	143.74	239.79	0.000277	0.4	0.12
10	809.87	237.55	35.35	239.09	0.000459	0.37	0.14	55.68	239.31	0.000412	0.4	0.14	59.59	239.36	0.000415	0.41	0.14	143.74	239.88	0.000592	0.53	0.17
10	982.54	238.48	35.35	239.23	0.001905	0.43	0.25	55.68	239.42	0.000988	0.41	0.2	59.59	239.46	0.00087	0.4	0.18	143.74	239.97	0.000474	0.46	0.15
10	1194.08	239	35.35	239.78	0.004581	0.7	0.4	55.68	239.82	0.007479	0.94	0.51	59.59	239.83	0.007921	0.98	0.53	143.74	240.14	0.001787	0.65	0.27
10	1431.44	239.69	35.35	240.56	0.002401	0.55	0.29	55.68	240.69	0.002039	0.62	0.28	59.59	240.71	0.002042	0.64	0.29	143.74	240.81	0.006067	1.25	0.51
10	1623.99	240.39	35.35	241.08	0.003118	0.66	0.34	55.68	241.2	0.003579	0.77	0.37	59.59	241.22	0.003575	0.79	0.37	143.74	241.56	0.00252	0.85	0.33
10	1868.06	240.84	35.35	241.93	0.003889	0.61	0.36	55.68	242.05	0.003272	0.64	0.34	59.59	242.08	0.003231	0.65	0.34	143.74	242.3	0.003283	0.9	0.37
10	1958.54	241.27	35.35	242.18	0.002544	0.53	0.3	55.68	242.28	0.002723	0.63	0.32	59.59	242.3	0.00269	0.64	0.32	143.74	242.24	0.026356	1.81	0.97
10	2058.54	241.92	35.35	242.61	0.012405	0.94	0.62	55.68	242.72	0.010397	0.96	0.58	59.59	242.73	0.010263	0.97	0.58	143.74	243.11	0.003434	0.87	0.38
10	2217.27	242.73	35.35	243.41	0.00291	0.65	0.33	55.68	243.54	0.003438	0.8	0.37	59.59	243.56	0.003536	0.82	0.37	143.74	243.76	0.007002	1.35	0.55
10	2528.57	244.71	35.35	245.52	0	0	0	55.68	245.52	0	0	0	59.59	245.52	0	0.01	0	143.74	245.52	0.000001	0.01	0.01
10	2866.76	246.09	35.35	246.6	0	0	0	55.68	246.6	0	0	0	59.59	246.6	0	0	0	143.74	246.6	0.000001	0.01	0.01
10	3233.89	246.06	35.35	247.32	0.030515	1.54	0.98	55.68	247.43	0.031208	1.57	1	59.59	247.44	0.032608	1.63	1.02	143.74	247.48	0.000004	0.02	0.01
10	3536.58	246.83	35.35	247.62	0.025863	2.06	0.99	55.68	247.79	0.024468	2.25	0.99	59.59	247.82	0.024672	2.3	1	143.74	248.25	0.000269	0.18	0.1
10	3958.32	247.58	35.35	249.22	0.001139	0.42	0.21	55.68	249.34	0.001028	0.47	0.2	59.59	249.36	0.001006	0.47	0.2	143.74	249.22	0.020677	1.77	0.88
10	4268.68	248.18	35.35	249.69	0.001998	0.66	0.29	55.68	249.83	0.002945	0.8	0.35	59.59	249.85	0.003106	0.82	0.36	143.74	250.33	0.001246	0.74	0.25
10	5071.33	252.63	8.84	252.86	0.564258	4.2	3.77	13.92	252.92	0.545937	3.76	3.63	14.9	253.07	0.03653	1.15	0.98	35.93	253.1	0.001585	0.24	0.2
10	5309.03	253.71	8.84	253.94	0.000102	0.05	0.05	13.92	253.94	0.000253	0.08	0.08	14.9	253.86	8.583817	10.16	13.06	35.93	253.94	0.001687	0.2	0.2
10	5424.49	254.05	8.84	254.49	0.000106	0.07	0.05	13.92	254.49	0.000262	0.12	0.09	14.9	254.49	0.0003	0.12	0.09	35.93	254.49	0.001743	0.3	0.22
10	5512.18	254.46	8.84	254.8	0.043814	0.99	1.01	13.92	254.83	0.043041	1.1	1.03	14.9	254.84	0.042385	1.07	1.02	35.93	254.95	0.030573	1.21	0.93
10	5702.99	255.44	8.84	256.02	0.00231	0.36	0.26	13.92	256.08	0.002368	0.43	0.27	14.9	256.09	0.002384	0.44	0.28	35.93	256.23	0.002635	0.55	0.3
10	5853.39	256.34	8.84	256.73	0.018129	1.06	0.74	13.92	256.81	0.017787	1.22	0.76	14.9	256.82	0.018174	1.26	0.77	35.93	257.05	0.02302	1.38	0.86
10	6082.07	257.38	8.84	258	0.00249	0.59	0.3	13.92	258.13	0.002635	0.68	0.32	14.9	258.18	0.002755	0.65	0.32	35.93	258.06	0.02591	2.03	0.99
10	6195.31	257.78	8.84	258.43	0.007252	0.86	0.5	13.92	258.55	0.00637	0.95	0.48	14.9	258.59	0.005531	0.92	0.46	35.93	259.13	0.003637	0.78	0.37
10	6295.08	259.03	8.84	259.46	0.01558	0.8	0.65	13.92	259.51	0.016554	0.96	0.7	14.9	259.51	0.019136	1.04	0.75	35.93	259.7	0.01246	1.26	0.67
10	6404.46	259.78	8.84	260.31	0.004551	0.56	0.37	13.92	260.39	0.004505	0.66	0.39	14.9	260.41	0.004281	0.67	0.38	35.93	260.6	0.005505	0.96	0.46
10	6582.02	261.18	8.84	261.64	0.015837	1.19	0.72	13.92	261.73	0.017008	1.38	0.77	14.9	261.74	0.018884	1.46	0.81	35.93	262.09	0.014869	1.34	0.72
10	6664.15	261.65	8.84	262.4	0.005399	0.6	0.4	13.92	262.49	0.004823	0.65	0.4	14.9	262.51	0.004562	0.64	0.39	35.93	262.73	0.00421	0.86	0.4
10	6772.27	263.25	8.84	263.51	0.02975	1.17	0.91	13.92	263.56	0.033261	1.4	0.99	14.9	263.57	0.034567	1.45	1.01	35.93	263.74	0.029065	1.79	1
10	6927.78	265.14	8.84	265.78	0.008414	0.82	0.52	13.92	265.88	0.008067	0.91	0.52	14.9	265.9	0.007933	0.93	0.52	35.93	266.13	0.008842	1.22	0.58
2	475.9	244.17	112.87	245.18	0.005503	0.72	0.43	193.88	245.2	0.011439	1.09	0.62	214.02	245.22	0.011567	1.13	0.63	497.65	245.76	0.001239	0.71	0.24
2	776.57	244.51	100.27	246.09	0.001692	0.73	0.28	173.24	246.26	0.001401	0.77	0.26	191.88	246.29	0.001401	0.78	0.26	445.91	246.38	0.004116	1.43	0.46
2	1570.68	246.97	100.27	247.81	0.002915	0.88	0.35	173.24	247.96	0.003928	1.14	0.42	191.88	247.99	0.003974	1.18	0.43	445.91	248.62	0.002136	1.23	0.34
2	1789.55	247.3	53.33	248.17	0.00076	0.39	0.17	95.68	248.39	0.000781	0.46	0.18	106.91	248.45	0.000839	0.49	0.19	249.76	248.94	0.000675	0.57	0.18
2	1938.49	247.67	49.28	248.32	0.001344	0.5	0.23	87.81	248.54	0.001132	0.54	0.22	98.16	248.6	0.001037	0.55	0.21	228.82	249.06	0.000854	0.66	0.21
2	2144.95	248.23	49.28	248.68	0.001998	0.43	0.26	87.81	248.85	0.001924	0.55	0.27	98.16	248.89	0.001897	0.57	0.27	228.82	249.3	0.001511	0.7	0.26
2	2337.37	248.99	49.28	249.21	0.000632	0.13	0.12	87.81	249.22	0.001919	0.24	0.22	98.16	249.26	0.00189	0.27	0.22	228.82	249.6	0.001611	0.51	0.25
2	2529.68	249.2	35.88	249.5	0.000343	0.08	0.09	64.67	249.5	0.001114	0.15	0.16	71.38	249.5	0.001357	0.17	0.18	167.92	249.81	0.001269	0.32	0.2
2	2656.35	249.44	35.88	249.62	0.034349	0.78	0.87	64.67	249.8	0.007657	0.6	0.46	71.38	249.83	0.006238	0.61	0.43	167.92	250.08	0.004009	0.81	0.39
2	2926.09	250.5	35.88	250.93	0.00149	0.36	0.22	64.67	251.01	0.002456	0.53	0.29	71.38	251.03	0.002686	0.57	0.31	167.92	251.22	0.003676	0.84	0.38
2	3198.01	251.89	35.88	252.16	0.037437	1.18	0.99	64.67	252.32	0.010736	0.98	0.59	71.38	252.36	0.009341	0.99	0.56	167.92	252.59	0.006137	1.09	0.49

2	3398.3	252.92	35.88	253.24	0.002004	0.36	0.25	64.67	253.31	0.002862	0.48	0.3	71.38	253.33	0.00301	0.5	0.31	167.92	253.51	0.003709	0.75	0.37
2	3589.74	253.73	35.88	254.15	0.019658	1.25	0.79	64.67	254.33	0.011725	1.24	0.65	71.38	254.36	0.011105	1.25	0.64	167.92	254.64	0.010537	1.67	0.67
3	43.54	244.91	19.73	246.04	0.001	0.42	0.2	31.86	246.25	0.001002	0.42	0.2	34.28	246.27	0.001001	0.43	0.2	81.66	246.52	0.001001	0.55	0.21
3	377.38	247.16	19.73	247.34	0.036127	0.94	0.93	31.86	247.36	0.025308	0.91	0.8	34.28	247.36	0.029292	0.98	0.86	81.66	247.45	0.018458	1.11	0.75
3	618.9	248.38	19.73	248.64	0.001288	0.22	0.18	31.86	248.69	0.001328	0.27	0.2	34.28	248.7	0.001293	0.27	0.2	81.66	248.84	0.001451	0.41	0.23
3	928.49	249.36	19.73	249.67	0.005045	0.46	0.37	31.86	249.77	0.005729	0.54	0.4	34.28	249.78	0.006046	0.56	0.42	81.66	249.96	0.005272	0.53	0.39
3	1205.3	250.15	19.73	250.6	0.001355	0.37	0.21	31.86	250.67	0.001132	0.39	0.2	34.28	250.69	0.001096	0.39	0.2	81.66	250.86	0.001056	0.49	0.21
3	1412.13	250.94	19.73	251.02	2.600698	4.86	6.94	31.86	251.11	0.220528	2.71	2.38	34.28	251.15	0.100402	2.16	1.67	81.66	251.39	0.005129	0.71	0.42
3	1764.4	252.78	19.73	252.9	0.000356	0.09	0.09	31.86	252.9	0.000927	0.14	0.15	34.28	252.9	0.001073	0.15	0.16	81.66	252.9	0.006092	0.36	0.37
3	2046.26	253.69	19.73	253.92	0.045338	1.14	1.06	31.86	253.97	0.037339	1.28	1.01	34.28	253.99	0.000217	0.1	0.08	81.66	253.99	0.001232	0.24	0.19
3	2342.9	254.71	19.73	255.03	0.041608	1.14	1.03	31.86	255.23	0.001034	0.3	0.18	34.28	254.95	1.06877	4.28	4.82	81.66	255.13	0.104236	2.37	1.74
3	2512.97	255.5	19.73	255.99	0.035034	1.33	1	31.86	256.03	0.000122	0.11	0.06	34.28	256.03	0.000141	0.12	0.07	81.66	256.03	0.0008	0.29	0.16
3	2615.5	255.69	19.73	256.16	0.076835	2.49	1.57	31.86	256.25	0.000362	0.13	0.1	34.28	256.25	0.000419	0.14	0.11	81.66	256.25	0.002376	0.32	0.26
3	2820.49	256.5	19.73	256.81	0.000328	0.11	0.09	31.86	256.81	0.000855	0.17	0.15	34.28	256.81	0.00099	0.18	0.16	81.66	256.93	0.001829	0.35	0.24
3	3109.74	257.71	19.73	258.01	0.031828	1.09	0.92	31.86	258.06	0.030768	1.28	0.94	34.28	258.07	0.03091	1.32	0.95	81.66	258.19	0.007079	0.86	0.49
3	3347.79	258.8	19.73	259.3	0.001849	0.39	0.24	31.86	259.38	0.001858	0.46	0.26	34.28	259.39	0.001864	0.48	0.26	81.66	259.54	0.003122	0.77	0.35
3	3581.64	259.78	19.73	260.11	0.006999	0.63	0.45	31.86	260.17	0.006509	0.73	0.46	34.28	260.19	0.006337	0.75	0.45	81.66	260.43	0.003822	0.84	0.39
3	3780.31	260.31	19.73	260.88	0.002204	0.46	0.27	31.86	260.98	0.002299	0.55	0.29	34.28	261	0.002372	0.56	0.29	81.66	261.2	0.002933	0.81	0.35
3	3952.94	260.81	19.73	261.46	0.005775	0.74	0.44	31.86	261.58	0.005878	0.8	0.45	34.28	261.6	0.005647	0.81	0.44	81.66	261.86	0.00465	0.96	0.43
3	4225	261.57	19.73	262.49	0.002665	0.7	0.32	31.86	262.68	0.002916	0.79	0.34	34.28	262.7	0.003026	0.81	0.35	81.66	263.08	0.004095	0.98	0.41
3	4449.66	262.13	19.73	263.2	0.003858	0.86	0.39	31.86	263.42	0.00396	0.89	0.4	34.28	263.46	0.003891	0.9	0.4	81.66	263.92	0.003463	1	0.39
3	4692.47	264.47	19.73	265.16	0.015257	1.18	0.71	31.86	265.31	0.01316	1.24	0.68	34.28	265.33	0.013377	1.24	0.68	81.66	265.62	0.013409	1.26	0.69
3	4900.63	267.28	9.87	267.62	0.003985	0.46	0.34	15.93	267.68	0.004321	0.54	0.36	17.14	267.69	0.0042	0.54	0.36	40.83	267.82	0.003433	0.56	0.34
3	5120.49	269.53	9.87	269.62	3.145129	5.98	7.85	15.93	269.68	0.793257	3.52	4.1	17.14	269.7	0.474096	3.03	3.26	40.83	269.79	0.009417	0.59	0.5
3	5398.7	271.89	9.87	272.21	0.000598	0.12	0.12	15.93	272.21	0.001558	0.2	0.19	17.14	272.21	0.001804	0.21	0.21	40.83	272.25	0.005826	0.43	0.38
3	5697.64	272.67	9.87	273.29	0.027051	1.95	0.99	15.93	273.54	0.01501	1.81	0.78	17.14	273.62	0.011861	1.69	0.7	40.83	274.46	0.005397	1.24	0.49
3	5990.29	277.17	9.87	277.5	0.008316	0.63	0.48	15.93	277.54	0.011517	0.74	0.57	17.14	277.54	0.014197	0.81	0.63	40.83	277.6	0.030321	1.42	0.96
3	6204.23	279.22	9.87	279.62	0.01188	0.82	0.59	15.93	279.7	0.008519	0.86	0.53	17.14	279.73	0.007332	0.83	0.49	40.83	279.97	0.00467	0.72	0.4
3	6365.18	280.92	9.87	281.29	0.008915	0.56	0.48	15.93	281.32	0.011156	0.72	0.56	17.14	281.32	0.013128	0.78	0.61	40.83	281.4	0.019202	1.21	0.78
3	6517.12	281.96	9.87	282.67	0.009635	0.97	0.57	15.93	282.78	0.007101	0.55	0.44	17.14	282.79	0.006438	0.54	0.42	40.83	282.93	0.005028	0.7	0.41
3	6695.41	284.97	9.87	285.21	0.020311	0.76	0.71	15.93	285.23	0.03031	1.03	0.89	17.14	285.23	0.037006	1.13	0.98	40.83	285.31	0.024455	1.22	0.85
3	6883.76	287.2	9.87	287.54	0.007863	0.6	0.47	15.93	287.63	0.006474	0.61	0.44	17.14	287.64	0.00599	0.6	0.42	40.83	287.77	0.007553	0.88	0.51
3	6990.13	288.49	9.87	288.79	0.019544	0.84	0.72	15.93	288.82	0.025854	1.1	0.85	17.14	288.82	0.029768	1.18	0.91	40.83	288.97	0.021204	1.44	0.84
3	7028.93	289.04	9.87	289.33	0.009023	0.66	0.5	15.93	289.4	0.007986	0.77	0.5	17.14	289.41	0.007703	0.78	0.49	40.83	289.57	0.009471	1.12	0.59
3	7155.36	290.21	9.87	290.71	0.013602	1.02	0.65	15.93	290.79	0.01654	1.16	0.73	17.14	290.8	0.017247	1.21	0.75	40.83	291	0.0139	1.52	0.73
3	7295.37	291.25	9.87	292.14	0.008151	1.2	0.56	15.93	292.33	0.008058	1.3	0.57	17.14	292.37	0.007928	1.31	0.57	40.83	292.72	0.011011	1.59	0.68
3	7463.73	294.42	9.87	295.2	0.026587	1.97	0.99	15.93	295.38	0.027652	1.98	1.01	17.14	295.41	0.027164	2	1	40.83	295.72	0.025886	2.56	1.05
3	7573.45	298	9.87	298.5	0.031667	1.28	0.95	15.93	298.57	0.028699	1.46	0.95	17.14	298.58	0.029078	1.51	0.96	40.83	298.78	0.026912	1.89	0.99
4	291.68	249.22	17.77	250.63	0.047972	2.71	1.34	27.85	250.77	0.014126	1.61	0.74	29.8	250.78	0.014094	1.62	0.74	71.87	250.84	0.001802	0.66	0.27
4	604.89	251.43	17.77	251.92	0.000985	0.32	0.18	27.85	251.72	0.037482	1.29	1.02	29.8	251.96	0.001642	0.44	0.24	71.87	251.95	0.011901	1.17	0.65
4	881.38	252.51	17.77	253.05	0.000286	0.2	0.1	27.85	253.22	0.000164	0.19	0.08	29.8	253.19	0.000223	0.22	0.1	71.87	253.55	0.000177	0.27	0.09
4	1112.16	253.46	17.77	253.74	0.041407	1.23	1.04	27.85	253.79	0.036419	1.36	1.02	29.8	253.81	0.034529	1.36	1	71.87	253.92	0.005308	0.65	0.41
4	1305	254.14	17.77	254.7	0.001646	0.45	0.24	27.85	254.8	0.001755	0.48	0.25	29.8	254.9	0.000447	0.27	0.13	71.87	254.86	0.00427	0.8	0.4
4	1415.46	254.45	17.77	254.96	0.004195	0.63	0.37	27.85	255.06	0.004041	0.71	0.38	29.8	255	0.008471	0.93	0.54	71.87	255.29	0.004001	0.92	0.4
4	1498.64	254.71	17.77	255.31	0.004194	0.66	0.38	27.85	255.4	0.004068	0.75	0.39	29.8	255.44	0.003402	0.72	0.36	71.87	255.63	0.004316	1.01	0.43
4	1650.92	255.22	17.77	255.78	0.002472	0.54	0.29	27.85	255.87	0.002558	0.63	0.31	29.8	255.88	0.00263	0.65	0.32	71.87	256.14	0.002817	0.79	0.34
4	1833.63	255.89	17.77	256.47	0.007048	0.92	0.5	27.85	256.6	0.007583	1	0.52	29.8	256.62	0.007534	1.01	0.52	71.87	256.93	0.007768	1.14	0.55
4	1963.87	256.43	17.77	257.11	0.00334	0.71	0.35	27.85	257.26	0.003426	0.79	0.37	29.8	257.28	0.003514	0.8	0.37	71.87	257.67	0.00407	0.89	0.4
4	2155.79	257.22	17.77	257.89	0.005263	0.81	0.43	27.85	258.05	0.005077	0.82	0.43	29.8	258.07	0.004943	0.83	0.43	71.87	258.42	0.003799	0.92	0.4
4	2415.28	258.4	17.77	259.18	0.004674	0.76	0.41	27.85	259.33	0.004818	0.82	0.42	29.8	259.34	0.004925	0.84	0.43	71.87	259.6	0.005795	1.16	0.49
4	2563.19	259.3	17.77	259.99	0.006677	0.87	0.48	27.85	260.13	0.006451	0.9	0.48	29.8	260.15	0.006208	0.91	0.47	71.87	260.43	0.005382	1.13	0.48
4	2842.18	261.11	17.77	261.57	0.004767	0.57	0.38	27.85	261.65	0.004564	0.64	0.39	29.8	261.66	0.004689	0.66	0.39	71.87	261.87	0.004723	0.88	0.42
4	3104.87	262.01	17.77	262.82	0.004866	0.77	0.41	27.85	262.94	0.005405	0.85	0.44	29.8	262.97	0.005316	0.86	0.44	71.87	263.22	0.005865	1.21	0.5
4	3247.76	262.94	17.77	263.71	0.008478	0.91	0.53	27.85	263.82	0.007408	0.96	0.51	29.8	263.84	0.007439	0.96	0.52	71.87	264.1	0.006437	1.1	0.5

4	3351.08	263.4	17.77	264.47	0.006537	0.98	0.49	27.85	264.63	0.007955	0.83	0.51	29.8	264.64	0.007907	0.85	0.51	71.87	264.83	0.007988	1.16	0.55
4	3457.74	264.39	17.77	265.2	0.006855	0.8	0.48	27.85	265.33	0.005489	0.8	0.44	29.8	265.34	0.005546	0.82	0.44	71.87	265.56	0.00589	1.11	0.49
4	3569.99	265.34	17.77	265.85	0.004997	0.8	0.42	27.85	265.96	0.00598	0.94	0.47	29.8	265.98	0.006038	0.95	0.47	71.87	266.27	0.007201	1.24	0.54
4	3715.83	265.63	17.77	266.5	0.003924	0.83	0.39	27.85	266.66	0.003973	0.95	0.41	29.8	266.69	0.004017	0.98	0.41	71.87	267.14	0.004838	1.13	0.46
4	3967.74	268.1	17.77	268.41	0.02174	1.01	0.78	27.85	268.47	0.018192	1.07	0.74	29.8	268.48	0.017361	1.08	0.73	71.87	268.71	0.009043	1.14	0.58
4	4077.84	268.46	17.77	268.93	0.002198	0.44	0.27	27.85	269	0.00251	0.54	0.3	29.8	269.02	0.002563	0.55	0.3	71.87	269.21	0.003473	0.78	0.37
4	4294.01	271.54	17.77	271.86	0.033088	1.03	0.92	27.85	271.9	0.035293	1.23	0.98	29.8	271.91	0.035102	1.26	0.99	71.87	272.05	0.031264	1.61	1
4	4481.3	274.56	17.77	274.95	0.009256	0.76	0.53	27.85	275.02	0.009025	0.88	0.54	29.8	275.03	0.009066	0.91	0.55	71.87	275.22	0.009806	1.25	0.61
4	4660.68	276.97	17.77	277.44	0.023793	1.15	0.83	27.85	277.5	0.024974	1.35	0.88	29.8	277.51	0.024926	1.37	0.89	71.87	277.7	0.022093	1.7	0.89
4	4815.68	279.43	17.77	279.8	0.010588	0.81	0.56	27.85	279.88	0.01019	0.9	0.57	29.8	279.89	0.010183	0.92	0.57	71.87	280.06	0.010697	1.27	0.63
4	4923.63	281.04	17.77	281.26	0.026162	0.88	0.81	27.85	281.33	0.025997	1.09	0.85	29.8	281.34	0.026197	1.13	0.86	71.87	281.51	0.024278	1.61	0.91
4	5058.54	283.28	17.77	283.71	0.012109	0.81	0.59	27.85	283.77	0.012174	0.95	0.62	29.8	283.79	0.012146	0.96	0.62	71.87	283.96	0.01289	1.3	0.68
4	5176.87	285.8	17.77	286.14	0.035748	1.28	1	27.85	286.21	0.03469	1.4	1.01	29.8	286.22	0.034296	1.41	1.01	71.87	286.38	0.029725	1.68	0.99
4	5318.43	288.7	17.77	289.01	0.012643	0.89	0.62	27.85	289.07	0.01292	1.04	0.65	29.8	289.08	0.013014	1.07	0.65	71.87	289.26	0.014562	1.45	0.73
4	5510.25	292.74	17.77	292.93	0.038575	0.87	0.93	27.85	292.96	0.036371	1.03	0.95	29.8	292.97	0.035794	1.06	0.95	71.87	293.07	0.028461	1.38	0.93
5	232.37	215.2	252.65	216.61	0.001002	0.67	0.22	401.04	216.81	0.001001	0.76	0.23	343.07	216.73	0.001001	0.73	0.23	930.16	217.24	0.001	0.94	0.24
5	719.5	216.08	252.65	217.16	0.001322	0.74	0.25	401.04	217.36	0.001261	0.82	0.25	343.07	217.29	0.001295	0.8	0.26	930.16	217.76	0.001097	0.95	0.25
5	1054.43	215.95	252.65	217.54	0.000918	0.61	0.21	401.04	217.74	0.000966	0.72	0.22	343.07	217.67	0.000968	0.69	0.22	930.16	218.14	0.0011	0.95	0.25
5	1593.07	215.86	252.65	218.19	0.001482	0.73	0.26	401.04	218.36	0.001231	0.75	0.25	343.07	218.29	0.001242	0.72	0.24	930.16	218.8	0.001264	0.97	0.26
5	1935.04	216.47	252.65	218.38	0.000311	0.38	0.12	401.04	218.56	0.000366	0.46	0.14	343.07	218.49	0.000355	0.44	0.14	930.16	219.04	0.000432	0.64	0.16
5	2617.84	216.74	252.65	218.68	0.000485	0.48	0.16	401.04	218.88	0.000465	0.53	0.16	343.07	218.81	0.000472	0.51	0.16	930.16	219.39	0.000442	0.66	0.16
5	2964.04	216.68	252.65	218.94	0.001551	0.85	0.28	401.04	219.13	0.001424	0.92	0.27	343.07	219.06	0.00147	0.89	0.28	930.16	219.61	0.00101	0.97	0.24
5	3463.1	217.38	252.65	219.4	0.000681	0.5	0.18	401.04	219.55	0.000655	0.55	0.18	343.07	219.5	0.000654	0.53	0.18	930.16	219.94	0.00065	0.69	0.19
5	3909.61	217.98	241.58	219.93	0.001489	0.86	0.27	385.77	220.03	0.000984	0.75	0.23	417.01	220.03	0.00117	0.81	0.25	905.1	220.43	0.000941	0.9	0.23
5	4284.7	218.7	241.58	220.33	0.000785	0.58	0.2	385.77	220.42	0.001304	0.8	0.26	417.01	220.49	0.000344	0.43	0.13	905.1	220.71	0.000708	0.7	0.2
5	5069.47	219.32	241.58	221.03	0.000566	0.56	0.17	385.77	221.25	0.000489	0.59	0.16	417.01	221.12	0.001063	0.81	0.24	905.1	221.55	0.000697	0.8	0.2
5	5273.51	218.85	241.58	221.17	0.000874	0.68	0.21	385.77	221.38	0.001063	0.85	0.24	417.01	221.36	0.001331	0.94	0.27	905.1	221.75	0.001921	1.35	0.34
5	5546.47	219.32	241.58	221.43	0.001027	0.74	0.23	385.77	221.67	0.001065	0.87	0.24	417.01	221.7	0.001123	0.9	0.25	905.1	222.15	0.000864	0.96	0.23
5	5760.79	219.35	241.58	221.58	0.000693	0.62	0.19	385.77	221.84	0.000772	0.75	0.21	417.01	221.88	0.000811	0.79	0.21	905.1	222.3	0.001048	1.07	0.25
5	6008.3	219.2	241.58	221.82	0.001052	0.75	0.23	385.77	222.09	0.001024	0.86	0.24	417.01	222.14	0.001033	0.88	0.24	905.1	222.63	0.001266	1.2	0.28
5	6282.7	220.13	241.58	222.11	0.001131	0.84	0.25	385.77	222.38	0.001148	0.97	0.26	419.01	222.44	0.001166	1	0.26	905.1	222.96	0.001151	1.21	0.27
5	6531.49	220.73	241.58	222.44	0.001681	0.95	0.29	385.77	222.7	0.001422	0.97	0.28	419.01	222.75	0.00138	0.99	0.28	905.1	223.27	0.001201	1.15	0.27
5	7033.29	220.75	241.58	223.1	0.001023	0.89	0.24	385.77	223.38	0.000449	0.67	0.16	419.01	223.48	0.000377	0.63	0.15	905.1	223.77	0.000689	0.95	0.21
5	7533.61	221.35	216.7	223.49	0.001506	0.87	0.28	347.72	223.69	0.000438	0.53	0.15	380.34	223.75	0.000404	0.52	0.15	830.88	224.15	0.00042	0.64	0.16
5	8261.57	223.14	216.7	224.44	0.000868	0.53	0.2	347.72	224.41	0.002425	0.86	0.33	380.34	224.45	0.002611	0.92	0.34	830.88	224.87	0.002618	1.25	0.37
5	8684.37	223.75	216.7	224.87	0.000916	0.39	0.19	347.72	225.09	0.000889	0.51	0.2	380.34	225.14	0.000893	0.53	0.2	830.88	225.57	0.000867	0.71	0.21
5	8914.46	224.18	216.7	225.37	0.007961	1.06	0.54	347.72	225.54	0.005758	1.15	0.49	380.34	225.58	0.00542	1.17	0.48	830.88	225.92	0.002691	1.11	0.36
5	9195.67	224.24	216.7	226.07	0.000893	0.55	0.2	347.72	226.21	0.000926	0.62	0.21	380.34	226.24	0.000936	0.63	0.21	830.88	226.38	0.000808	0.62	0.2
5	9449.62	224.33	216.7	226.52	0.005087	1.06	0.46	347.72	226.68	0.005214	1.25	0.48	380.34	226.46	0.02353	2.12	0.97	830.88	226.69	0.005221	1.26	0.48
5	9618.39	224.4	216.7	227.07	0.000127	0.24	0.08	347.72	226.93	0.000624	0.52	0.17	380.34	226.95	0.000693	0.55	0.18	830.88	227.1	0.00161	0.85	0.28
5	9853.63	225.41	216.7	227.17	0.016349	2.07	0.84	347.72	227.26	0.000509	0.37	0.15	380.34	227.3	0.000516	0.39	0.15	830.88	227.67	0.000613	0.51	0.17
5	10042.2	227.74	216.7	227.34	0.025897		0	347.72	227.55	0.022815		0	380.34	227.59	0.023494		0	830.88	227.91	0.000384	0.07	0.09
5	10463.1	225.73	216.7	227.71	0.022641	2.57	1	347.72	228.01	0.000095	0.18	0.07	380.34	228.07	0.000094	0.18	0.07	830.88	228.08	0.000428	0.38	0.14
5	10685.2	227.31	216.7	228.21	0.030801	1.7	1.01	347.72	228.32	0.027706	1.71	0.97	380.34	228.33	0.028025	1.78	0.99	830.88	228.44	0.001118	0.42	0.21
5	11068.6	227.64	216.7	228.87	0.025814	1.72	0.95	347.72	229	0.026247	1.83	0.97	380.34	229.16	0.000318	0.26	0.11	830.88	229.2	0.001262	0.54	0.23
5	11389	227.85	216.7	229.46	0.014787	1.82	0.78	347.72	229.85	0.000403	0.37	0.14	380.34	229.56	0.022787	2.12	0.95	830.88	229.94	0.001458	0.76	0.26
5	11679.5	228.85	216.7	229.83	0.024254	1.96	0.96	347.72	230.06	0.000693	0.44	0.17	380.34	230.21	0.000377	0.37	0.13	830.88	230.4	0.000857	0.65	0.21
5	12077.5	228.68	216.7	231.2	0.00102	0.71	0.23	347.72	230.81	0.01959	2.23	0.91	380.34	230.83	0.02037	2.33	0.94	830.88	231.23	0.011579	2.44	0.77
5	12265.3	229.16	216.7	231.34	0.000467	0.44	0.15	347.72	231.43	0.00079	0.61	0.2	380.34	231.47	0.000776	0.62	0.2	830.88	231.84	0.000839	0.79	0.22
5	12447.1	229.68	216.7	231.48	0.001507	0.66	0.26	347.72	231.63	0.001518	0.76	0.27	380.34	231.66	0.001478	0.77	0.27	830.88	232.04	0.001431	0.97	0.28
5	12680.4	229.92	216.7	231.93	0.002631	0.92	0.34	347.72	232.09	0.00276	1.07	0.36	380.34	232.12	0.002784	1.1	0.37	830.88	232.46	0.002499	1.29	0.37
5	13068.9	230.56	216.7	232.79	0.001861	0.89	0.3	347.72	232.9	0.002783	1.19	0.38	380.34	232.97	0.001751	0.98	0.3	830.88	233.32	0.001925	1.24	0.33
5	13353.1	230.98	216.7	233.26	0.001468	0.82	0.27	347.72	233.47	0.001459	0.94	0.28	380.34	233.47	0.001806	1.04	0.31	830.88	233.88	0.002102	1.38	0.35
5	13585.8	231.26	216.7	233.54	0.001058	0.61	0.22	347.72	233.76	0.001124	0.74	0.24	380.34	233.8	0.001171	0.78	0.24	830.88	234.29	0.001445	1.12	0.29

5	13726.2	232.11	216.7	233.72	0.002598	0.97	0.35	347.72	233.94	0.002216	1.05	0.33	380.34	233.98	0.002242	1.09	0.34	830.88	234.49	0.001933	1.31	0.34
5	14039	232.47	216.7	234.32	0.001412	0.88	0.27	347.72	234.51	0.00156	1.03	0.29	380.34	234.56	0.001546	1.05	0.29	830.88	235.05	0.001613	1.33	0.31
5	14298	232.39	216.7	234.71	0.001633	0.95	0.29	347.72	234.94	0.001717	1.11	0.31	380.34	234.98	0.001722	1.13	0.31	830.88	235.5	0.00177	1.42	0.33
5	14701.8	233.72	216.7	235.3	0.001323	0.86	0.26	347.72	235.53	0.001248	0.94	0.26	380.34	235.57	0.001238	0.96	0.26	830.88	236.06	0.001097	1.11	0.26
5	14969.7	234.37	216.7	235.8	0.002661	1.07	0.36	347.72	235.97	0.002057	1.05	0.33	380.34	236.01	0.00201	1.06	0.32	830.88	236.41	0.001227	1.02	0.27
5	15197.3	234.91	216.7	236.36	0.002108	0.97	0.32	347.72	236.46	0.002265	1.08	0.34	380.34	236.48	0.002113	1.05	0.33	830.88	236.76	0.001973	1.19	0.33
5	15454.6	234.91	216.7	236.79	0.001372	0.75	0.26	347.72	236.88	0.001209	0.75	0.25	380.34	236.9	0.001296	0.79	0.25	830.88	237.19	0.00156	1.03	0.29
5	15650.2	235.12	216.7	237.14	0.003454	1.3	0.42	347.72	237.23	0.006441	1.8	0.57	380.34	237.27	0.006454	1.82	0.57	830.88	237.61	0.005757	2.07	0.57
5	15902.5	234.99	216.7	237.62	0.000914	0.67	0.21	347.72	237.85	0.00092	0.77	0.22	380.34	237.9	0.000923	0.79	0.22	830.88	238.29	0.00124	1.1	0.27
5	16253.9	235.72	216.7	238.04	0.002258	1.09	0.34	347.72	238.28	0.002232	1.24	0.35	380.34	238.33	0.002224	1.26	0.35	830.88	238.82	0.00247	1.64	0.39
5	16601.8	236.13	164.85	238.61	0.001014	0.7	0.23	266.1	238.87	0.001143	0.87	0.25	293.82	238.93	0.001188	0.92	0.26	637.85	239.51	0.001337	1.24	0.29
5	17211.8	238.07	164.85	241.2	0.000147	0.35	0.09	266.1	241.16	0.00044	0.6	0.16	293.82	241.4	0.000092	0.3	0.07	637.85	242.05	0.000078	0.34	0.07
5	17494.1	238.62	164.85	241.26	0.006035	1.39	0.52	266.1	241.39	0.002171	0.89	0.32	293.82	241.46	0.001692	0.83	0.28	637.85	242.08	0.000198	0.41	0.11
5	17631.5	239.2	164.85	241.87	0.00058	0.5	0.17	266.1	241.8	0.007908	1.76	0.61	293.82	241.8	0.009642	1.95	0.68	637.85	242.12	0.000551	0.58	0.17
5	17830.6	239.81	164.85	242.04	0.005872	1.72	0.54	266.1	241.9	0.019565	3.19	1	293.82	242.01	0.019843	3.19	1	637.85	242.27	0.00145	0.73	0.26
5	18254.3	241.54	164.85	243.66	0.002329	0.87	0.32	266.1	243.94	0.001424	0.82	0.27	293.82	243.99	0.001369	0.82	0.26	637.85	243.77	0.018725	2.66	0.94
5	19210.5	244.35	60.24	244.48	0.859882	3.47	4.21	98.8	244.64	0.000016	0.03	0.02	105.8	244.64	0.000018	0.04	0.02	251.22	244.79	0.000086	0.11	0.06
5	19462.8	244.97	60.24	245.3	0.000069	0.04	0.04	98.8	245.3	0.000186	0.07	0.07	105.8	245.3	0.000213	0.08	0.07	251.22	245.3	0.001204	0.18	0.17
5	19591.8	245.32	60.24	245.77	0.030499	1.27	0.94	98.8	245.83	0.031056	1.52	0.99	105.8	245.83	0.032214	1.58	1.01	251.22	245.89	0.005042	0.72	0.41
5	19749.9	245.71	60.24	246.51	0.001619	0.57	0.25	98.8	246.63	0.001707	0.67	0.27	105.8	246.65	0.001694	0.68	0.27	251.22	246.71	0.006004	1.36	0.52
5	19890.9	245.69	60.24	246.76	0.002129	0.64	0.29	98.8	246.9	0.002258	0.75	0.31	105.8	246.91	0.002359	0.78	0.32	251.22	247.16	0.001723	0.84	0.29
5	20079.7	246.09	60.24	247.2	0.002803	0.75	0.34	98.8	247.36	0.002905	0.85	0.35	105.8	247.38	0.002803	0.86	0.35	251.22	247.58	0.003929	1.22	0.43
5	20412.2	246.85	60.24	248.06	0.002405	0.76	0.32	98.8	248.25	0.002569	0.92	0.34	105.8	248.28	0.002656	0.95	0.35	251.22	248.67	0.002793	1.19	0.38
5	20623.6	247.55	60.24	248.63	0.002985	0.84	0.35	98.8	248.84	0.003034	0.98	0.37	105.8	248.88	0.003039	0.98	0.37	251.22	249.29	0.003038	1.27	0.39
5	21021.4	248.97	60.24	249.79	0.002908	0.84	0.35	98.8	250.07	0.000197	0.26	0.1	105.8	250.19	0.000096	0.19	0.07	251.22	250.08	0.001222	0.65	0.24
5	21149.2	249.29	60.24	250.19	0.003467	0.82	0.37	98.8	250.04	0.02792	1.94	1.01	105.8	250.14	0.01517	1.62	0.77	251.22	250.33	0.006286	1.26	0.52
5	21266.6	249.64	60.24	250.55	0.002582	0.75	0.32	98.8	250.37	0.024225	1.87	0.95	105.8	250.39	0.024045	1.9	0.95	251.22	250.76	0.002612	0.91	0.34
5	21491.6	250.33	60.24	251.09	0.002028	0.55	0.27	98.8	251.31	0.001219	0.54	0.23	105.8	251.34	0.001241	0.56	0.23	251.22	251.6	0.000204	0.28	0.1
5	21610.7	250.48	60.24	251.18	0.029489	1.73	1	98.8	251.4	0.000625	0.33	0.16	105.8	251.42	0.000581	0.33	0.15	251.22	251.63	0.000756	0.44	0.18
5	21861.1	251.24	60.24	252.11	0.001061	0.46	0.21	98.8	251.89	0.026911	1.57	0.94	105.8	251.9	0.026951	1.61	0.95	251.22	252.09	0.021743	2.03	0.93
5	22039.4	251.63	60.24	252.5	0.011951	1.31	0.66	98.8	252.85	0.001903	0.69	0.28	105.8	252.87	0.001901	0.69	0.28	251.22	253	0.001712	0.72	0.28
5	22263.7	252.86	60.24	253.28	0.028715	1.56	0.96	98.8	253.39	0.002645	0.58	0.31	105.8	253.4	0.002603	0.58	0.31	251.22	253.53	0.003142	0.75	0.35
5	22416.5	253.25	60.24	253.73	0.029052	1.7	0.99	98.8	254.05	0.008059	1.23	0.56	105.8	253.88	0.027202	1.93	1	251.22	254.03	0.059463	3.26	1.52
5	22692.3	253.81	60.24	254.63	0.03219	1.47	0.99	98.8	254.71	0.028797	1.67	0.98	105.8	254.73	0.027838	1.69	0.97	251.22	254.85	0.00025	0.19	0.1
5	22950	254.25	60.24	255.78	0.001556	0.59	0.25	98.8	255.93	0.001703	0.73	0.28	105.8	256.01	0.000012	0.06	0.02	251.22	255.84	0.017844	2.16	0.87
5	23158.2	254.63	60.24	256.17	0.002473	0.77	0.32	98.8	256.34	0.002433	0.85	0.33	105.8	255.91	0.023502	2.38	0.99	251.22	256.35	0.014534	2.08	0.8
5	23349.8	255.83	60.24	256.66	0.002759	0.95	0.35	98.8	256.86	0.003382	1.22	0.41	105.8	257.07	0.00193	1.05	0.32	251.22	257.55	0.003213	1.69	0.43
5	23569.7	255.87	60.24	257.24	0.002352	0.74	0.31	98.8	257.44	0.001883	0.78	0.29	105.8	257.49	0.001696	0.76	0.28	251.22	258.08	0.000025	0.12	0.04
5	23813.7	256.46	60.24	257.82	0.002522	0.71	0.32	98.8	257.96	0.002735	0.86	0.34	105.8	257.99	0.002773	0.89	0.35	251.22	257.95	0.018639	2.23	0.9
5	24077.7	258.21	60.24	258.72	0.004793	0.73	0.41	98.8	258.84	0.004075	0.83	0.4	105.8	258.86	0.00396	0.84	0.39	251.22	258.84	0.025313	2.08	0.99
5	24284.7	258.92	60.24	259.44	0.002526	0.63	0.31	98.8	259.55	0.002802	0.77	0.34	105.8	259.57	0.002868	0.8	0.34	51.22	259.74	0.000203	0.26	0.1
5	24548.4	259.65	60.24	260.24	0.003799	0.74	0.37	98.8	260.37	0.003565	0.86	0.38	105.8	260.39	0.003515	0.88	0.38	51.22	260.05	0.031759	1.4	0.97
5	24868.9	260.54	60.24	261.39	0.00338	0.79	0.36	98.8	261.54	0.003769	0.99	0.4	105.8	261.56	0.003852	1.02	0.41	51.22	261.46	0.001556	0.59	0.25
5	25211.7	261.93	60.24	262.58	0.003547	0.77	0.37	98.8	262.73	0.003171	0.88	0.37	105.8	262.75	0.003096	0.9	0.36	51.22	262.46	0.007831	0.94	0.52
5	25496.8	262.86	60.24	263.41	0.002377	0.64	0.3	98.8	263.54	0.002502	0.78	0.32	105.8	263.55	0.002558	0.8	0.33	51.22	263.41	0.001706	0.55	0.26
5	25784.4	264.31	47.64	264.33	0.005247	0.08	0.24	76.42	264.44	0.004492	0.2	0.29	81.42	264.46	0.004418	0.18	0.28	195.62	264.64	0.006359	0.56	0.42
5	25980.4	265.42	47.64	265.6	0.033749	1.02	0.92	76.42	265.65	0.034496	1.27	0.98	81.42	265.66	0.033975	1.29	0.98	195.62	265.61	0.441395	3.92	3.38
5	26367.9	266.63	47.64	266.95	0.028946	1.33	0.93	76.42	267.03	0.024219	1.44	0.89	81.42	267.03	0.026549	1.52	0.93	195.62	267.12	0.000332	0.21	0.11
5	26576.4	267.1	47.64	267.82	0.001282	0.4	0.21	76.42	267.92	0.001371	0.48	0.23	81.42	267.93	0.001353	0.49	0.23	195.62	267.81	0.023063	1.66	0.9
5	26757.9	267.86	47.64	268.4	0.02166	1.33	0.83	76.42	268.49	0.018246	1.42	0.8	81.42	268.5	0.018767	1.46	0.81	195.62	268.94	0.00247	0.89	0.33
5	27102.2	269.53	47.64	269.65	5.486582	7.56	10.26	76.42	269.68	4.154578	7.42	9.2	81.42	269.68	3.855337	7.37	8.93	195.62	270.2	0.005902	1.16	0.49
5	27639.1	272.11	47.64	272.71	0.000044	0.05	0.04	76.42	272.71	0.000113	0.08	0.06	81.42	272.71	0.000128	0.08	0.06	195.62	272.71	0.000738	0.2	0.15
5	28014.6	273.72	47.64	274.26	0.032673	1.51	1	76.42	274.35	0.028513	1.69	0.98	81.42	274.37	0.026901	1.69	0.96	195.62	274.54	0.000469	0.29	0.14
5	28335.9	274.67	47.64	275.74	0.001595	0.62	0.26	76.42	275.93	0.001747	0.74	0.28	81.42	275.95	0.001782	0.75	0.28	195.62	275.78	0.02295	2.42	0.99

5	28635.4	275.03	47.64	276.31	0.002362	0.81	0.32	76.42	276.57	0.002795	0.88	0.35	81.42	276.6	0.002798	0.9	0.35	195.62	276.49	0.023213	2.55	1.01
5	28964.8	275.64	47.64	277.2	0.003132	1	0.38	76.42	277.51	0.002951	1.06	0.37	81.42	277.55	0.003022	1.07	0.38	195.62	278.34	0.001968	1.1	0.32
5	29242	278.32	47.64	278.98	0.023124	1.77	0.92	76.42	279.15	0.02058	1.88	0.89	81.42	279.18	0.018997	1.87	0.86	195.62	279.49	0.023174	2.53	1
5	29466.2	279.47	29.54	280.55	0.001996	0.62	0.28	47.61	280.72	0.002111	0.73	0.3	50.45	280.74	0.002171	0.75	0.31	121.36	281.23	0.002036	0.92	0.31
5	30439.1	284.5	29.54	284.79	0.016576	1.07	0.71	47.61	284.9	0.013447	1.18	0.68	50.45	284.92	0.012409	1.17	0.65	121.36	285.15	0.011961	1.57	0.7
5	31231.2	287.38	29.54	287.98	0.001732	0.51	0.25	47.61	288.11	0.001888	0.62	0.28	50.45	288.12	0.001944	0.63	0.28	121.36	288.47	0.002027	0.87	0.31
5	31951.1	290.62	29.54	291.18	0.031304	1.55	1	47.61	291.27	0.030303	1.78	1.02	50.45	291.31	0.003335	0.67	0.35	121.36	291.38	0.012038	1.31	0.67
5	32244.6	291.2	29.54	292.52	0.001553	0.54	0.25	47.61	292.69	0.001612	0.62	0.26	50.45	292.49	0.00505	0.96	0.45	121.36	292.95	0.002843	1.01	0.36
5	32745.5	296.33	9.85	296.57	0.035524	1.08	0.95	15.87	296.61	0.039604	1.29	1.04	16.82	296.62	0.037295	1.29	1.01	40.5	296.77	0.031725	1.41	0.98
5	33002.3	298.47	9.85	298.87	0.003892	0.5	0.34	15.87	298.96	0.003779	0.55	0.35	16.82	298.96	0.003872	0.57	0.35	40.5	299.14	0.004127	0.78	0.39
5	33259.6	300.37	9.85	300.75	0.01919	0.98	0.74	15.87	300.81	0.020269	1.13	0.78	16.82	300.83	0.019419	1.13	0.77	40.5	301.02	0.017624	1.35	0.77
5	33509	302.38	9.85	302.74	0.004155	0.52	0.36	15.87	302.82	0.003968	0.59	0.36	16.82	302.82	0.004043	0.61	0.36	40.5	303.01	0.004079	0.77	0.39
5	33714.8	303.64	9.85	303.82	0.006243	0.44	0.4	15.87	303.86	0.005974	0.52	0.41	16.82	303.87	0.005865	0.52	0.4	40.5	304	0.005245	0.67	0.41
5	34113.3	306.42	9.85	306.74	0.006417	0.62	0.44	15.87	306.8	0.006727	0.74	0.46	16.82	306.81	0.006861	0.76	0.47	40.5	306.98	0.007883	1.06	0.54
5	34486.7	309.3	9.85	309.58	0.009056	0.7	0.51	15.87	309.66	0.008562	0.76	0.51	16.82	309.67	0.008335	0.77	0.51	40.5	309.87	0.007162	0.94	0.51
5	34907.4	313.07	9.85	313.41	0.009105	0.64	0.5	15.87	313.47	0.009525	0.75	0.53	16.82	313.47	0.009827	0.77	0.54	40.5	313.62	0.011426	1.04	0.62

Existing Local Waterways 1D MODEL RESULTS - South

			10 year ARI					50 year ARI					100 year ARI					1000 year ARI				
Waterway	**Chainage**	**Channel Base Elevation**	Q Total	W.S. Elev	Energy Slope	Vel Chnl	Froude #	Q Total	W.S. Elev	Energy Slope	Vel Chnl	Froude #	Q Total	W.S. Elev	Energy Slope	Vel Chnl	Froude #	Q Total	W.S. Elev	Energy Slope	Vel Chnl	Froude #
	(m)	(m) AHD	(m3/s)	(m) AHD	(m/m)	(m/s)		(m3/s)	(m) AHD	(m/m)	(m/s)		(m3/s)	(m) AHD	(m/m)	(m/s)		(m3/s)	(m) AHD	(m/m)	(m/s)	
1	0	245.92	22.76	246.14	0.035696	0.79	0.88	44.96	246.18	0.000073	0.04	0.04	53.96	246.18	0.000105	0.05	0.05	123.77	246.18	0.000554	0.11	0.11
1	190.1	247.1	22.76	247.41	0.000001	0.01	0	44.96	247.41	0.000002	0.01	0.01	53.96	247.41	0.000003	0.01	0.01	123.77	247.41	0.000018	0.03	0.02
1	288.44	247.3	22.76	248.01	0.035862	1.24	0.99	44.96	248.05	0.000003	0.01	0.01	53.96	248.05	0.000005	0.01	0.01	123.77	248.05	0.000025	0.03	0.03
1	505.58	248.02	22.76	248.48	0.486013	6.17	3.92	44.96	248.71	0.2664	5.84	3.09	53.96	248.78	0.226167	5.72	2.89	123.77	249.13	0.415875	5.14	3.54
1	734.96	249.51	22.76	250.62	0	0	0	44.96	250.62	0.000002	0.01	0.01	53.96	250.62	0.000002	0.01	0.01	123.77	250.62	0.000012	0.02	0.02
1	897.66	250.46	22.76	251.21	0.026414	2.05	1	44.96	251.13	0.166861	4.84	2.47	53.96	251.22	0.131854	4.66	2.24	123.77	251.67	0.144419	3.63	2.18
1	1042.9	251.69	22.76	252.43	0.036271	1.28	1	44.96	252.45	0.00001	0.02	0.02	53.96	252.45	0.000014	0.02	0.02	123.77	252.45	0.000074	0.05	0.04
1	1283.21	253.48	22.76	253.89	0.002253	0.46	0.27	44.96	253.8	0.028341	1.42	0.94	53.96	253.82	0.028914	1.51	0.96	123.77	253.96	0.02699	1.8	0.98
1	1515.55	254.81	22.76	255.08	0.022893	0.89	0.77	44.96	255.12	0.037066	1.21	1	53.96	255.14	0.036739	1.26	1	123.77	255.18	0.000202	0.1	0.08
1	1719.99	256.3	22.76	256.6	0.003449	0.35	0.3	44.96	256.73	0.003093	0.46	0.31	53.96	256.77	0.003122	0.5	0.32	123.77	256.72	0.025965	1.29	0.88
1	1899.6	256.99	22.76	257.55	0.009146	0.92	0.55	44.96	257.61	0.008776	0.99	0.55	53.96	257.65	0.008476	1.02	0.55	123.77	257.98	0.002678	0.81	0.34
1	2110.64	257.84	22.76	258.78	0.003939	0.68	0.37	44.96	258.83	0.004291	0.76	0.39	53.96	258.85	0.004392	0.79	0.4	123.77	258.91	0.011484	1.26	0.65
1	2258.55	259.33	22.76	259.71	1.003608	7.26	5.37	44.96	259.87	0.58946	6.99	4.36	53.96	259.92	1.01287	6.89	5.32	123.77	260.01	0.005357	0.51	0.39
1	2540.77	262.39	22.76	262.68	0.000016	0.02	0.02	44.96	262.68	0.000062	0.04	0.04	53.96	262.68	0.000089	0.05	0.05	123.77	262.68	0.000469	0.12	0.11
1	2778.22	263.47	22.76	263.97	0.032299	1.52	1	44.96	264.09	0.000022	0.05	0.03	53.96	264.09	0.000031	0.06	0.03	123.77	264.09	0.000164	0.13	0.07
1	2966.11	264.25	22.76	265.25	0.002544	0.56	0.3	44.96	265.09	0.028672	1.82	1	53.96	264.89	0.320169	4.45	3.09	123.77	265.4	0.00008	0.1	0.05
1	3123.17	264.79	22.76	265.88	0.008611	1.11	0.56	44.96	265.95	0.025895	1.84	0.97	53.96	266.01	0.000017	0.04	0.02	123.77	265.91	0.227751	5.58	2.88
1	3298.87	266.21	22.76	267.1	0.005743	1.16	0.49	44.96	267.65	0.004414	0.87	0.41	53.96	267.17	0.023592	2.45	1	123.77	267.71	0.000073	0.1	0.05
1	3483.28	267.32	22.5	268.3	0.007505	1.25	0.55	44.43	268.61	0.00709	1.47	0.56	53.2	268.88	0.003721	0.86	0.39	122.12	268.84	0.025488	2.17	1
1	3627.22	267.96	22.5	269.24	0.005524	1.06	0.47	44.43	269.55	0.005253	1	0.46	53.2	269.57	0.006804	1.15	0.52	122.12	269.64	0.024572	2.29	1
1	3712.77	268.39	22.5	269.67	0.004051	0.85	0.4	44.43	269.97	0.004341	0.9	0.41	53.2	270.04	0.004144	0.92	0.41	122.12	270.38	0.002493	0.92	0.34
1	4018.39	270.75	13.61	271.46	0.015217	1.62	0.77	26.97	271.75	0.012982	1.87	0.75	32.27	271.8	0.015079	2.07	0.81	74.15	272.18	0.0209	2.89	1
1	4222.04	272.97	13.61	273.8	0.008648	1.31	0.59	26.97	274.07	0.009652	1.62	0.65	32.27	274.19	0.008722	1.62	0.62	74.15	274.35	0.004707	1.07	0.44
1	4402.19	274.53	13.61	275.13	0.005923	0.87	0.46	26.97	275.36	0.004892	1.04	0.45	32.27	275.42	0.004935	1.11	0.46	74.15	275.57	0.013085	2.03	0.77
1	4611.34	275.66	13.61	276.71	0.010719	1.5	0.66	26.97	276.97	0.015984	1.85	0.81	32.27	277.08	0.016534	1.8	0.81	74.15	277.68	0.007172	1.36	0.55
1	4747.27	276.82	13.61	277.94	0.007282	1.25	0.54	26.97	278.32	0.005979	1.31	0.51	32.27	278.43	0.00599	1.34	0.51	74.15	278.8	0.01067	1.82	0.69
1	4853.93	278.08	13.61	279.02	0.015369	1.33	0.73	26.97	279.24	0.013994	1.5	0.73	32.27	279.32	0.012887	1.49	0.71	74.15	279.82	0.007336	1.39	0.56
1	4929.41	278.73	13.61	279.88	0.00775	0.82	0.5	26.97	280.05	0.007286	0.92	0.51	32.27	280.11	0.007359	0.93	0.51	74.15	280.37	0.006478	1.15	0.51
1	5110.92	280.97	13.61	281.72	0.014473	1.28	0.71	26.97	281.95	0.016831	1.27	0.75	32.27	281.99	0.016311	1.33	0.75	74.15	282.21	0.019505	1.71	0.85
1	5323.14	283.6	13.61	284.46	0.011609	1.36	0.66	26.97	284.76	0.010656	1.23	0.63	32.27	284.81	0.011008	1.3	0.64	74.15	285.18	0.010195	1.37	0.63
2	238.01	221.44	133.12	222.23	0.000148	0.16	0.08	231.6	222.23	0.000449	0.29	0.13	160.98	222.23	0.000217	0.2	0.09	551.37	222.36	0.001551	0.62	0.26
2	446.64	222.29	133.12	222.86	0.004585	0.58	0.38	231.6	222.86	0.013872	1	0.66	160.98	222.86	0.006704	0.7	0.46	551.37	223.07	0.012682	1.39	0.69
2	757.91	223.71	133.12	224.11	0.004088	0.37	0.32	231.6	224.33	0.002502	0.45	0.28	160.98	224.19	0.003272	0.39	0.3	551.37	224.65	0.002805	0.79	0.34
2	1001.32	225.05	133.12	225.77	0.011698	1.24	0.65	231.6	225.81	0.021961	1.81	0.91	160.98	225.77	0.01644	1.48	0.77	551.37	226.04	0.01603	1.97	0.82
2	1261.27	226.54	133.12	227.52	0.004355	1.11	0.44	231.6	227.72	0.003386	0.78	0.36	160.98	227.6	0.003729	0.86	0.39	551.37	227.94	0.003857	1.08	0.41
2	1390.94	227.98	133.12	228.46	0.016081	0.88	0.67	231.6	228.54	0.020641	1.1	0.78	160.98	228.47	0.019445	0.99	0.74	551.37	228.75	0.015249	1.42	0.74
2	1478.66	228.92	133.12	229.12	0.004966	0.32	0.34	231.6	229.25	0.004535	0.54	0.37	160.98	229.17	0.004606	0.39	0.34	551.37	228.98	0.512469	1.46	2.79
2	1699.11	229.94	133.12	230.82	0.014732	1.63	0.76	231.6	230.94	0.017891	2.09	0.87	160.98	230.85	0.017014	1.82	0.82	551.37	231.07	0.000404	0.36	0.13
2	1854.35	231.08	133.12	231.5	0.257052	4.16	2.8	231.6	231.65	0.127313	3.63	2.08	160.98	231.55	0.191495	4.01	2.49	551.37	231.75	0.000485	0.27	0.13
2	2031.92	231.67	133.12	232.39	0.000043	0.06	0.04	231.6	232.39	0.000129	0.1	0.06	160.98	232.39	0.000062	0.07	0.04	551.37	232.39	0.000732	0.24	0.15
2	2272.99	232.94	133.12	234.32	0.079464	2.83	1.64	231.6	234.38	0.00014	0.12	0.07	160.98	234.37	0.064903	2.57	1.48	551.37	234.38	0.000791	0.29	0.16
2	2352	233.8	133.12	234.77	0.000246	0.15	0.09	231.6	234.77	0.000745	0.26	0.16	160.98	234.77	0.00036	0.18	0.11	551.37	234.77	0.004223	0.61	0.37
2	2642.37	235.34	133.12	236.37	0.000028	0.05	0.03	231.6	236.37	0.000085	0.09	0.05	160.98	236.37	0.000041	0.06	0.04	551.37	236.37	0.000484	0.22	0.13
2	2733.31	235.9	133.12	237	0.000017	0.05	0.02	231.6	237	0.000051	0.08	0.04	160.98	237	0.000025	0.06	0.03	551.37	237	0.000289	0.19	0.1
2	2887.27	236.54	133.12	237.24	0.136801	3.68	2.15	231.6	237.37	0.000202	0.14	0.08	160.98	237.32	0.087516	3.4	1.78	551.37	237.37	0.001144	0.34	0.2
2	3053.72	237.92	133.12	238.06	0.000092	0.03	0.04	231.6	238.06	0.000278	0.06	0.07	160.98	238.06	0.000134	0.04	0.05	551.37	238.06	0.001577	0.14	0.18
2	3260.4	238.74	133.12	239.09	0.080549	2.24	1.55	231.6	239.3	0.026399	1.61	0.94	160.98	239.21	0.029139	1.54	0.97	551.37	239.58	0.02286	2.19	0.96
2	3405.93	239.06	133.12	239.76	0.000751	0.21	0.15	231.6	239.9	0.000943	0.3	0.18	160.98	239.78	0.000942	0.24	0.17	551.37	240.3	0.000959	0.48	0.2
2	3648.15	239.35	133.12	240.5	0.430141	5.15	3.58	231.6	240.65	0.249554	4.68	2.85	160.98	240.54	0.331615	5.03	3.23	551.37	240.83	0.006971	1.11	0.52
2	3937.02	241.61	133.12	242.06	0.000072	0.06	0.05	231.6	242.06	0.000218	0.11	0.08	160.98	242.06	0.000105	0.07	0.06	551.37	242.06	0.001237	0.26	0.19
2	4041.77	242.1	133.12	242.6	0.000022	0.04	0.03	231.6	242.6	0.000068	0.07	0.05	160.98	242.6	0.000033	0.05	0.03	551.37	242.6	0.000385	0.16	0.11
2	4214.03	242.77	133.12	243.19	0.000027	0.04	0.03	231.6	243.19	0.00008	0.07	0.05	160.98	243.19	0.000039	0.05	0.03	551.37	243.19	0.000455	0.17	0.12
2	4522.76	244.15	133.12	244.6	0.000051	0.09	0.04	231.6	244.6	0.000153	0.15	0.08	160.98	244.6	0.000074	0.1	0.05	551.37	244.6	0.000867	0.36	0.18
2	4695.85	244.42	133.12	245.25	0.000018	0.04	0.02	231.6	245.25	0.000055	0.07	0.04	160.98	245.25	0.000027	0.05	0.03	551.37	245.68	0.000113	0.18	0.07

2	4826.03	245.14	133.12	246.1	0.017813	1.7	0.82	231.6	246.22	0.018191	2.04	0.87	160.98	246.13	0.018771	1.84	0.86	551.37	246.34	0.000171	0.22	0.09
2	4930.58	245.47	133.12	246.87	0.000008	0.05	0.02	231.6	246.65	0.035216	2.32	1.15	160.98	246.5	0.07066	2.77	1.56	551.37	246.79	0.000166	0.19	0.08
2	4990.72	246.25	133.12	246.88	0.024032	1.76	0.93	231.6	246.92	0.000037	0.07	0.04	160.98	246.92	0.000018	0.05	0.03	551.37	246.92	0.000208	0.17	0.09
2	5120.79	246.2	133.12	247.96	0.003586	1.08	0.4	231.6	247.89	0.016371	2.17	0.85	160.98	247.71	0.022114	2.15	0.95	551.37	248.18	0.000159	0.26	0.09
2	5290.53	246.88	12.79	248.5	0.000615	0.33	0.15	23.76	249.01	0.000183	0.23	0.09	26.5	248.92	0.000355	0.3	0.12	62.26	248.41	0.026953	1.96	1
2	5465.21	247.76	12.79	248.72	0.021443	1.68	0.88	23.76	249.01	0.01219	1.69	0.71	26.5	248.97	0.018629	2.03	0.87	62.26	249.73	0.002867	0.82	0.35
2	5632.77	248.79	12.79	250.14	0.003864	0.48	0.34	23.76	250.24	0.004023	0.6	0.36	26.5	250.28	0.003308	0.59	0.34	62.26	250.4	0.006211	0.99	0.48
2	5850.96	250.83	12.79	251.17	0.005396	0.53	0.39	23.76	251.25	0.00494	0.64	0.4	26.5	251.25	0.005849	0.7	0.43	62.26	251.49	0.003626	0.81	0.38
2	5978.37	251.35	12.79	251.91	0.002254	0.4	0.26	23.76	251.92	0.006507	0.71	0.45	26.5	251.95	0.005755	0.71	0.43	62.26	252.08	0.00794	1.06	0.54
2	6195.1	252.7	12.79	253.13	0.004652	0.54	0.37	23.76	253.22	0.005373	0.7	0.42	26.5	253.23	0.00594	0.75	0.45	62.26	253.45	0.0049	0.96	0.44
2	6357.44	253.44	12.79	253.94	0.000924	0.29	0.17	23.76	253.93	0.003798	0.57	0.35	26.5	253.95	0.003575	0.58	0.34	62.26	254.14	0.003843	0.78	0.38
2	6517.05	254.24	12.79	254.62	0.040652	1.1	1.01	23.76	254.78	0.008208	0.83	0.52	26.5	254.57	0.338358	3.59	3	62.26	254.98	0.008053	1.17	0.56
2	6633.22	254.46	12.79	255.53	0.03529	1.31	1	23.76	255.63	0.031853	1.52	1	26.5	255.66	0.000911	0.33	0.18	62.26	255.68	0.00437	0.75	0.4
2	6729.03	255.14	12.79	255.78	0.000645	0.29	0.15	23.76	255.96	0.000894	0.35	0.18	26.5	255.76	0.00329	0.63	0.34	62.26	256	0.005002	0.82	0.43
2	6892.62	256.12	12.79	256.73	0.032596	1.48	1	23.76	256.88	0.032592	1.48	1	26.5	256.93	0.023503	1.33	0.86	62.26	257.22	0.010638	1.15	0.62
2	7102.04	257.72	12.79	257.99	0.036643	1.21	0.99	23.76	258.16	0.002171	0.47	0.27	26.5	258.18	0.002361	0.5	0.28	62.26	258.36	0.003046	0.76	0.35
2	7287.01	258.76	12.79	259.44	0.003162	0.68	0.34	23.76	259.29	0.028208	1.86	1	26.5	259.31	0.028441	1.93	1.01	62.26	259.51	0.001397	0.34	0.21
2	7444.22	259.35	12.79	259.98	0.003757	0.67	0.36	23.76	260.25	0.002032	0.67	0.29	26.5	260.29	0.002035	0.7	0.29	62.26	260.15	0.025347	2.15	1
2	7561.16	260.04	12.79	260.58	0.007693	0.88	0.51	23.76	260.68	0.011112	1.18	0.63	26.5	260.72	0.010584	1.21	0.62	62.26	261.2	0.003293	0.88	0.37
2	7671.98	260.59	12.79	261.3	0.005767	1	0.47	23.76	261.55	0.005757	1.15	0.49	26.5	261.59	0.006083	1.2	0.5	62.26	261.6	0.005272	0.76	0.43
2	7873.8	261.48	12.79	262.47	0.005916	1.13	0.49	23.76	262.72	0.005833	1.14	0.49	26.5	262.77	0.005624	1.17	0.49	62.26	263.04	0.010146	1.84	0.68
2	8027.48	263.63	6.4	264	0.037123	1.28	1.01	11.88	264.09	0.032012	1.52	1	13.25	264.11	0.031258	1.57	1	31.13	264.52	0.007225	1.28	0.55
2	8178.81	264.56	6.4	265.49	0.00428	0.88	0.41	11.88	265.77	0.005222	0.9	0.44	13.25	265.84	0.005416	0.84	0.44	31.13	265.99	0.013875	1.32	0.7
2	8245.09	265.83	6.4	266.34	0.034052	1.54	1.02	11.88	266.48	0.029554	1.71	1	13.25	266.5	0.029277	1.75	1	31.13	266.89	0.013446	1.35	0.7
2	8314.57	266.87	6.4	267.38	0.007192	0.73	0.47	11.88	267.5	0.007284	0.9	0.5	13.25	267.53	0.007255	0.93	0.51	31.13	267.71	0.010605	1.37	0.64
2	8488.12	269.56	6.4	270.01	0.033663	1.42	1	11.88	270.12	0.030992	1.61	1	13.25	270.14	0.030346	1.66	1	31.13	270.37	0.025878	2.06	0.99
2	8627.58	271.6	6.4	272.29	0.009331	1.08	0.58	11.88	272.49	0.010193	1.17	0.61	13.25	272.52	0.010364	1.2	0.62	31.13	272.78	0.011554	1.57	0.69
2	8863.27	276.41	6.4	276.8	0.036201	1.3	1	11.88	276.89	0.032299	1.52	1	13.25	276.91	0.031808	1.57	1	31.13	277.12	0.027615	1.92	1
2	9040	280.32	6.4	280.75	0.015036	1.13	0.7	11.88	280.88	0.016453	1.4	0.76	13.25	280.9	0.016678	1.45	0.77	31.13	281.14	0.019157	1.94	0.87
2	9186.9	284.66	6.4	284.99	0.037481	1.24	1.01	11.88	285.07	0.033351	1.47	1	13.25	285.09	0.032433	1.51	1	31.13	285.27	0.027884	1.94	1.01
3	510.94	245.4	127.64	246.36	0.027079	1.93	0.99	2330.51	247.98	0.014418	4.03	0.94	251.82	246.59	0.024507	2.16	0.99	532.17	246.94	0.018818	2.66	0.94
3	681.32	246.6	127.64	247.7	0.003314	0.99	0.38	2330.51	249.76	0.005449	3.14	0.62	251.82	248.04	0.0037	1.28	0.43	532.17	248.49	0.004388	1.82	0.5
3	773.39	247.43	127.64	248.09	0.005379	1.02	0.46	2330.51	250.25	0.005339	2.94	0.6	251.82	248.42	0.00425	1.16	0.44	532.17	248.92	0.003756	1.46	0.44
3	932.86	248.55	127.64	249.03	0.007568	0.99	0.52	2330.51	251.1	0.004696	2.71	0.56	251.82	249.25	0.007826	1.3	0.57	532.17	249.64	0.006627	1.69	0.57
3	1120.6	249.49	127.64	250.17	0.004872	0.97	0.44	2330.51	252.05	0.006214	2.86	0.63	251.82	250.42	0.004849	1.18	0.46	532.17	250.77	0.005411	1.54	0.51
3	1306.71	250.69	127.64	251.3	0.006792	1.11	0.52	2330.51	253.26	0.004381	2.66	0.54	251.82	251.53	0.006473	1.41	0.54	532.17	251.9	0.005833	1.78	0.55
3	1411.37	251.23	127.64	252	0.006605	1.09	0.51	2330.51	253.73	0.007458	3.25	0.7	251.82	252.21	0.006768	1.42	0.55	532.17	252.55	0.0069	1.87	0.59
3	1549.98	252.04	127.64	252.88	0.007468	1.34	0.56	2330.51	254.72	0.00783	3.39	0.72	251.82	253.14	0.008275	1.71	0.62	532.17	253.51	0.009303	2.25	0.69
3	1684.16	252.87	127.64	253.77	0.00619	1.27	0.51	2330.51	255.69	0.010087	4.14	0.83	251.82	254.06	0.006137	1.63	0.55	532.17	254.51	0.006294	2.16	0.59
3	1911.83	254.13	117.37	255.11	0.005326	1.24	0.48	207.46	257.15	0.000075	0.35	0.07	234.49	255.42	0.005352	1.56	0.51	499.05	255.9	0.005083	1.87	0.53
3	2049.5	254.57	117.37	255.89	0.006555	1.45	0.54	207.46	257.16	0.000481	0.69	0.17	234.49	256.22	0.007378	1.86	0.6	499.05	256.68	0.008548	2.49	0.69
3	2155.49	255.14	117.37	256.52	0.005144	1.29	0.48	207.46	257.23	0.001784	1.06	0.31	234.49	256.93	0.005399	1.58	0.52	499.05	257.47	0.005456	2.08	0.56
3	2330.44	256	117.37	257.41	0.005006	1.35	0.48	207.46	257.69	0.005957	1.69	0.55	234.49	257.84	0.00493	1.63	0.5	499.05	258.43	0.004873	1.97	0.53
3	2520.13	256.76	117.37	258.45	0.005961	1.31	0.51	207.46	258.77	0.005237	1.51	0.5	234.49	258.83	0.005563	1.6	0.52	499.05	259.37	0.00535	2.02	0.55
3	2608.3	257.21	117.37	258.99	0.006395	1.35	0.53	207.46	259.28	0.006716	1.6	0.56	234.49	259.35	0.006629	1.66	0.57	499.05	259.85	0.006314	2.19	0.59
3	2743.21	258.13	117.37	259.84	0.00631	1.38	0.53	207.46	260.16	0.006289	1.62	0.55	234.49	260.22	0.006341	1.7	0.56	499.05	260.73	0.006614	2.19	0.61
3	2969.51	260.11	117.37	261.34	0.006735	1.28	0.53	207.46	261.6	0.006159	1.48	0.53	234.49	261.66	0.00604	1.54	0.54	499.05	262.13	0.005421	1.97	0.55
3	3103.67	260.14	117.37	261.95	0.003177	1.14	0.39	207.46	262.24	0.003858	1.4	0.44	234.49	262.31	0.003992	1.47	0.45	499.05	262.8	0.004946	1.99	0.53
3	3292.1	261.42	117.37	263.22	0.02359	2.39	1	207.46	263.53	0.0222	2.64	1	234.49	263.61	0.022437	2.66	1	499.05	264.16	0.016892	2.99	0.93
3	3511.59	264.54	117.37	265.66	0.005559	1.29	0.5	207.46	265.96	0.005565	1.53	0.52	234.49	266.03	0.005507	1.59	0.52	499.05	266.5	0.006134	2.14	0.58
3	3692.17	265.67	117.37	266.73	0.006472	1.36	0.53	207.46	267.03	0.006492	1.59	0.55	234.49	267.1	0.006554	1.66	0.56	499.05	267.61	0.006214	2.18	0.59
3	3903.07	267.1	99.64	268.49	0.012252	1.63	0.71	177.52	268.74	0.011529	1.92	0.72	199.62	268.8	0.011262	1.98	0.72	433.52	269.25	0.011247	2.5	0.76
3	4004.73	268.39	99.64	269.72	0.011679	1.53	0.69	177.52	269.97	0.012103	1.79	0.72	199.62	270.01	0.012164	1.87	0.73	433.52	270.41	0.011474	2.47	0.77
3	4196.34	270.3	99.64	271.51	0.007388	1.35	0.56	177.52	271.79	0.007397	1.6	0.58	199.62	271.85	0.007422	1.66	0.59	433.52	272.31	0.008066	2.18	0.65
3	4455.01	271.25	99.64	273.19	0.005783	1.42	0.52	177.52	273.56	0.00637	1.61	0.55	199.62	273.64	0.006466	1.66	0.56	433.52	274.19	0.006415	2.1	0.59
3	4682.47	272.38	99.64	274.41	0.004824	1.3	0.47	177.52	274.81	0.004589	1.43	0.47	199.62	274.91	0.004617	1.44	0.48	433.52	275.48	0.004645	1.85	0.51
3	4937.02	274.77	99.64	276.25	0.012779	1.67	0.72	177.52	276.55	0.011947	1.79	0.72	199.62	276.61	0.011299	1.83	0.71	433.52	277.05	0.009525	2.33	0.7
4	0	223.34	9.37	223.45	0	0	0	15.46	223.45	0.000001	0	0	16.54	223.45	0.000001	0	0	40.43	223.45	0.000005	0.01	0.01
4	297.25	223.18	9.37	223.45	0	0	0	15.46	223.45	0.000001	0	0	16.54	223.45	0.000001	0	0	40.43	223.45	0.000004	0.01	0.01

4	642.91	225.41	9.37	225.9	0	0	0	15.46	225.82	0.627725	4.07	3.9	16.54	225.83	0.599566	4.05	3.83	40.43	225.9	0	0	0
4	788.88	226.26	9.37	226.65	0.032095	1.5	1	15.46	226.76	0.00001	0.03	0.02	16.54	226.76	0.000011	0.03	0.02	40.43	226.76	0.000068	0.07	0.05
4	956.83	227.17	9.37	227.39	0.001287	0.17	0.17	15.46	227.29	0.042984	0.79	0.95	16.54	227.29	0.046031	0.81	0.98	40.43	227.38	0.033586	0.82	0.87
4	1125.18	227.85	9.37	228.12	0.038273	1.14	0.99	15.46	228.18	0.037754	1.17	0.99	16.54	228.18	0.038724	1.2	1.01	40.43	228.36	0.001804	0.37	0.24
4	1370.22	229.01	9.37	229.47	0.001983	0.34	0.24	15.46	229.53	0.001997	0.4	0.25	16.54	229.54	0.001993	0.41	0.25	40.43	229.48	0.02633	1.3	0.89
4	1544.16	229.86	9.37	230.18	0.014621	0.76	0.63	15.46	230.24	0.014371	0.88	0.64	16.54	230.25	0.014426	0.9	0.65	40.43	230.6	0.002607	0.63	0.31
4	1706.3	230.42	9.37	231.04	0.002618	0.43	0.28	15.46	231.11	0.002709	0.49	0.3	16.54	231.12	0.002727	0.5	0.3	40.43	231.2	0.006446	0.88	0.48
4	1855.74	231.64	9.37	231.81	0.009088		0	15.46	231.67	0.155867		0	16.54	231.69	0.121282		0	40.43	232.19	0.000138	0.11	0.07
4	1924.89	232.27	9.37	232.51	0.042198	0.94	0.98	15.46	232.54	0.001917	0.22	0.21	16.54	232.54	0.002195	0.24	0.23	40.43	232.54	0.013156	0.58	0.56
4	2066.09	233.29	9.37	233.64	0.003142	0.41	0.3	15.46	233.57	0.04107	1.15	1.02	16.54	233.59	0.03334	1.1	0.93	40.43	233.8	0.006364	0.79	0.46
4	2181.3	234.13	9.37	234.25	0.0151	0.31	0.51	15.46	234.4	0.002899	0.36	0.28	16.54	234.41	0.003061	0.37	0.29	40.43	234.49	0.006756	0.69	0.46
4	2411.45	235.23	9.37	235.61	0.002921	0.44	0.3	15.46	235.58	0.010956	0.85	0.58	16.54	235.6	0.010249	0.82	0.56	40.43	235.85	0.00496	0.77	0.42
4	2592.75	236.22	9.37	236.55	0.011767	0.72	0.57	15.46	236.7	0.00383	0.57	0.35	16.54	236.71	0.003942	0.59	0.36	40.43	236.85	0.006288	0.94	0.48
4	2812.96	237.31	9.37	237.7	0.002883	0.43	0.3	15.46	237.72	0.005796	0.65	0.42	16.54	237.74	0.005642	0.66	0.42	40.43	237.97	0.004119	0.77	0.39
4	3046.68	238.32	9.37	238.84	0.010264	0.69	0.53	15.46	238.96	0.004876	0.62	0.39	16.54	238.98	0.004989	0.64	0.4	40.43	239.15	0.006344	0.9	0.48
4	3294.59	239.83	9.37	240.16	0.003198	0.43	0.31	15.46	240.2	0.005067	0.59	0.39	16.54	240.22	0.004992	0.59	0.39	40.43	240.41	0.004099	0.76	0.39
4	3750.73	242.02	9.37	242.3	0.007616	0.59	0.46	15.46	242.4	0.004548	0.54	0.37	16.54	242.4	0.004599	0.55	0.37	40.43	242.53	0.005251	0.7	0.42
4	3960.36	243.79	9.37	243.99	0.04262	0.86	0.96	15.46	244.03	0.016559	0.59	0.61	16.54	244.03	0.016199	0.59	0.61	40.43	244.11	0.012759	0.78	0.6
4	4158.85	245.27	9.37	245.54	0.003117	0.4	0.3	15.46	245.58	0.004435	0.52	0.36	16.54	245.58	0.004511	0.53	0.37	40.43	245.71	0.005414	0.75	0.43
4	4301.97	246.24	9.37	246.44	0.020229	0.81	0.72	15.46	246.52	0.010963	0.75	0.56	16.54	246.53	0.010679	0.76	0.56	40.43	246.68	0.008754	0.88	0.54
4	4416.52	246.89	9.37	247.08	0.002624	0.23	0.24	15.46	247.14	0.003345	0.32	0.29	16.54	247.14	0.003401	0.34	0.3	40.43	247.3	0.004069	0.48	0.34
4	4607.52	248.01	9.37	247.94	0.011377		0	15.46	248.02	0.007898	0.07	0.27	16.54	248.03	0.007692	0.1	0.29	40.43	248.2	0.006176	0.28	0.35
4	4822.04	249.65	9.37	249.89	0.007547	0.59	0.46	15.46	249.93	0.010369	0.78	0.55	16.54	249.93	0.010626	0.81	0.56	40.43	250.05	0.013503	1.09	0.66
4	5070.5	251.51	9.37	251.78	0.007651	0.6	0.46	15.46	251.86	0.006011	0.65	0.43	16.54	251.87	0.00591	0.65	0.43	40.43	252.05	0.005225	0.85	0.44
4	5252.61	252.62	9.37	252.97	0.005689	0.56	0.41	15.46	253.02	0.00693	0.72	0.47	16.54	253.03	0.00706	0.74	0.47	40.43	253.19	0.007986	1.05	0.54
4	5463.92	254.2	9.37	254.52	0.009971	0.71	0.53	15.46	254.61	0.008168	0.77	0.5	16.54	254.62	0.008065	0.78	0.5	40.43	254.82	0.007378	1.02	0.52
5	6052.53	227.33	29.96	227.73	0.009412	0.86	0.55	56.06	227.85	0.009418	1.08	0.58	65.07	227.88	0.009407	1.14	0.59	147.13	228.11	0.009399	1.53	0.63
5	6385.64	229.5	29.96	230.1	0.005564	0.84	0.45	56.06	230.26	0.005801	1.07	0.48	65.07	230.31	0.005859	1.13	0.49	147.13	230.63	0.006293	1.53	0.54
5	6672.06	230.73	22.55	231.33	0.003077	0.6	0.33	42.82	231.51	0.002979	0.72	0.34	49.51	231.55	0.002925	0.75	0.34	112.89	231.9	0.002703	0.99	0.35
5	6810.28	230.75	22.55	231.81	0.004223	0.63	0.37	42.82	231.95	0.003732	0.76	0.37	49.51	231.99	0.003661	0.79	0.38	112.89	232.29	0.003248	1	0.38
5	6854.66	231.17	22.55	232	0.004824	0.68	0.4	42.82	232.13	0.005139	0.84	0.43	49.51	232.17	0.005112	0.87	0.44	112.89	232.45	0.00435	1.07	0.43
5	7074.93	231.83	22.55	233.14	0.00563	0.84	0.45	42.82	233.34	0.00586	0.97	0.47	49.51	233.38	0.005977	1.02	0.48	112.89	233.66	0.007369	1.33	0.56
5	7325.1	234.34	22.55	234.87	0.008713	0.9	0.54	42.82	235.05	0.008086	0.97	0.53	49.51	235.09	0.007847	1.01	0.53	112.89	235.38	0.006282	1.22	0.51
5	7452.39	235.19	14.8	235.65	0.00378	0.59	0.35	28.31	235.79	0.003668	0.72	0.37	32.91	235.83	0.003744	0.76	0.38	74.56	236.07	0.00415	1.01	0.42
5	7599.04	236.24	14.8	236.55	0.012526	0.89	0.61	28.31	236.66	0.012413	1.11	0.65	32.91	236.69	0.01196	1.15	0.64	74.56	236.92	0.010271	1.4	0.64
5	8092.16	239.15	14.8	240.43	0.005369	0.96	0.45	28.31	240.7	0.005758	0.99	0.47	32.91	240.76	0.005962	1.01	0.48	74.56	241.06	0.006845	1.26	0.53
5	8191.88	241.43	14.8	241.79	0.036155	1.32	1.01	28.31	241.89	0.032214	1.54	1	32.91	241.92	0.03159	1.59	1	74.56	242.15	0.02268	1.71	0.9
5	8392.65	243.73	14.8	244.19	0.005634	0.64	0.42	28.31	244.31	0.00589	0.78	0.45	32.91	244.34	0.005931	0.82	0.45	74.56	244.54	0.006861	1.13	0.52
5	8651.19	246.93	14.8	247.11	0.032538	1.06	0.92	28.31	247.18	0.027336	1.16	0.88	32.91	247.2	0.026559	1.2	0.88	74.56	247.35	0.018971	1.41	0.81
5	8859.51	248.28	14.8	248.64	0.003278	0.42	0.31	28.31	248.72	0.003524	0.52	0.33	32.91	248.75	0.003595	0.55	0.34	74.56	248.92	0.00417	0.74	0.39
6	125	240.22	7.2	240.7	0.028744	1.64	0.98	14.25	240.86	0.027371	1.82	0.98	19.27	240.94	0.027147	1.9	0.99	39.86	241.07	0.000004	0.01	0.01
6	272.09	241.9	7.2	241.77	0.002766		0	14.25	241.97	0.002747	0.1	0.2	19.27	242.04	0.002553	0.2	0.23	39.86	242.07	0.010404	0.48	0.49
6	499.37	242.95	7.2	243.26	0.018836	0.9	0.72	14.25	243.47	0.002689	0.46	0.29	19.27	243.56	0.001876	0.46	0.26	39.86	243.85	0.000857	0.45	0.19
6	576.77	243.23	7.2	243.85	0.00367	0.47	0.33	14.25	243.86	0.012665	0.89	0.62	19.27	243.87	0.019397	1.13	0.77	39.86	243.97	0.026586	1.59	0.94
6	732.07	243.8	7.2	244.39	0.003311	0.52	0.33	14.25	244.58	0.00227	0.54	0.29	19.27	244.67	0.002146	0.58	0.28	39.86	244.93	0.002274	0.72	0.31
6	890.91	244.71	7.2	245.33	0.016577	1.42	0.76	14.25	245.47	0.027552	1.95	1	19.27	245.63	0.03032	1.65	1	39.86	245.83	0.029838	1.77	1.01
6	969.91	245.53	7.2	246.24	0.007382	0.87	0.5	14.25	246.48	0.005591	0.88	0.45	19.27	246.58	0.005402	0.92	0.45	39.86	246.85	0.005959	1	0.48
6	1069.05	246.77	7.2	247.08	0.009437	0.68	0.52	14.25	247.18	0.009371	0.83	0.54	19.27	247.26	0.008582	0.82	0.52	39.86	247.44	0.005559	0.92	0.46
6	1200.82	247.79	7.2	248.03	0.005529	0.45	0.38	14.25	248.11	0.005283	0.54	0.39	19.27	248.15	0.005278	0.6	0.4	39.86	248.25	0.006726	0.81	0.48
6	1272.07	248.72	7.2	248.87	0.043742	0.8	0.95	14.25	248.91	0.042976	0.99	1	19.27	248.94	0.038662	1.08	0.98	39.86	249.03	0.024183	1.24	0.85
6	1416.4	250.06	7.2	250.37	0.004425	0.41	0.34	14.25	250.45	0.004544	0.52	0.37	19.27	250.49	0.004748	0.59	0.38	39.86	250.61	0.00588	0.79	0.45
6	1543.99	250.88	7.2	251.27	0.137037	2.79	2	14.25	251.51	0.022048	1.08	0.8	19.27	251.55	0.019392	1.01	0.75	39.86	251.68	0.013659	1.17	0.68
6	1595.13	251.73	7.2	252.08	0.002391	0.36	0.26	14.25	252.1	0.006407	0.63	0.44	19.27	252.14	0.007166	0.73	0.47	39.86	252.24	0.008854	1.02	0.56
6	1697.92	253.41	7.2	253.6	0.044724	0.96	1.01	14.25	253.66	0.038802	1.18	1.01	19.27	253.69	0.036384	1.28	1	39.86	253.8	0.031077	1.57	1
6	1746.16	253.87	7.2	254.28	0.006199	0.52	0.41	14.25	254.36	0.006727	0.68	0.45	19.27	254.4	0.006971	0.76	0.47	39.86	254.55	0.007653	0.98	0.52
6	1807.33	254.6	7.2	254.92	0.023824	0.94	0.79	14.25	255	0.021547	1.16	0.8	19.27	255.05	0.020704	1.26	0.81	39.86	255.2	0.019619	1.58	0.84
6	1864.33	255.36	7.2	255.76	0.009781	0.81	0.55	14.25	255.87	0.011012	1.08	0.61	19.27	255.92	0.011703	1.23	0.65	39.86	256.11	0.013435	1.65	0.74
6	1922.71	255.98	7.2	256.4	0.012695	0.95	0.63	14.25	256.53	0.012144	1.14	0.65	19.27	256.61	0.011843	1.25	0.65	39.86	256.84	0.011016	1.54	0.67
6	2093.95	258.81	7.2	259.1	0.020208	1.05	0.77	14.25	259.2	0.021019	1.3	0.82	19.27	259.27	0.021538	1.34	0.83	39.86	259.42	0.022313	1.75	0.9

6	2145.68	259.46	7.2	259.77	0.008275	0.68	0.49	14.25	259.88	0.007729	0.85	0.51	19.27	259.94	0.007576	0.94	0.52	39.86	260.14	0.007657	1.2	0.55
6	2181.27	260.06	7.2	260.33	0.036899	1.19	0.99	14.25	260.42	0.031985	1.42	0.98	19.27	260.47	0.032026	1.56	1.01	39.86	260.63	0.02831	1.86	1
6	2234.7	260.99	7.2	261.31	0.010242	0.77	0.55	14.25	261.41	0.011051	1.02	0.61	19.27	261.47	0.011095	1.13	0.62	39.86	261.65	0.01229	1.51	0.7
6	2279.81	261.57	7.2	261.88	0.01603	0.83	0.66	14.25	261.98	0.014228	1	0.66	19.27	262.04	0.013865	1.01	0.66	39.86	262.21	0.010739	1.22	0.63
6	2354.28	262.81	7.2	263.09	0.016678	0.9	0.69	14.25	263.18	0.018958	1.15	0.77	19.27	263.23	0.01919	1.29	0.79	39.86	263.34	0.026871	1.85	0.98
6	2495.67	264.26	7.2	265.09	0.012616	1.37	0.68	14.25	265.33	0.012993	1.64	0.72	19.27	265.44	0.013657	1.81	0.75	39.86	265.82	0.012713	2.17	0.77
6	2613.72	266.59	7.2	267.11	0.025331	1.71	0.94	14.25	267.31	0.023738	2	0.95	19.27	267.43	0.022324	2.11	0.94	39.86	267.7	0.027022	2.73	1.08
7	661.09	229.87	64.01	230.03	0.030266	0.78	0.83	122.37	230.13	0.029424	1.14	0.9	144.48	230.18	0.026108	1.07	0.85	317.54	230.36	0.00001	0.03	0.02
7	1007.84	229.54	64.01	230.14	0.000001	0.01	0.01	122.37	230.3	0.000004	0.03	0.01	144.48	230.35	0.000005	0.03	0.01	317.54	230.37	0.000021	0.06	0.03
7	1186.57	230.11	64.01	230.2	1.448053	4	5.31	122.37	230.3	0.624191	4.27	3.93	144.48	230.35	0.318665	3.47	2.9	317.54	230.6	0.030828	1.7	1.01
7	1450.35	232.08	64.01	232.44	0.000228	0.1	0.08	122.37	232.44	0.000833	0.19	0.15	144.48	232.44	0.001161	0.22	0.18	317.54	232.6	0.002318	0.49	0.28
7	1652.76	233.62	40.36	233.32	0.031303		0	97.85	233.21	1.073686		0	117.84	233.24	0.830263		0	256.69	233.49	0.270115		0
7	1874.4	235.28	40.36	235.7	0.033192	1.45	1	97.85	235.87	0.000103	0.11	0.06	117.84	235.87	0.00015	0.13	0.07	256.69	235.87	0.000711	0.28	0.16
7	2022.81	236.65	40.36	237.04	0.003829	0.5	0.34	97.85	237.02	0.026544	1.26	0.89	117.84	237.04	0.030085	1.42	0.96	256.69	237.11	0.000662	0.25	0.15
7	2077.28	237.16	40.36	237.46	0.02561	1.17	0.86	97.85	237.41	0.448885	4.08	3.44	117.84	237.44	0.338298	3.97	3.07	256.69	237.58	0.001462	0.37	0.22
7	2172.75	238.01	40.36	238.26	0.034702	1.22	0.97	97.85	238.31	0.0001	0.07	0.05	117.84	238.31	0.000145	0.08	0.06	256.69	238.31	0.000688	0.19	0.14
7	2382.51	239.44	40.36	240.29	0.000002	0.01	0.01	97.85	240.29	0.000009	0.03	0.02	117.84	240.29	0.000014	0.04	0.02	256.69	240.29	0.000065	0.08	0.05
7	2772.97	241.26	39.26	242.76	0.023182	2.51	1	77.16	243.31	0.026181	2.06	1	94.5	243.39	0.02608	2.08	1	208.34	243.59	0.022346	2.16	0.95
7	2855.9	241.62	39.26	243.76	0.004902	1.43	0.48	77.16	244.2	0.004405	0.89	0.41	94.5	244.29	0.004459	0.87	0.41	208.34	244.53	0.005853	1.31	0.51
7	2930.57	244.29	39.26	244.78	0.005207	0.53	0.39	77.16	244.79	0.01796	1	0.72	94.5	244.85	0.014612	1.03	0.67	208.34	245.1	0.009692	1.35	0.62
7	3052.56	245.42	39.26	245.77	0.018096	1.02	0.73	77.16	245.99	0.006325	0.93	0.48	94.5	246.03	0.007171	1.02	0.52	208.34	246.22	0.009391	1.41	0.62
7	3143.83	246.32	39.26	246.77	0.006498	0.72	0.46	77.16	246.83	0.013807	1.19	0.68	94.5	246.88	0.012097	1.24	0.66	208.34	247.11	0.009677	1.55	0.64
7	3270.83	247.23	39.26	247.66	0.009326	0.75	0.53	77.16	247.81	0.005593	0.81	0.44	94.5	247.85	0.006093	0.9	0.47	208.34	248.06	0.007306	1.27	0.55
7	3329.53	247.51	39.26	248.38	0.015361	1.12	0.7	77.16	248.45	0.026059	1.69	0.95	94.5	248.5	0.025671	1.8	0.96	208.34	248.75	0.020901	2.11	0.92
7	3399.06	247.61	39.26	248.41	0.179513	5.11	2.58	77.16	249.23	0.005858	0.92	0.47	94.5	249.28	0.005801	0.98	0.47	208.34	249.54	0.006239	1.25	0.51
7	3490.69	249.57	39.26	250.22	0.001045	0.3	0.18	77.16	250.22	0.004034	0.6	0.36	94.5	250.22	0.006051	0.73	0.45	208.34	250.34	0.012755	1.33	0.68
7	3735.65	250.81	39.26	251.66	0.032023	1.53	1	77.16	251.91	0.012274	1.32	0.67	94.5	252.03	0.007894	1.21	0.56	208.34	252.27	0.004272	1.16	0.44
7	3926.01	251.38	39.26	253.08	0.00301	0.94	0.36	77.16	253.39	0.005163	1.11	0.47	94.5	253.41	0.006752	1.3	0.54	208.34	253.51	0.00921	1.67	0.64
7	4011.5	251.61	39.26	253.38	0.004434	1.08	0.44	77.16	253.78	0.004197	1.15	0.43	94.5	253.89	0.004456	1.21	0.45	208.34	254.26	0.006694	1.63	0.56
7	4120.06	252.35	39.26	253.7	0.001788	0.82	0.29	77.16	254.16	0.002491	0.85	0.33	94.5	254.28	0.002495	0.88	0.33	208.34	254.74	0.001848	0.99	0.31
7	4202.07	253.68	39.26	254.29	0.029804	1.32	0.94	77.16	254.52	0.008704	1.07	0.56	94.5	254.6	0.006231	1.04	0.49	208.34	255.02	0.002078	0.92	0.32
7	4317.96	254.81	39.26	255.23	0.003024	0.45	0.3	77.16	255.34	0.005235	0.72	0.42	94.5	255.38	0.006379	0.82	0.47	208.34	255.47	0.014834	1.29	0.72
7	4411.84	254.99	39.26	255.59	0.001475	0.34	0.22	77.16	255.82	0.001554	0.43	0.23	94.5	255.89	0.001558	0.47	0.24	208.34	256.24	0.001745	0.73	0.28
7	4436.11	255.35	39.26	255.82	0.003841	0.53	0.35	77.16	256.02	0.003013	0.57	0.32	94.5	256.09	0.002853	0.6	0.32	208.34	256.42	0.002612	0.87	0.34
7	4543.94	256.23	39.26	256.95	0.020009	1.25	0.8	77.16	257.04	0.002807	0.51	0.3	94.5	257.04	0.004212	0.62	0.37	208.34	257.18	0.007872	1.12	0.55
7	4671.73	256.59	39.26	257.9	0.003501	0.7	0.36	77.16	257.9	0.013456	1.37	0.7	94.5	258.02	0.008807	1.25	0.59	208.34	258.35	0.005638	1.38	0.51
7	4756.38	258.01	39.26	258.48	0.025	1.29	0.87	77.16	258.75	0.007087	1.06	0.52	94.5	258.77	0.008788	1.23	0.58	208.34	258.97	0.012133	1.83	0.73
7	4868.05	258.61	39.26	259.54	0.004576	0.92	0.42	77.16	259.64	0.009794	1.48	0.64	94.5	259.78	0.009363	1.38	0.61	208.34	260.1	0.006924	1.61	0.57
7	4944.23	259.27	39.26	259.92	0.004979	0.81	0.42	77.16	260.16	0.003756	0.84	0.38	94.5	260.24	0.003267	0.86	0.37	208.34	260.51	0.003461	1.15	0.4
7	5026.79	259.33	39.26	260.61	0.019608	1.38	0.81	77.16	260.74	0.022569	1.77	0.91	94.5	260.81	0.019486	1.81	0.87	208.34	261.07	0.017595	2.16	0.87
7	5082.06	260.08	39.26	261.32	0.007941	0.96	0.53	77.16	261.5	0.007168	1.17	0.53	94.5	261.54	0.007685	1.27	0.56	208.34	261.82	0.008017	1.58	0.6
7	5115.8	259.51	30.97	261.55	0.005585	0.94	0.46	61.13	261.74	0.006483	1.08	0.5	74.21	261.81	0.006082	1.1	0.49	165.81	262.1	0.00535	1.34	0.49
7	5241.08	261.82	30.97	262.51	0.011611	1.07	0.62	61.13	262.68	0.009572	1.29	0.61	74.21	262.73	0.01026	1.42	0.64	165.81	263	0.013226	1.86	0.75
7	5348.97	263.11	30.97	263.59	0.008483	1.03	0.55	61.13	263.76	0.010128	1.39	0.63	74.21	263.83	0.009841	1.46	0.63	165.81	264.23	0.009081	1.75	0.64
7	5492.72	263.91	30.97	264.56	0.005327	0.89	0.45	61.13	264.83	0.005134	0.97	0.45	74.21	264.9	0.005034	1.03	0.45	165.81	265.25	0.00456	1.32	0.46
7	5605.36	264.42	30.97	265.26	0.008072	1.27	0.57	61.13	265.52	0.008915	1.61	0.63	74.21	265.6	0.009771	1.76	0.66	165.81	265.94	0.015099	2.58	0.86
7	5676.96	264.83	30.97	265.74	0.005547	1.25	0.49	61.13	266.06	0.006476	1.61	0.56	74.21	266.17	0.006669	1.72	0.57	165.81	266.81	0.007719	2.14	0.64
7	5772.26	265.54	30.97	266.3	0.005763	1.05	0.48	61.13	266.63	0.004477	1.23	0.45	74.21	266.75	0.004224	1.29	0.45	165.81	267.41	0.003466	1.52	0.43
7	5883.84	266.33	30.97	267.03	0.007546	1.15	0.54	61.13	267.26	0.008078	1.46	0.59	74.21	267.35	0.0079	1.54	0.59	165.81	267.88	0.006557	1.87	0.58
7	5981.58	266.75	30.97	267.74	0.006972	1.16	0.53	61.13	268.01	0.007117	1.42	0.56	74.21	268.1	0.00727	1.51	0.57	165.81	268.58	0.007852	1.89	0.62
7	6064.43	267.54	30.97	268.4	0.009902	1.4	0.63	61.13	268.67	0.010111	1.75	0.67	74.21	268.76	0.010241	1.87	0.68	165.81	269.27	0.01102	2.38	0.75
7	6136.07	268.1	30.97	268.98	0.005686	0.99	0.47	61.13	269.26	0.00505	1.15	0.47	74.21	269.36	0.004801	1.2	0.46	165.81	269.91	0.003863	1.43	0.44
7	6230.86	268.96	30.97	269.76	0.015967	1.7	0.79	61.13	269.95	0.004564	0.95	0.43	74.21	269.95	0.006726	1.15	0.52	165.81	270.35	0.005128	1.44	0.5
7	6274.55	269.21	30.97	270.27	0.007427	1.42	0.57	61.13	270.32	0.022789	2.57	1	74.21	270.42	0.022265	2.7	1	165.81	271.05	0.021376	2.77	1
7	6340.11	269.9	30.97	270.73	0.006259	1.28	0.52	61.13	271.17	0.004799	1.44	0.48	74.21	271.3	0.004867	1.53	0.49	165.81	271.89	0.005636	2.06	0.56
7	6389.12	270.1	30.97	271.06	0.00797	1.45	0.58	61.13	271.41	0.007431	1.81	0.6	74.21	271.54	0.007418	1.94	0.61	165.81	272.12	0.008922	2.72	0.71
7	6496.78	270.7	30.97	271.9	0.008073	1.69	0.61	61.13	272.27	0.009795	2.2	0.7	74.21	272.4	0.010199	2.35	0.72	165.81	273.12	0.010878	3	0.78
7	6556.87	271.12	30.97	272.28	0.003199	1.07	0.38	61.13	272.74	0.002951	1.32	0.39	74.21	272.9	0.002928	1.4	0.4	165.81	273.74	0.002921	1.81	0.42
7	6584.13	271.45	30.97	272.37	0.007072	1.46	0.56	61.13	272.81	0.005984	1.72	0.55	74.21	272.97	0.00582	1.8	0.55	165.81	273.87	0.00482	1.68	0.5

7	6624.52	271.66	30.97	272.69	0.011667	1.8	0.71	61.13	273.06	0.011192	2.2	0.74	74.21	273.2	0.010774	2.31	0.73	165.81	273.95	0.009433	2.86	0.73
7	6737.3	272.43	30.97	273.62	0.005181	1.32	0.49	61.13	274.02	0.005324	1.64	0.52	74.21	274.16	0.005397	1.75	0.53	165.81	274.93	0.005457	2.21	0.56
7	6804.4	272.75	30.97	274.04	0.009381	1.71	0.65	61.13	274.44	0.009577	2.07	0.68	74.21	274.58	0.009577	2.17	0.69	165.81	275.43	0.004249	1.49	0.46
7	6904.15	273.4	30.97	275.02	0.011198	2.01	0.72	61.13	275.44	0.012173	2.5	0.78	74.21	275.58	0.012559	2.67	0.8	165.81	276.2	0.018439	3.62	1
7	6954.8	273.72	30.97	275.44	0.003675	1.32	0.43	61.13	275.99	0.004142	1.56	0.46	74.21	276.2	0.004542	1.55	0.48	165.81	277.13	0.003567	1.67	0.45
7	6979.76	274.11	30.97	275.54	0.007173	1.63	0.58	61.13	276.08	0.005876	1.8	0.55	74.21	276.3	0.005562	1.8	0.54	165.81	277.21	0.004756	1.81	0.51
7	7088.83	275.91	30.97	276.93	0.031589	2.39	1.11	61.13	277.14	0.03779	3.22	1.28	74.21	277.22	0.039372	3.49	1.32	165.81	277.78	0.030728	4.22	1.26
7	7236.87	279.85	30.97	280.86	0.023008	2.58	1	61.13	281.28	0.020846	2.99	1	74.21	281.44	0.020291	3.07	1	165.81	282.29	0.022958	2.64	1.01
7	7381.12	283.26	30.97	284.39	0.023213	1.76	0.92	61.13	284.61	0.021885	2.14	0.94	74.21	284.69	0.021347	2.25	0.94	165.81	285.15	0.017215	2.62	0.9

D. Carmichael River Model Results – Developed Conditions

Figure D1: 10 Year ARI Design Flood (Post-Development Conditions)

Figure D2: 50 Year ARI Design Flood (Post-Development Conditions)

Figure D3: 100 Year ARI Design Flood (Post-Development Conditions)

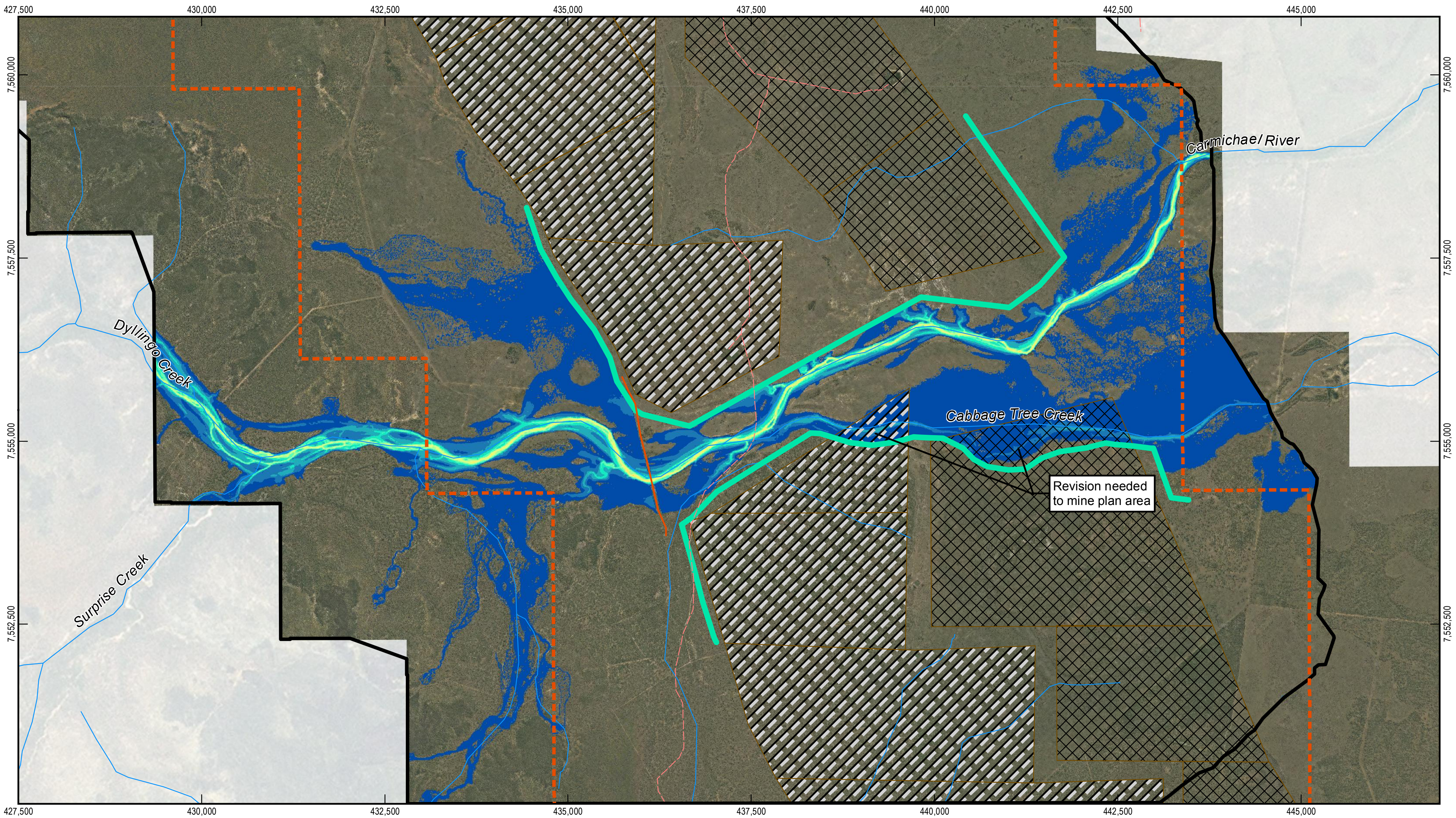
Figure D4: 1000 Year ARI Design Flood (Post-Development Conditions)

Figure D5: 10 Year ARI Afflux Map (Post-Development Conditions)

Figure D6: 50 Year ARI Afflux Map (Post-Development Conditions)

Figure D7: 100 Year ARI Afflux Map (Post-Development Conditions)

Figure D8: 1000 Year ARI Afflux Map (Post-Development Conditions)



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

Depth (m)

0.08 - 1.0	3.0 - 4.0	7.0 - 8.0
1.0 - 2.0	4.0 - 5.0	8.0 - 9.0
2.0 - 3.0	5.0 - 6.0	9.0 - 10.0
	6.0 - 7.0	10.0 - 11.0

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

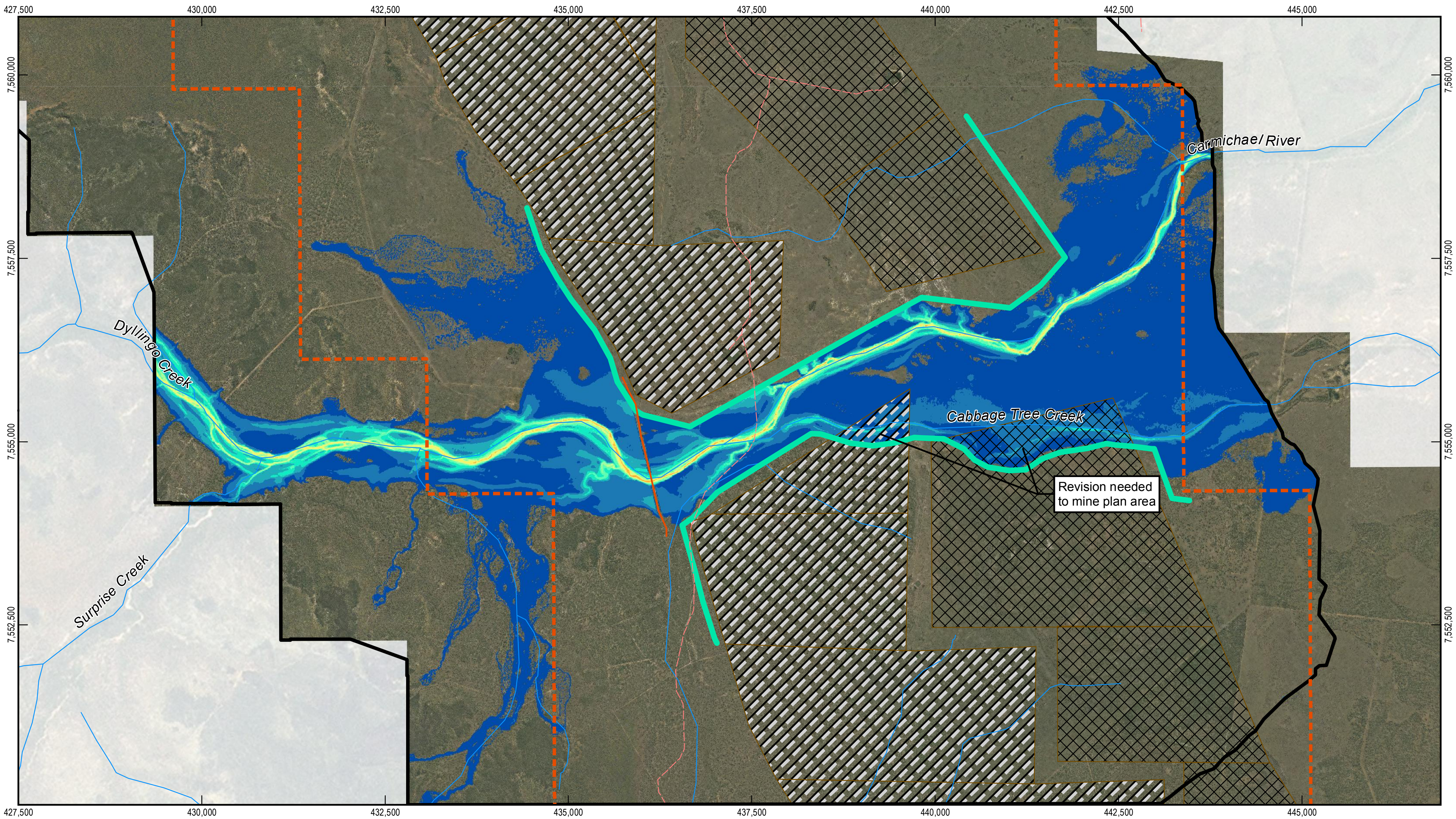
10 Year ARI Design Flood
Post Development - Depth

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

Figure D1

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_557-01_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 11.0

GHD adani

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

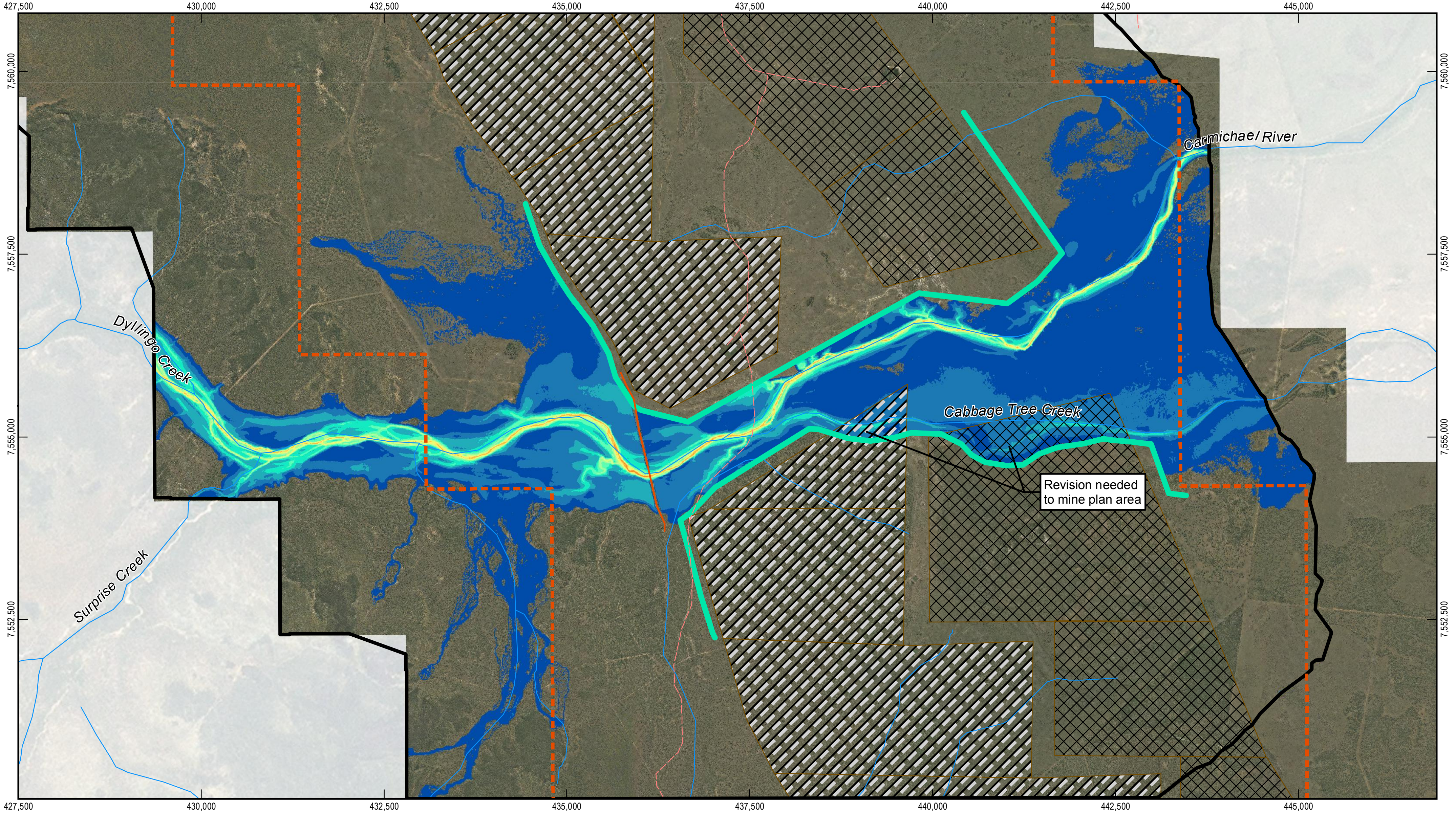
50 Year ARI Design Flood
Post Development - Depth

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

Figure D2

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_557-02_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 11.0

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

100 Year ARI Design Flood
Post Development - Depth

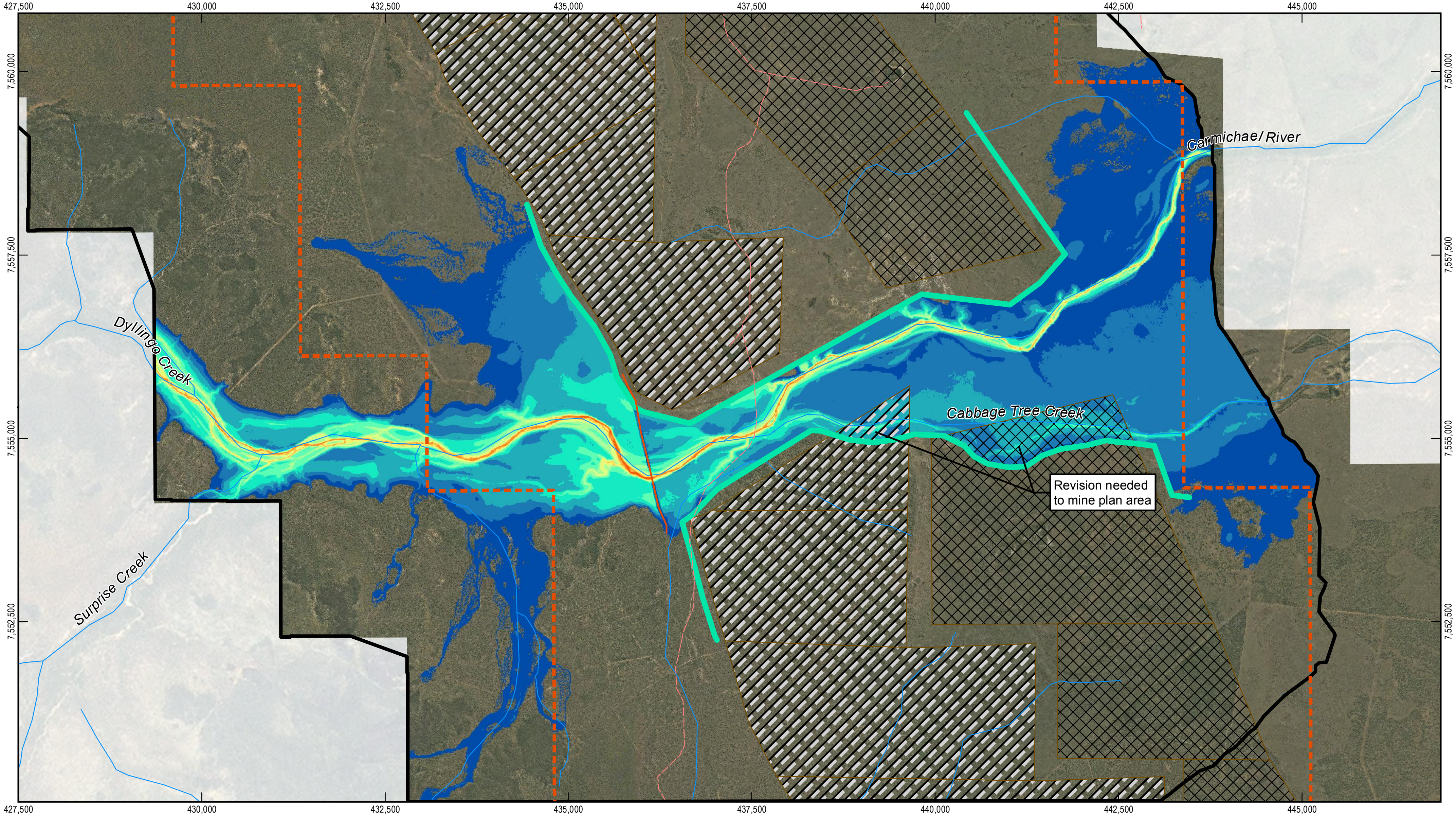
Job Number	41-25215
Revision	A
Date	28-08-2012

Figure D3

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_557-03_rev_a.mxd

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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area

Depth (m)

- 0.08 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0
- 9.0 - 10.0
- 10.0 - 11.0

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

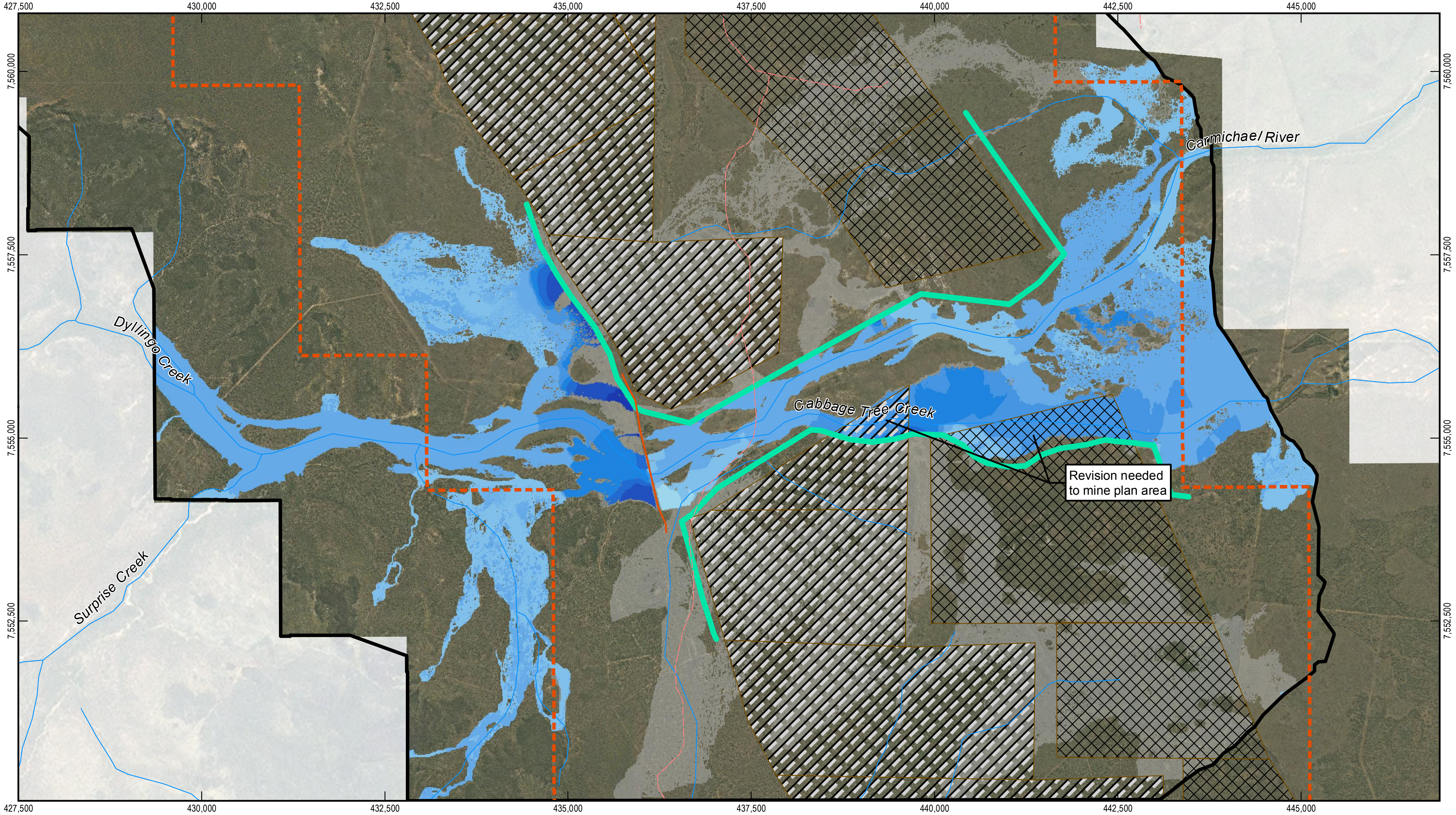
1000 Year ARI Design Flood Post Development - Depth

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

Figure D4

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_557-04_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Flood Extent Change

Afflux (m)

- -37.3 - -0.4
- -0.4 - -0.2
- -0.2 - 0.0
- 0.0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.2

GHD adani

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

10 Year ARI Design Flood Post Development - Afflux

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

Figure D5

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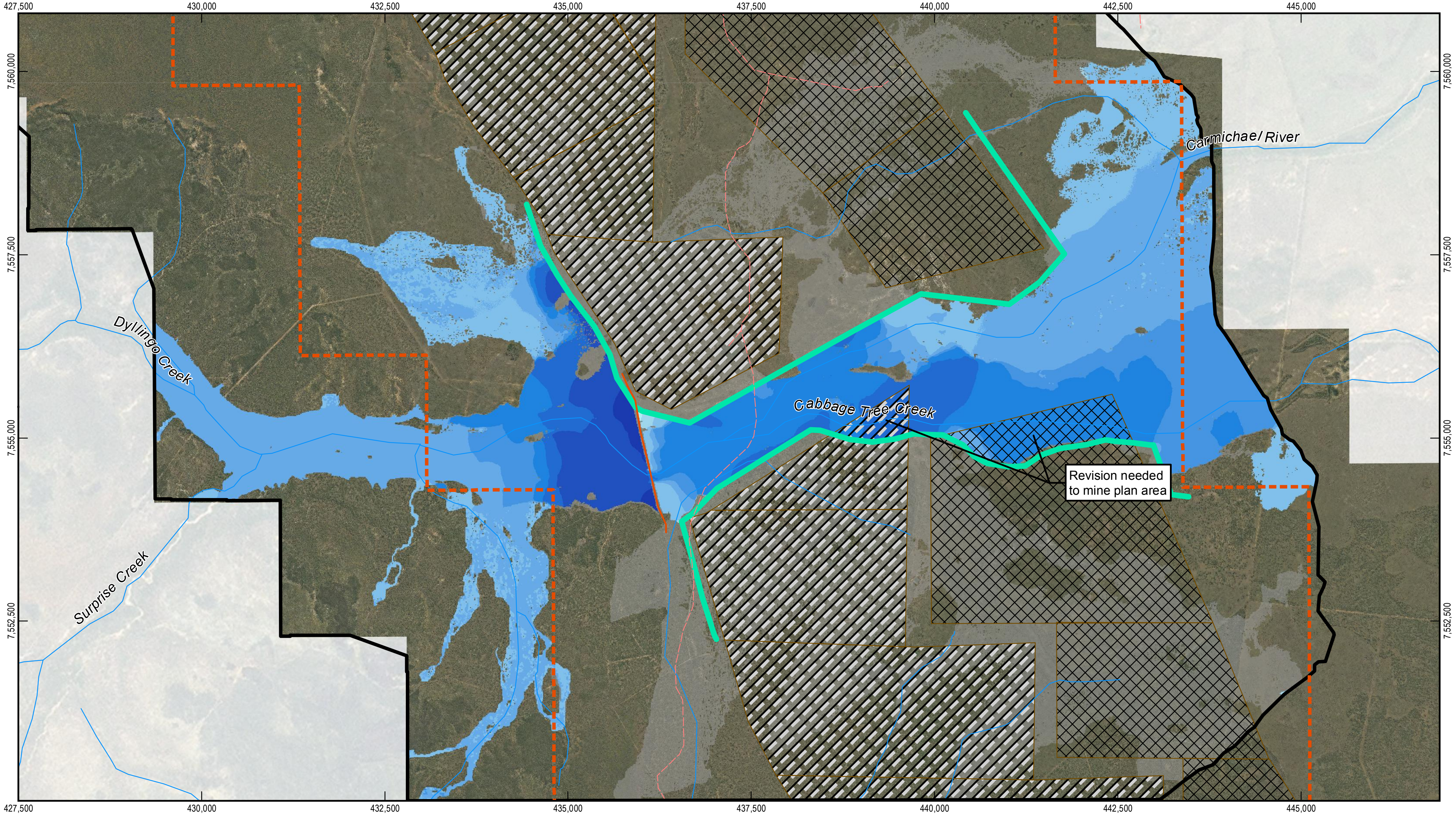
Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Flood Extent Change

Afflux (m)

- -37.3 - -0.4
- -0.4 - -0.2
- -0.2 - 0.0
- 0.0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.2

GHD adani

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

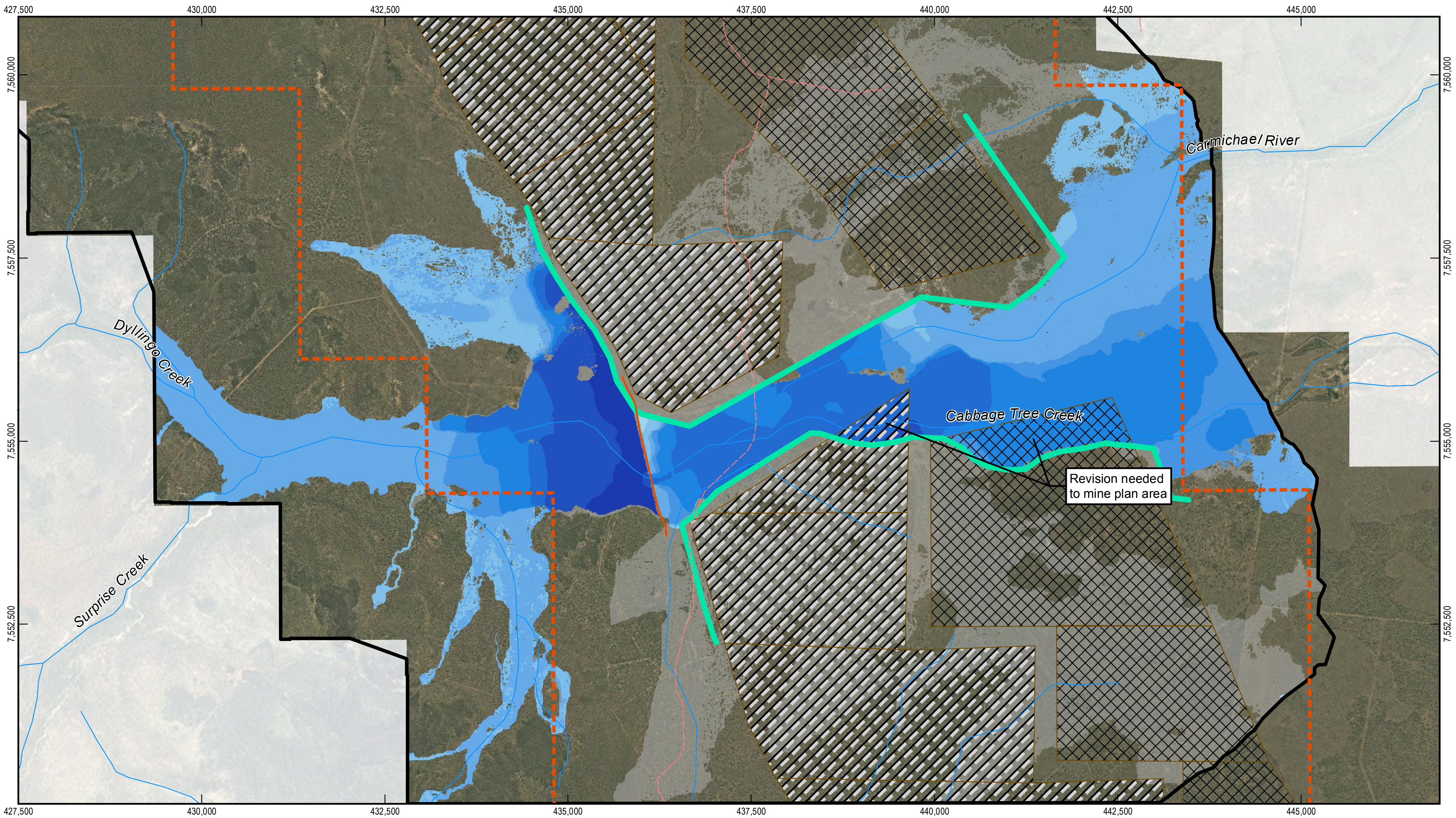
50 Year ARI Design Flood
Post Development - Afflux

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

Figure D6

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_558-02_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA



1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Flood Extent Change

Afflux (m)

- -37.3 - -0.4
- -0.4 - -0.2
- -0.2 - 0.0
- 0.0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.2

GHD adani

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

100 Year ARI Design Flood
Post Development - Afflux

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

Figure D7

G:\41\25215\GIS\Maps\MXD\500_SurfaceWater\Flood_Mitigation\41-25215_558-03_rev_a.mxd 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: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
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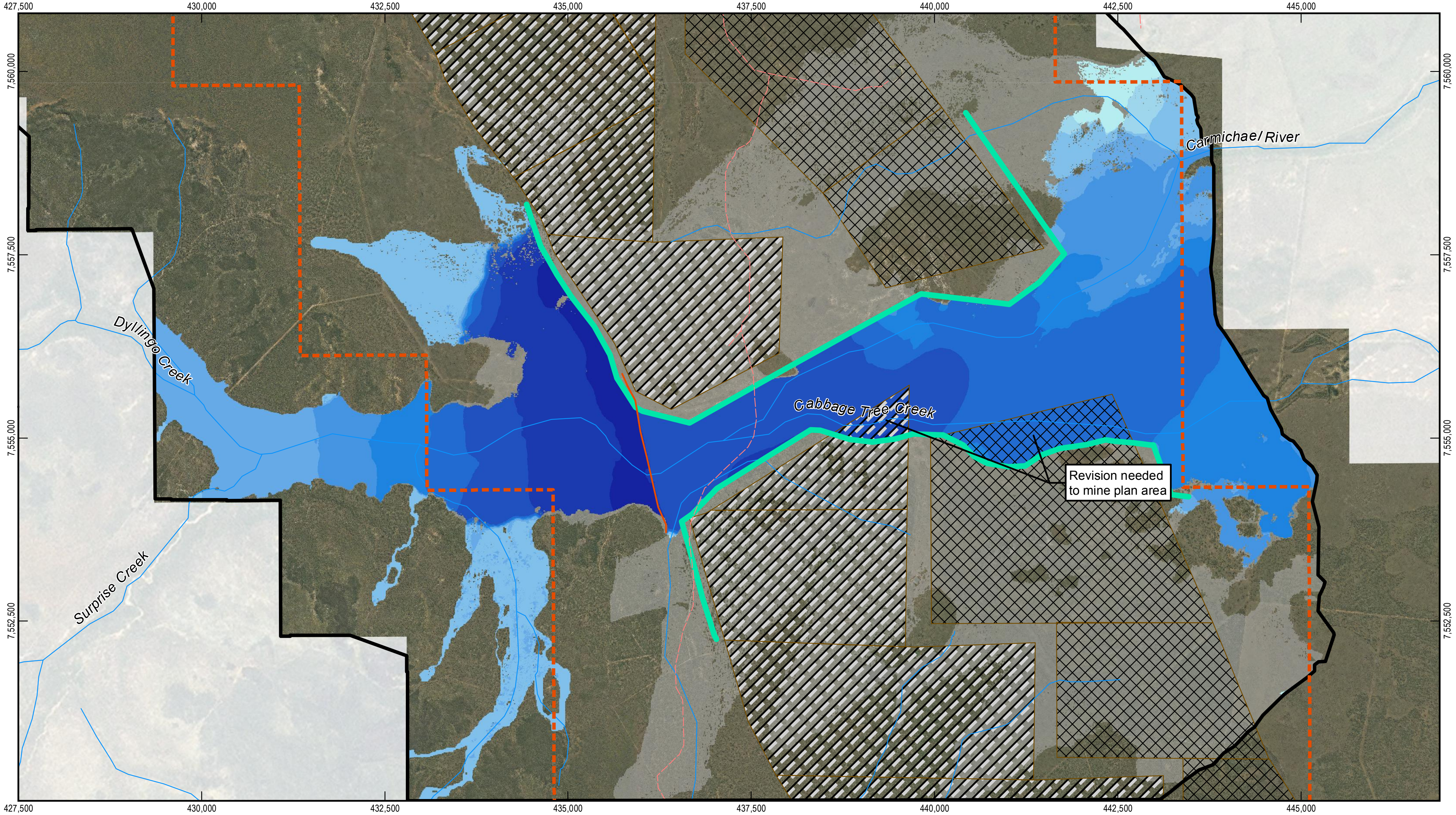

1:70,000 (at A4)

0 0.5 1 1.5 2 2.5

Kilometres

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

N

LEGEND

- Watercourse
- Track
- Minor Road
- Proposed Carmichael River Levees
- 2D Model Extent
- Mine Lease Area
- Waste Rock Dump Area
- Open Cut Mining Area
- Flood Extent Change

Afflux (m)

- -37.3 - -0.4
- -0.4 - -0.2
- -0.2 - 0.0
- 0.0 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.8
- 0.8 - 1.6
- 1.6 - 3.2
- 3.2 - 6.2

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

1000 Year ARI Design Flood
Post Development - Afflux

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

Figure D8

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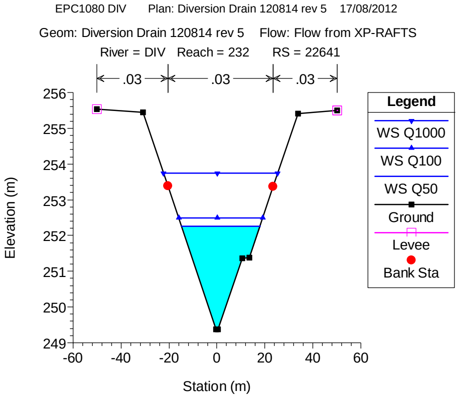
Data source: DME: EPC1690 (2010)/EPC1080 (2011); © Commonwealth of Australia (Geoscience Australia): Roads, Watercourse (2007); Adani Pty Ltd: Waste Rock Dump Area, Open Cut Area (2012)
GHD: Modelling, Levees (2012); Created by: BW, CA

E. Case study diversion drain modeling results

HEC-RAS modelled cross-sections

Table of HEC-RAS flow, velocity, and level results for the case study diversion drain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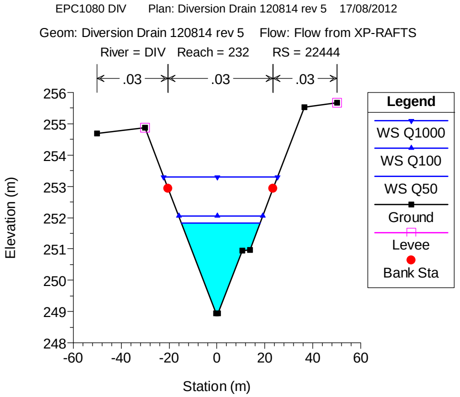
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 22641
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
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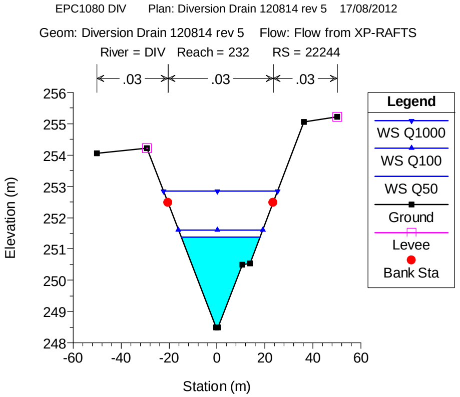
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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Legend
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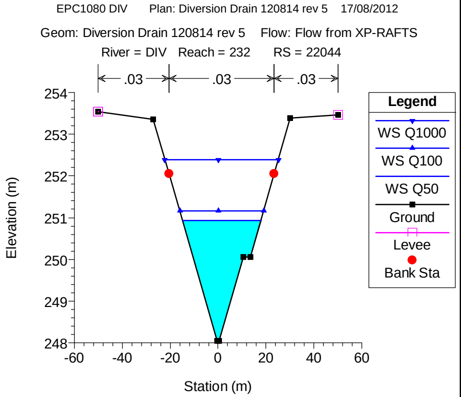
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
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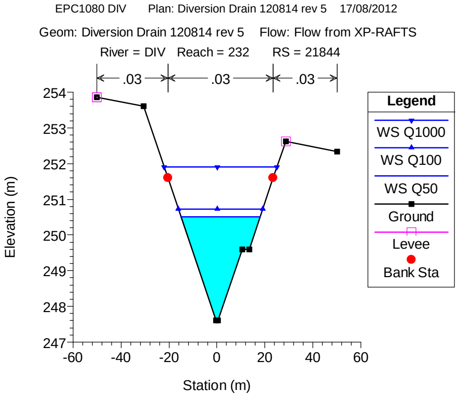
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
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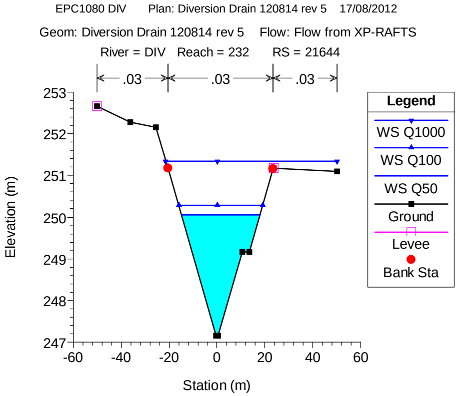
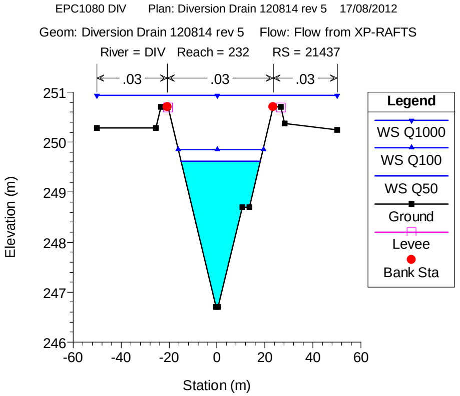
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 21644
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
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Legend
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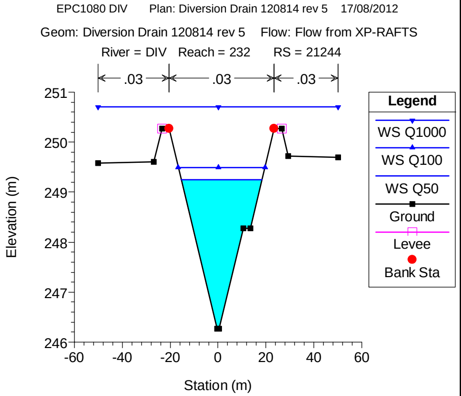
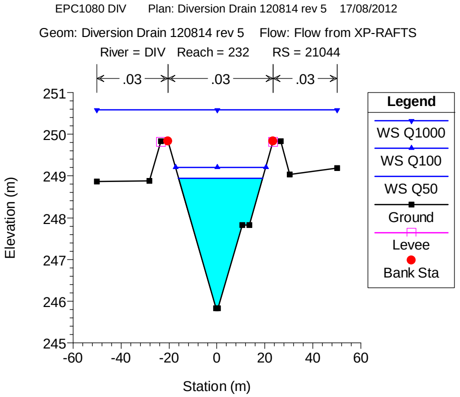
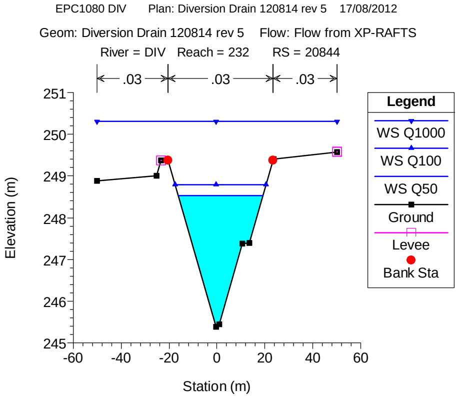
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 21244
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 21044
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20844
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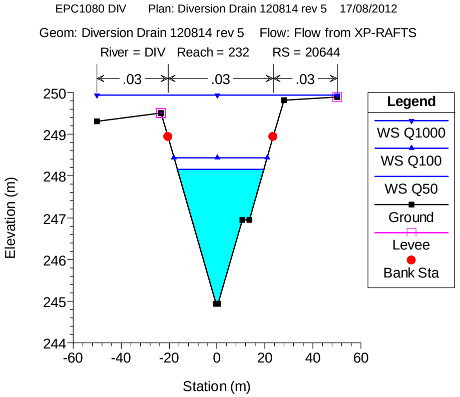
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20644
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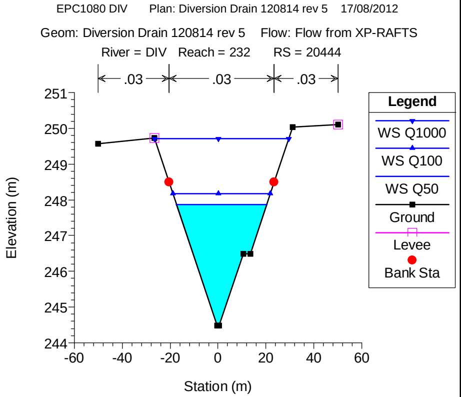
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20444
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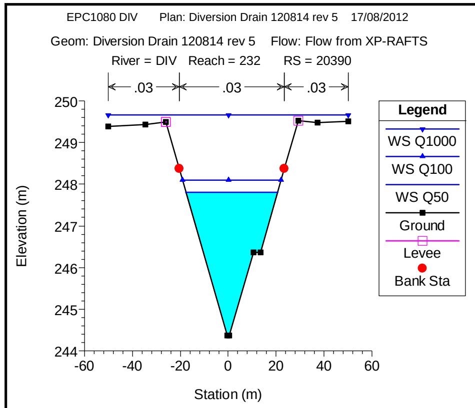
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20390
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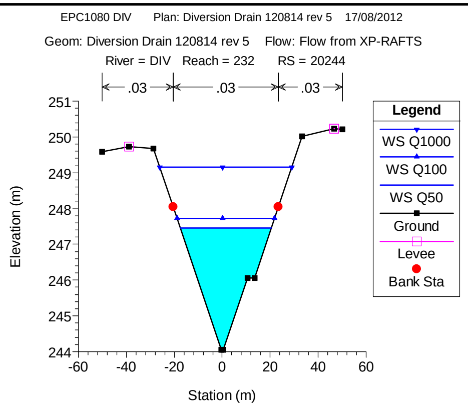
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20244
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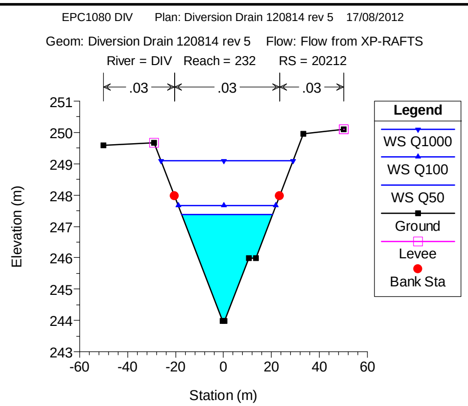
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20212
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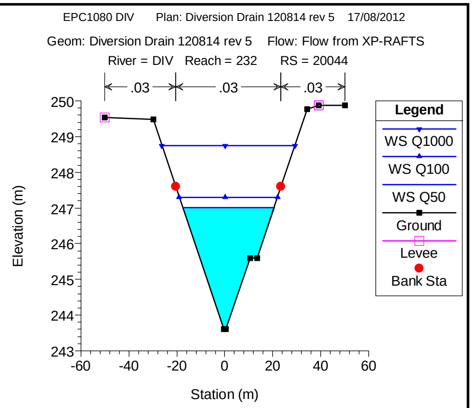
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 20044
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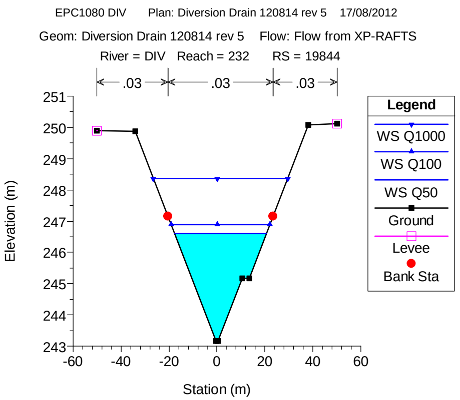
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19844
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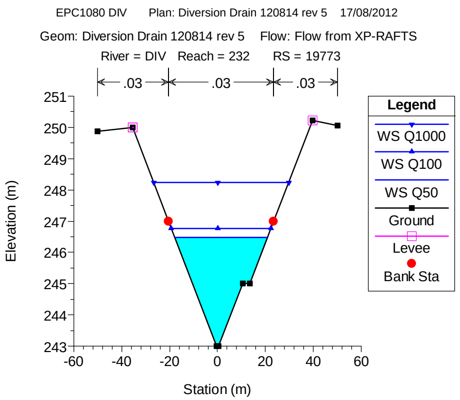
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19773
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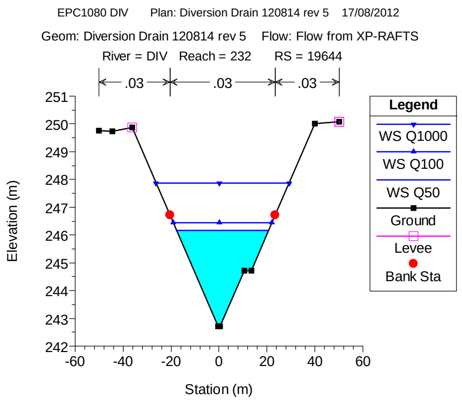
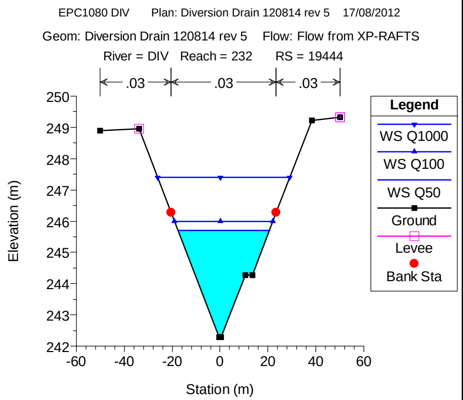
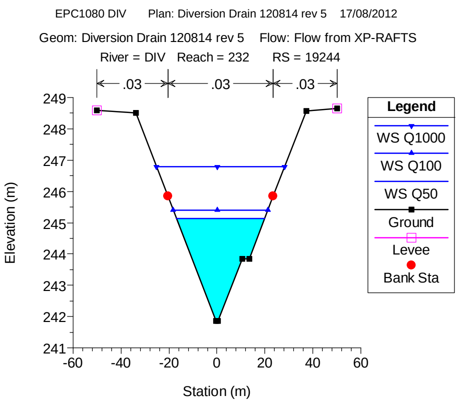
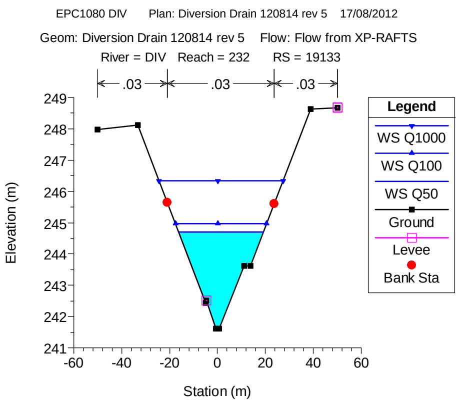
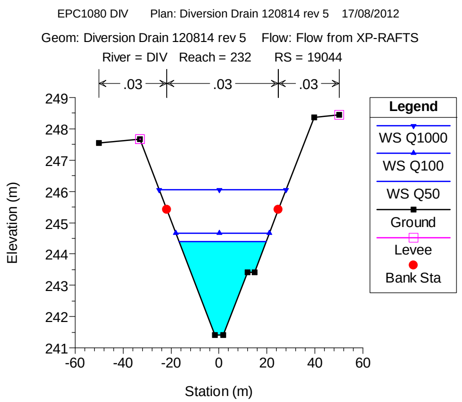
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19644
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19444
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19244
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19133
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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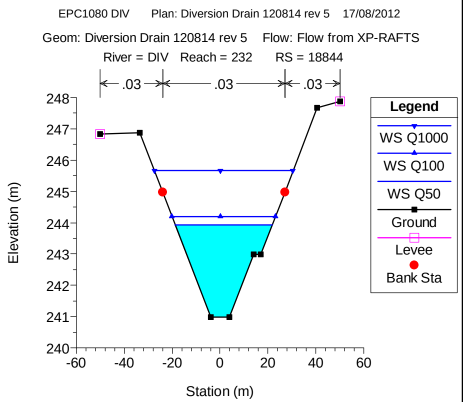
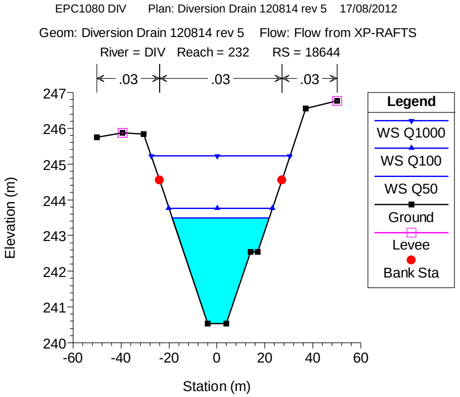
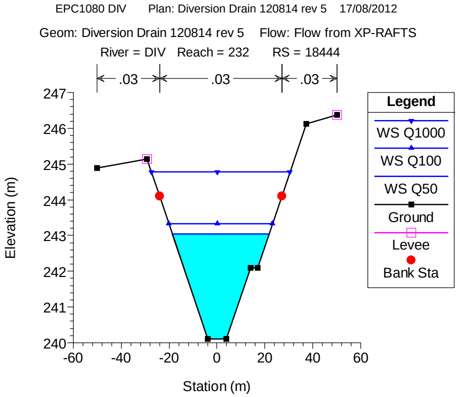
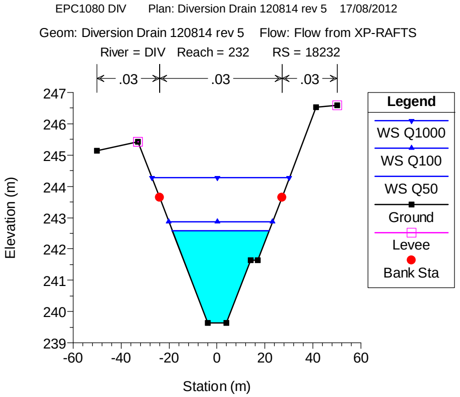
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 19044
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 18844
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 18644
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 18444
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 18232
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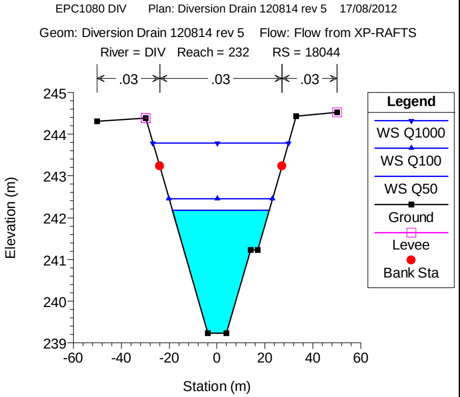
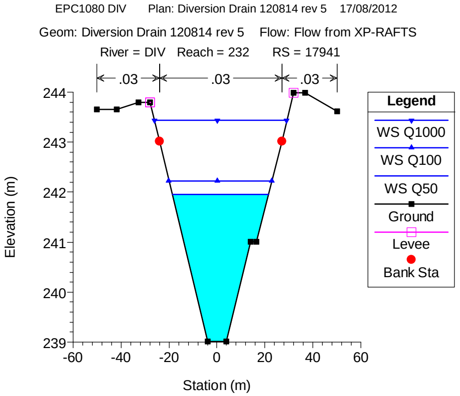
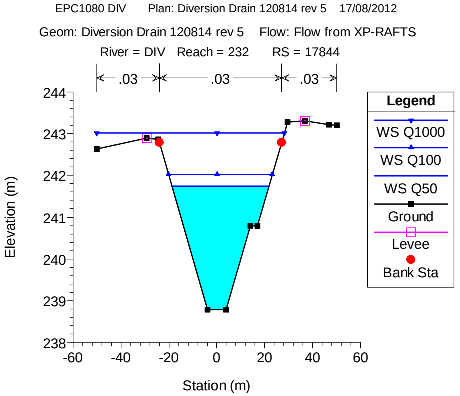
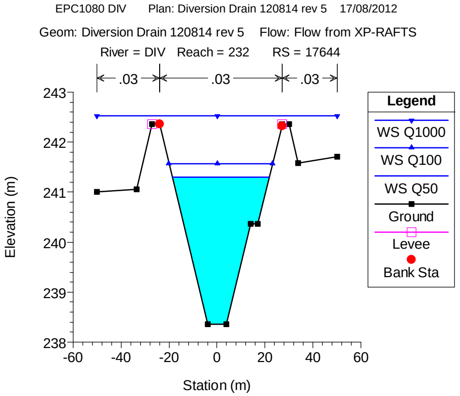
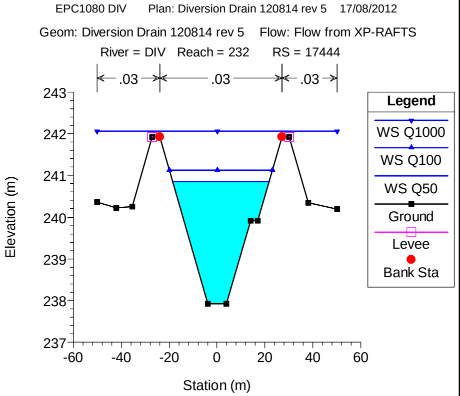
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

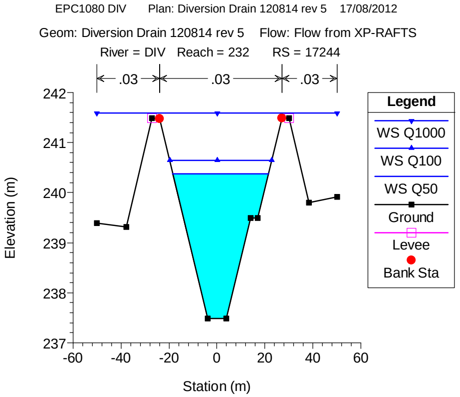

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 18044
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

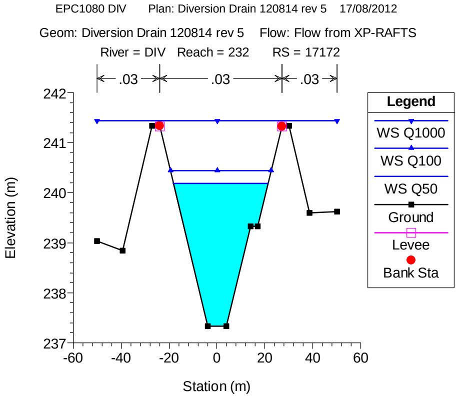

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17941
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17844
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17644
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17444
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17244
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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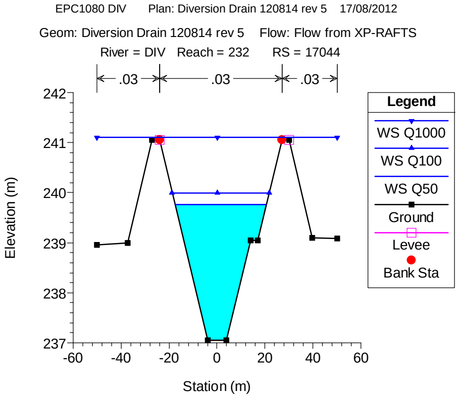
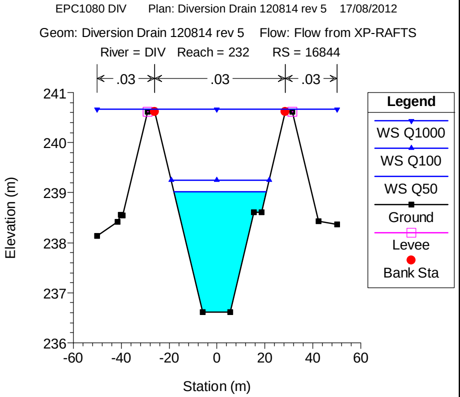
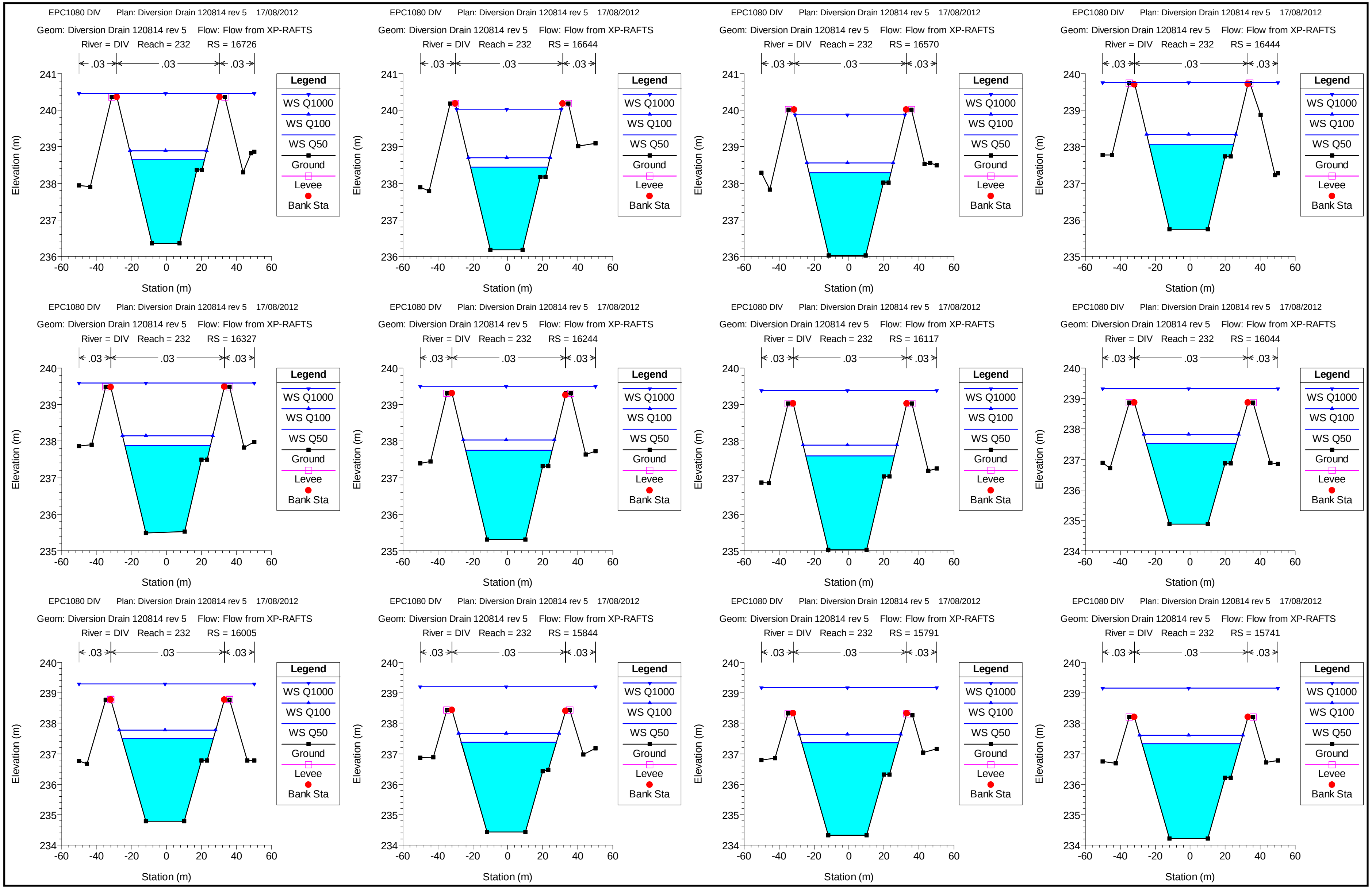
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17172
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 17044
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16844
.03 .03 .03
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta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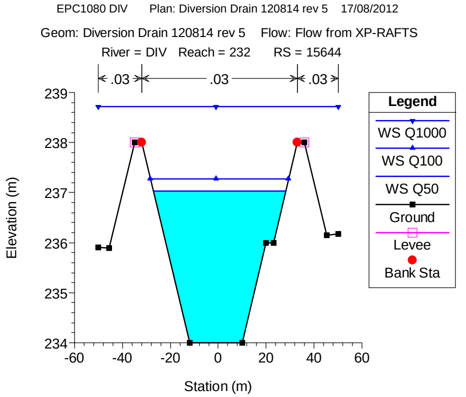
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16726
.03 .03 .03
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16644
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16570
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16444
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16327
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16244
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16117
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16044
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 16005
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15844
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15791
EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15741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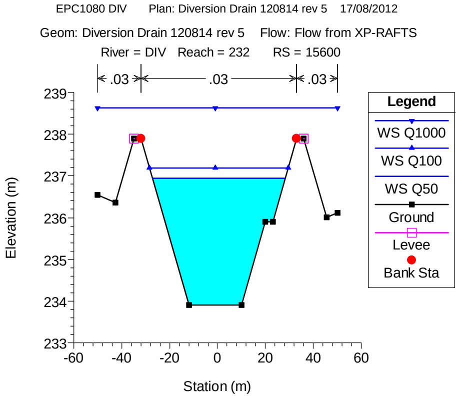
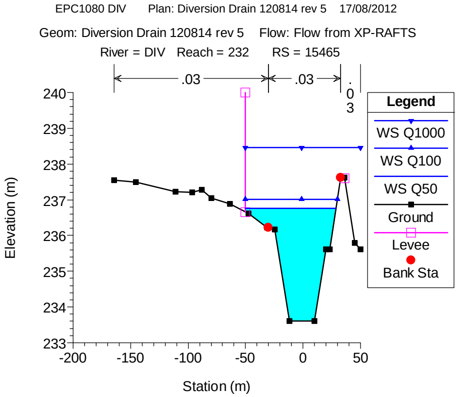
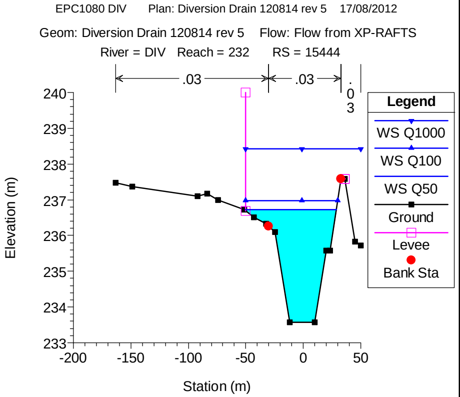
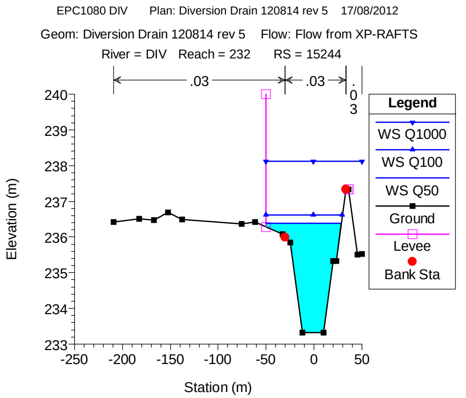
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15644
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15600
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15465
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15444
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)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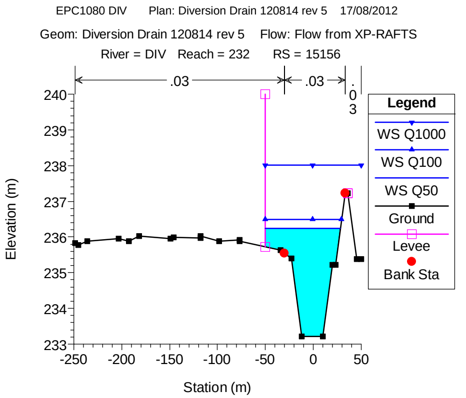
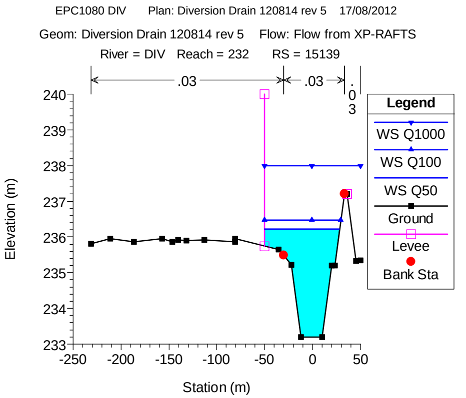
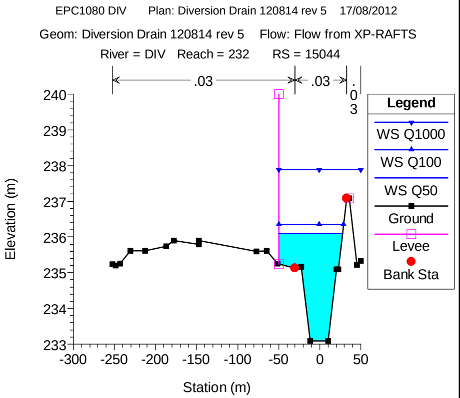
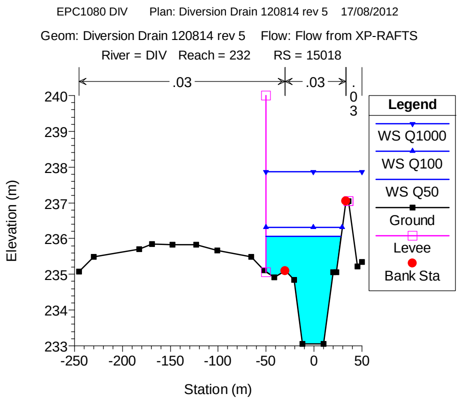
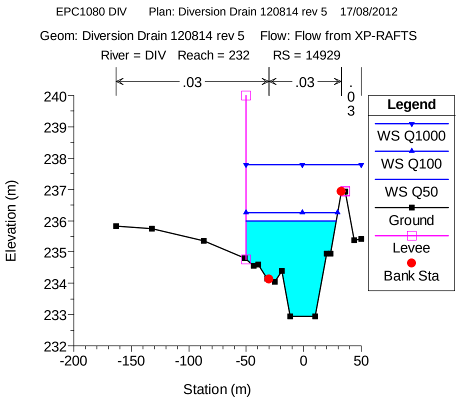
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15244
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

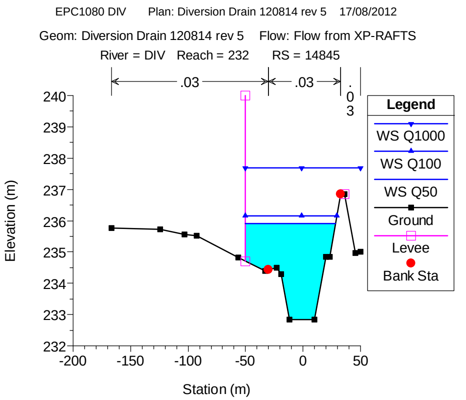

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15156
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

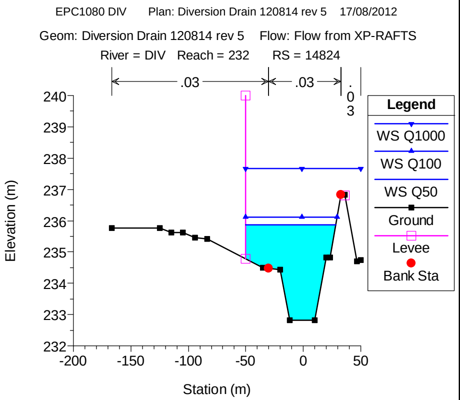

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15139
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

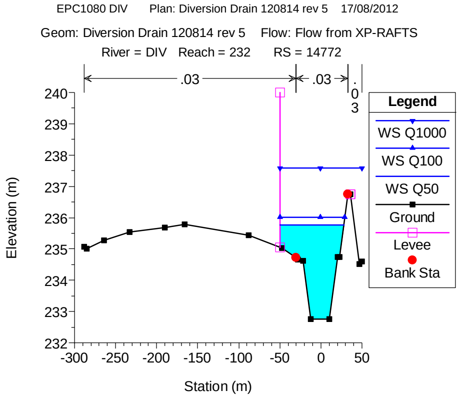

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15044
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

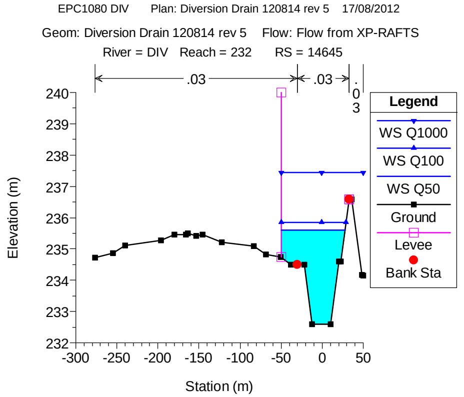

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 15018
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

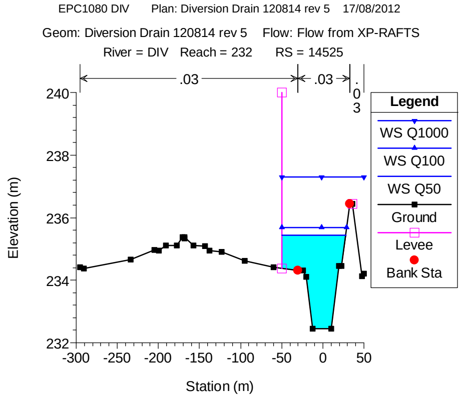

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14929
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

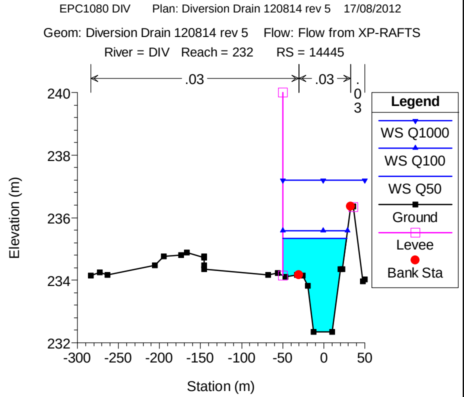

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14845
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

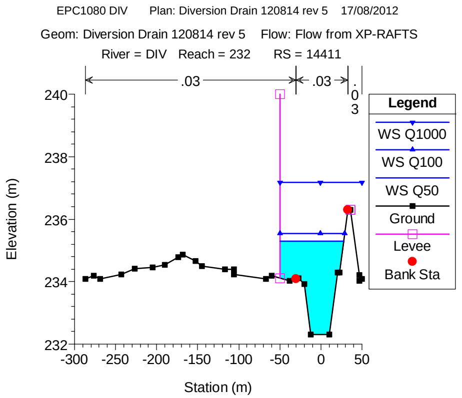

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14824
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

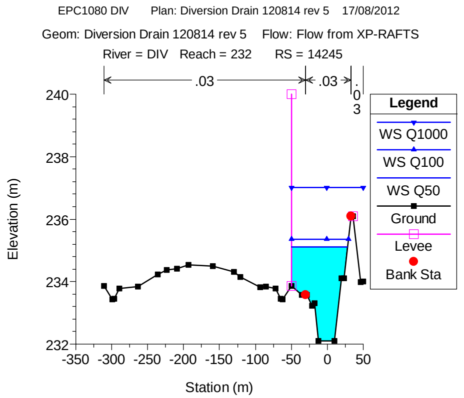

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14772
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

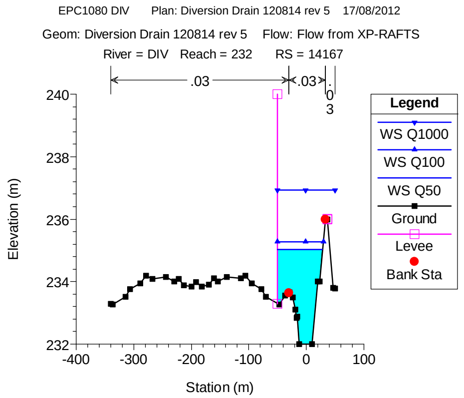

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14645
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

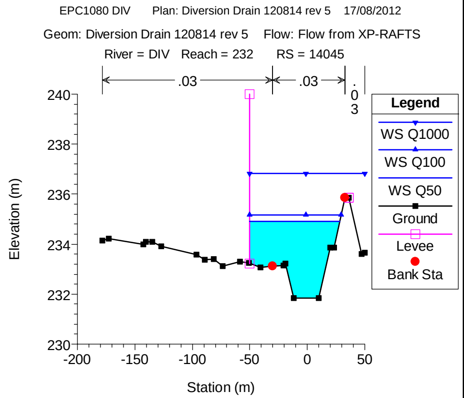

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14525
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

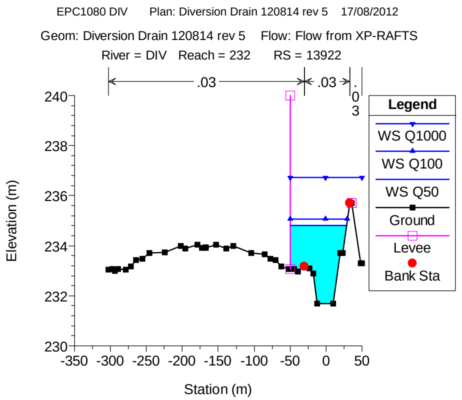

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14445
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

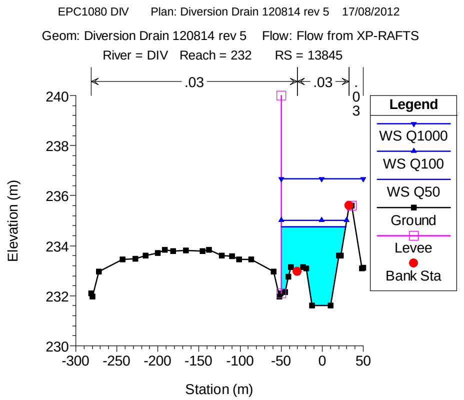

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14411
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

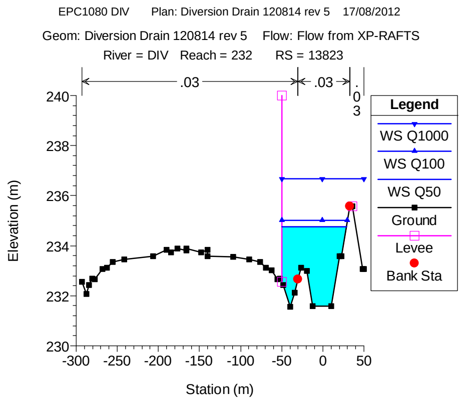

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14245
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

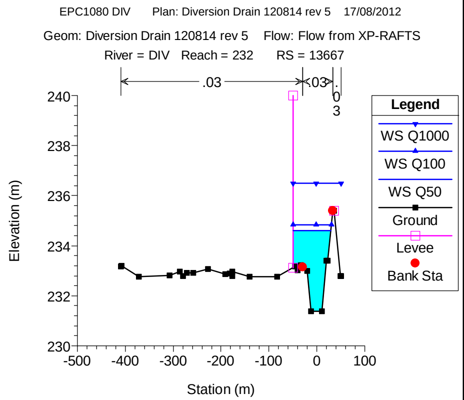

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14167
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

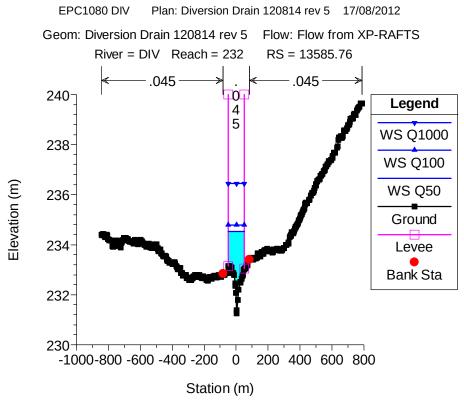

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 14045
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

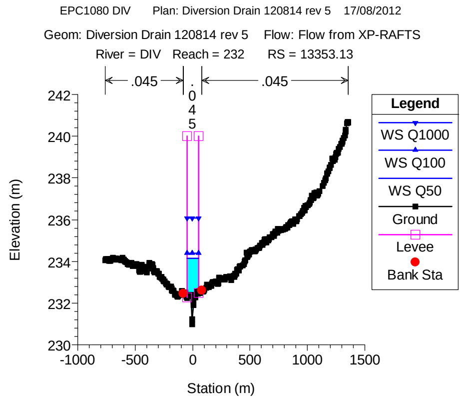

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13922
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

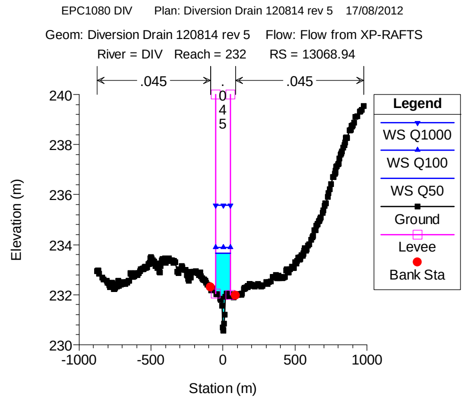

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13845
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

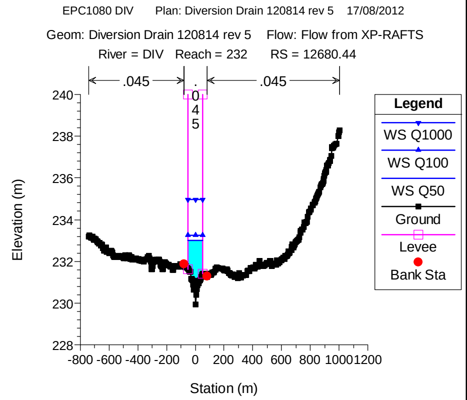

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13823
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

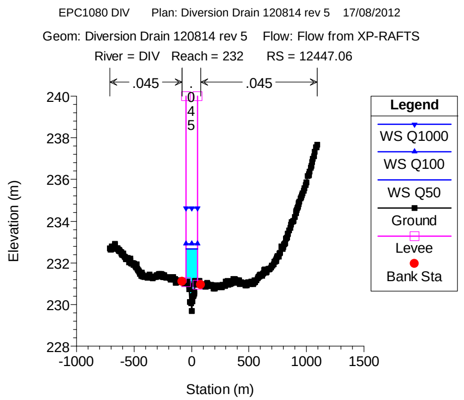

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13667
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta
Elevation (m)
Station (m)

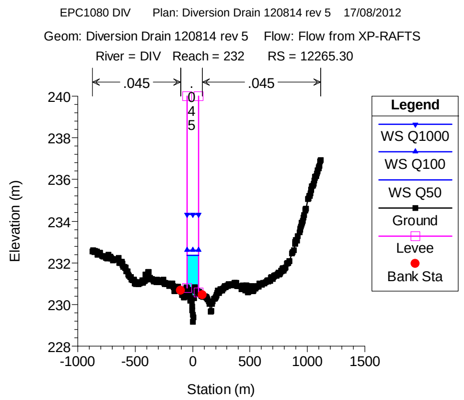

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13585.76
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

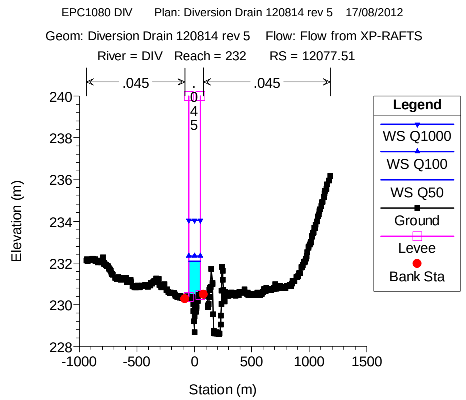

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13353.13
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

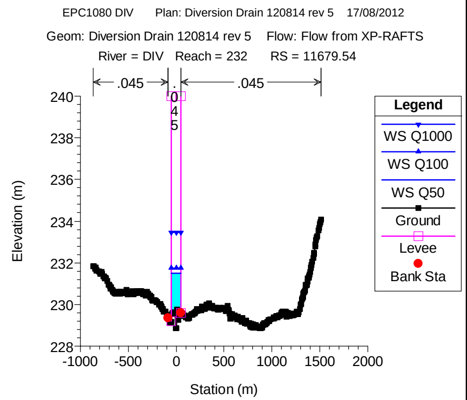

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 13068.94
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

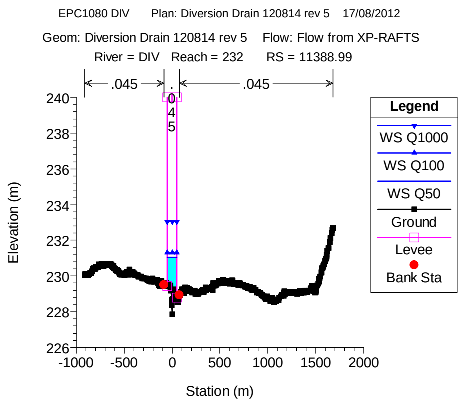

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 12680.44
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

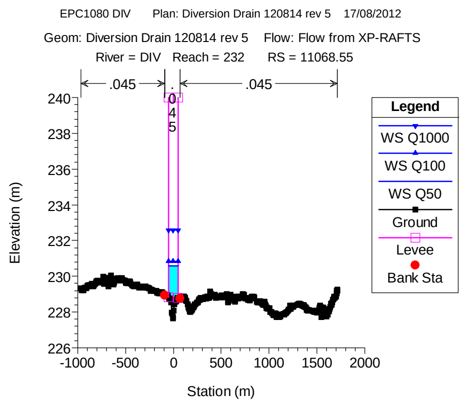

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 12447.06
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

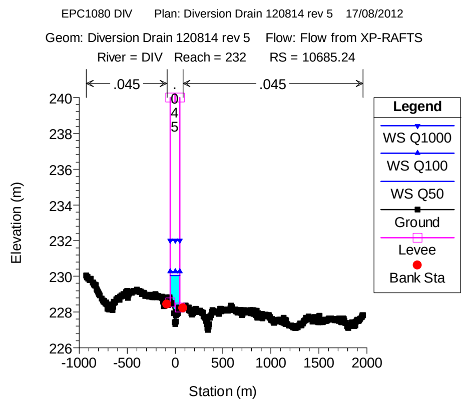

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 12265.30
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

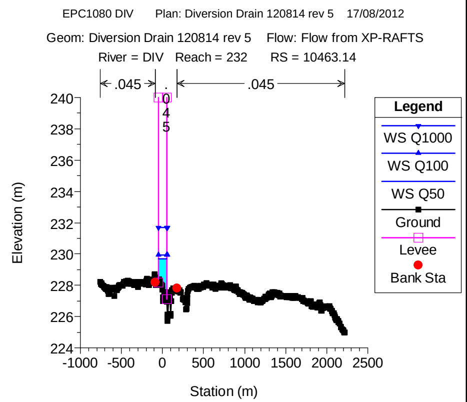

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 12077.51
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

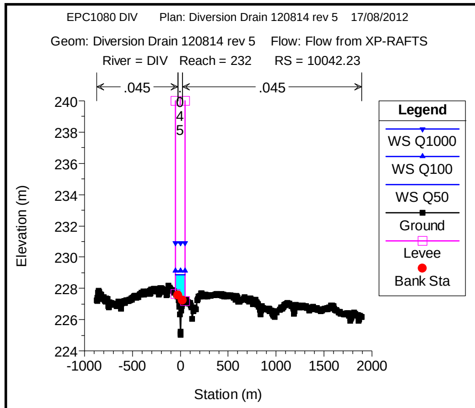

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 11679.54
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

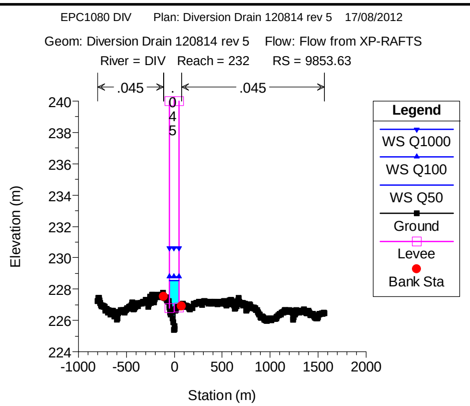

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 11388.99
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

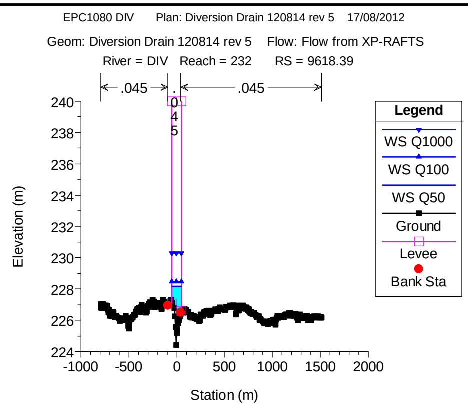

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 11068.55
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

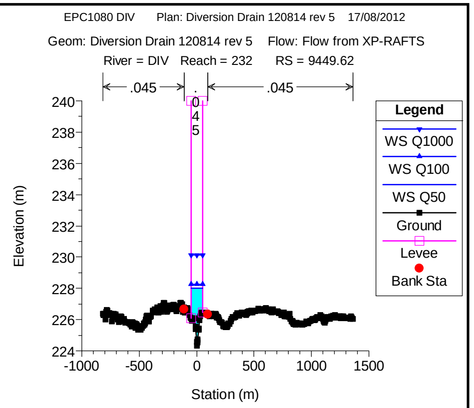

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 10685.24
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

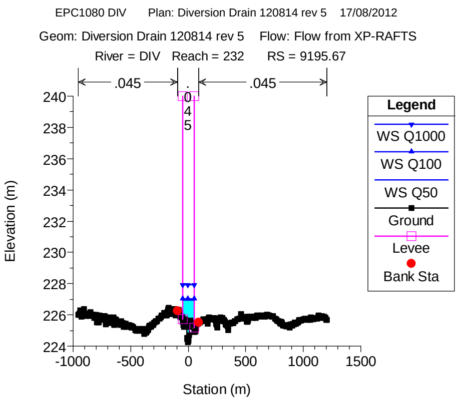

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 10463.14
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

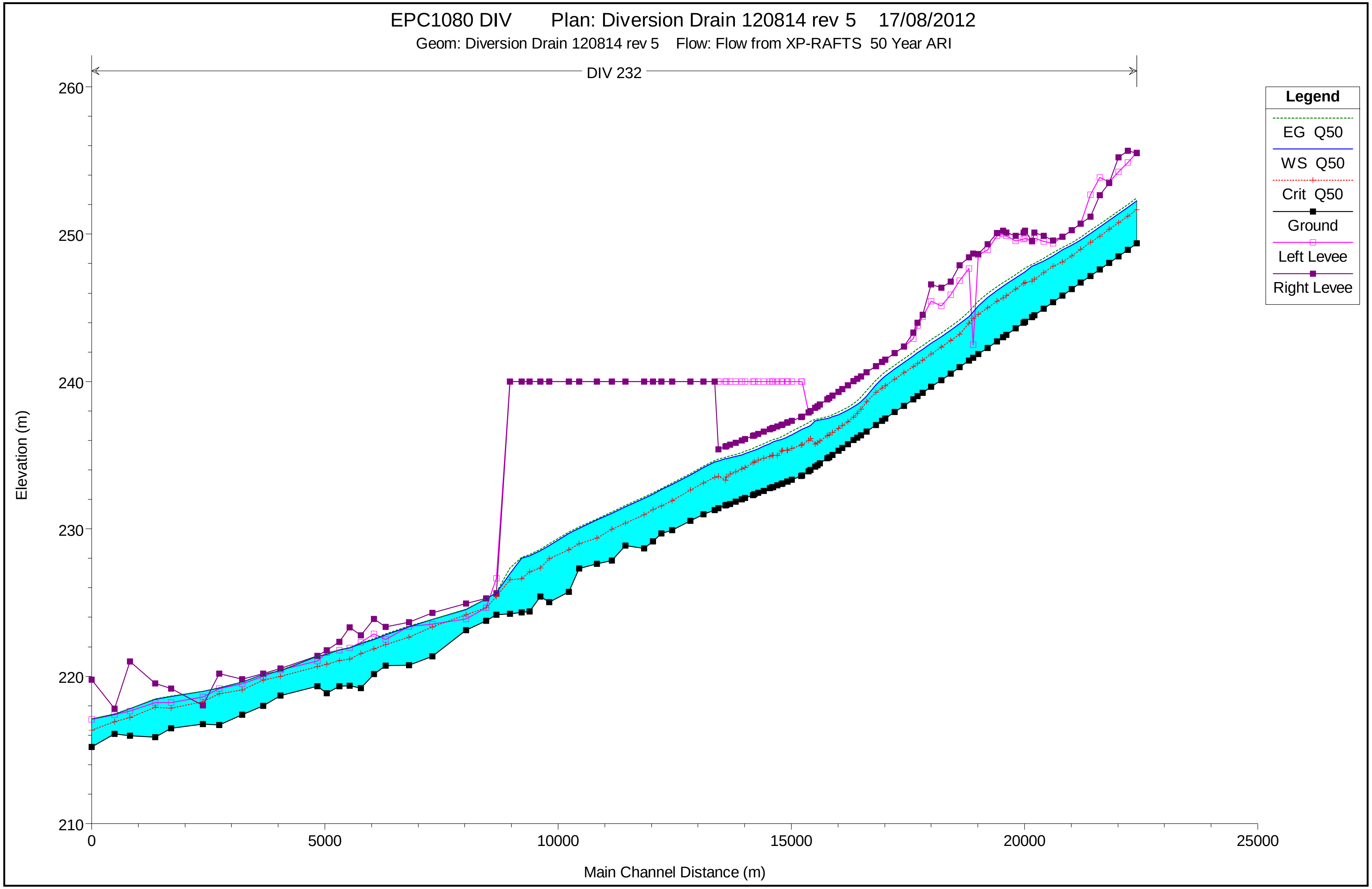

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 10042.23
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

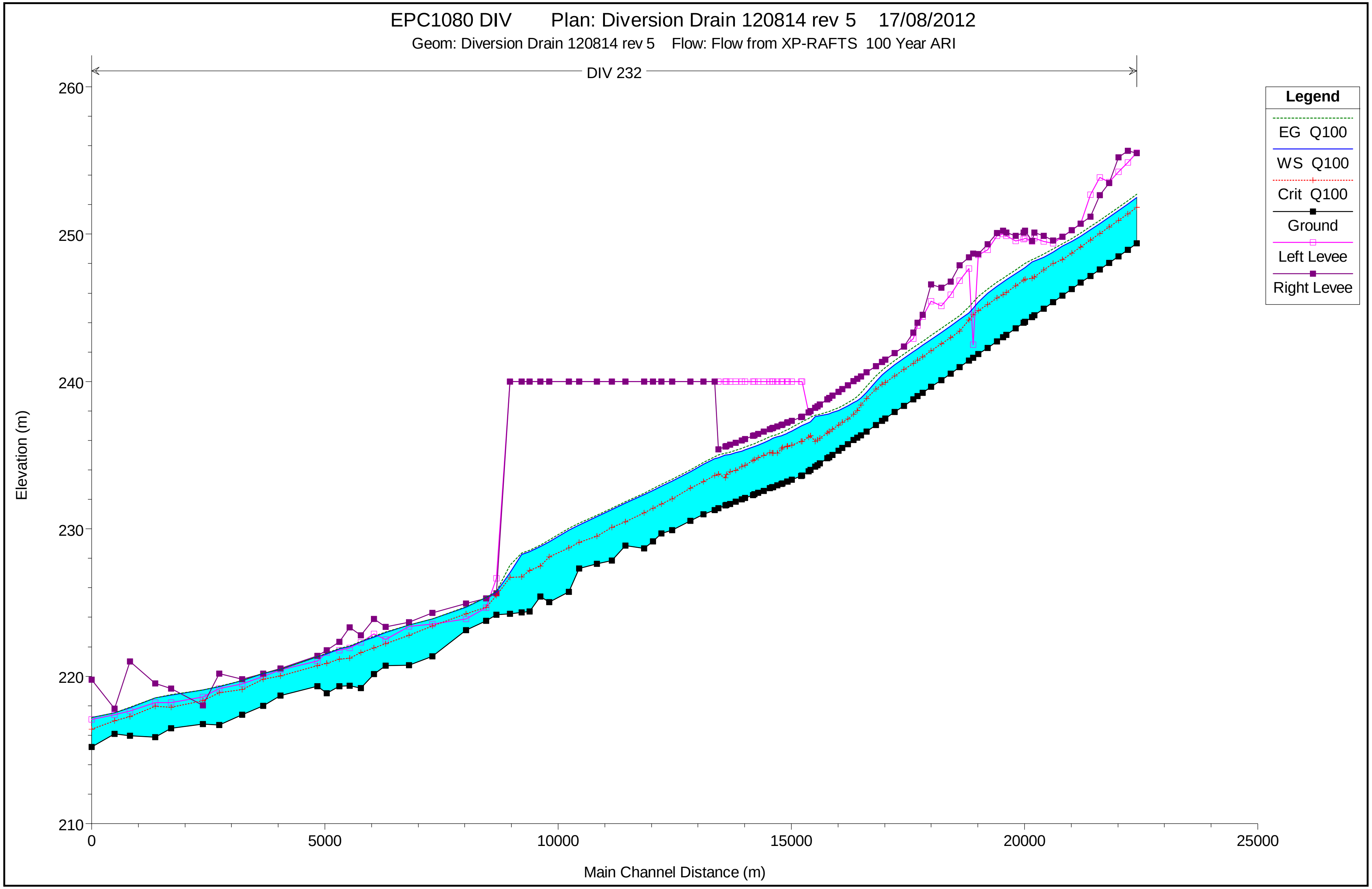

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 9853.63
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta

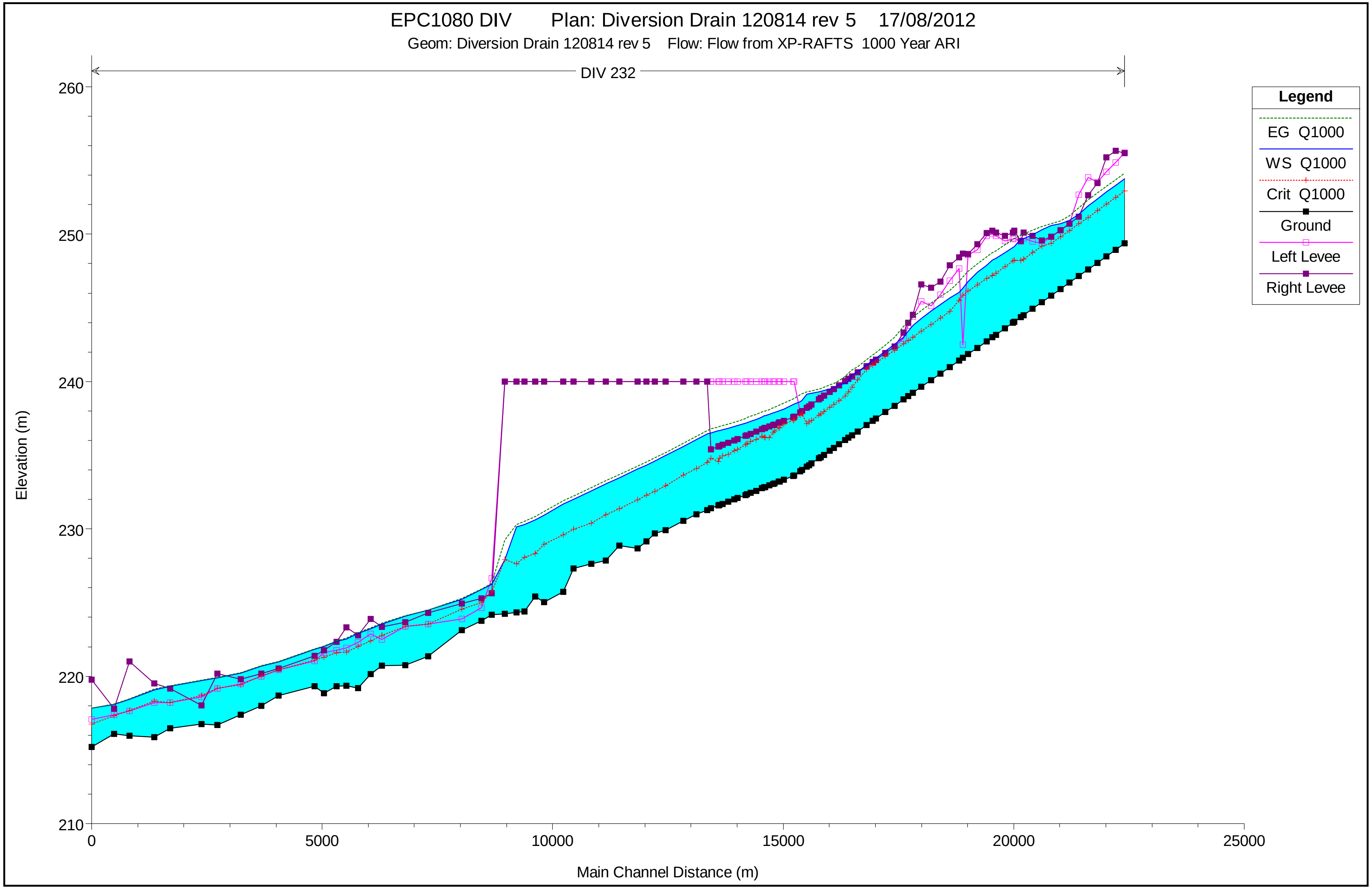

EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 9618.39
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 9449.62
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS
River = DIV Reach = 232 RS = 9195.67
.045
.045
Elevation (m)
Station (m)
Legend
WS Q1000
WS Q100
WS Q50
Ground
Levee
Bank Sta


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS 50 Year ARI
DIV 232
Legend
EG Q50
WS Q50
Crit Q50
Ground
Left Levee
Right Levee
Elevation (m)
260
250
240
230
220
210
0
5000
10000
15000
20000
25000
Main Channel Distance (m)


EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS 100 Year ARI
DIV 232
Legend
EG Q100
WS Q100
Crit Q100
Ground
Left Levee
Right Levee
Elevation (m)
260
250
240
230
220
210
0
5000
10000
15000
20000
25000
Main Channel Distance (m)



EPC1080 DIV Plan: Diversion Drain 120814 rev 5 17/08/2012
Geom: Diversion Drain 120814 rev 5 Flow: Flow from XP-RAFTS 1000 Year ARI
DIV 232
Legend
EG Q1000
WS Q1000
Crit Q1000
Ground
Left Levee
Right Levee
Elevation (m)
Main Channel Distance (m)
210
220
230
240
250
260
0
5000
10000
15000
20000
25000

HEC-RAS Plan: 120814 rev 5 River: DIV Reach: 232

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	L. Levee Frbrd	R. Levee Frbrd	Power Total	Shear Total
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)		(m)	(m)	(m)	(N/m s)	(N/m2)
232	22641	Q50	93.00	249.37	252.26	251.65	252.46	0.002252	1.98	46.86	32.77	0.53	2.89	3.27	3.24	-2393.89	31.04
232	22641	Q100	114.00	249.37	252.48	251.83	252.71	0.002252	2.10	54.36	34.99	0.54	3.11	3.05	3.02	-2393.89	33.72
232	22641	Q1000	297.00	249.37	253.74	252.92	254.14	0.002252	2.80	106.43	47.65	0.58	4.37	1.79	1.76	-2393.89	48.45
232	22444	Q50	93.00	248.94	251.82	251.21	252.02	0.002240	1.98	46.96	32.81	0.53	2.88	3.05	3.85	-2393.89	30.89
232	22444	Q100	114.00	248.94	252.04	251.38	252.26	0.002237	2.09	54.49	35.03	0.54	3.10	2.82	3.63	-2393.89	33.53
232	22444	Q1000	297.00	248.94	253.30	252.47	253.70	0.002240	2.80	106.60	47.63	0.58	4.36	1.56	2.37	-2393.89	48.28
232	22244	Q50	93.00	248.49	251.38	250.76	251.58	0.002211	1.97	47.17	32.87	0.53	2.89	2.84	3.85	-2393.89	30.58
232	22244	Q100	114.00	248.49	251.60	250.93	251.82	0.002211	2.08	54.72	35.09	0.53	3.11	2.62	3.63	-2393.89	33.22
232	22244	Q1000	297.00	248.49	252.86	252.03	253.25	0.002234	2.80	106.68	47.65	0.58	4.37	1.36	2.37	-2393.89	48.18
232	22044	Q50	93.00	248.05	250.93	250.32	251.13	0.002220	1.97	47.09	32.83	0.53	2.88	2.61	2.53	-2393.89	30.70
232	22044	Q100	114.00	248.05	251.16	250.49	251.38	0.002216	2.09	54.66	35.06	0.53	3.11	2.39	2.31	-2393.89	33.30
232	22044	Q1000	297.00	248.05	252.40	251.59	252.80	0.002294	2.82	105.78	47.45	0.58	4.35	1.15	1.07	-2393.89	49.26
232	21844	Q50	93.00	247.60	250.50	249.87	250.69	0.002149	1.95	47.65	33.00	0.52	2.90	3.36	2.13	-2393.89	29.92
232	21844	Q100	114.00	247.60	250.72	250.04	250.94	0.002149	2.06	55.28	35.24	0.53	3.12	3.14	1.91	-2393.89	32.49
232	21844	Q1000	297.00	247.60	251.91	251.14	252.33	0.002397	2.86	104.32	47.13	0.59	4.31	1.95	0.71	-2393.89	51.10
232	21644	Q50	93.00	247.16	250.06	249.44	250.26	0.002228	1.98	47.06	32.87	0.53	2.90	2.61	1.13	-2393.89	30.76
232	21644	Q100	114.00	247.16	250.28	249.61	250.50	0.002205	2.08	54.80	35.15	0.53	3.12	2.39	0.90	-2393.89	33.13
232	21644	Q1000	297.00	247.16	251.35	250.72	251.80	0.002872	3.00	103.29	71.40	0.64	4.19	1.32	-0.16	-2393.89	40.14
232	21437	Q50	93.00	246.70	249.62	248.96	249.81	0.002085	1.93	48.18	33.16	0.51	2.92	1.08	1.08	-2393.89	29.20
232	21437	Q100	114.00	246.70	249.85	249.14	250.06	0.002045	2.03	56.29	35.52	0.51	3.15	0.84	0.84	-2393.89	31.23
232	21437	Q1000	297.00	246.70	250.94	250.24	251.25	0.002090	2.61	133.34	100.00	0.55	4.24	-0.24	-0.24	-2393.89	26.74
232	21244	Q50	93.00	246.27	249.25	248.53	249.42	0.001851	1.85	50.32	33.80	0.48	2.98	1.02	1.02	-2393.89	26.56
232	21244	Q100	114.00	246.27	249.50	248.71	249.69	0.001801	1.93	58.96	36.26	0.48	3.23	0.77	0.77	-2393.89	28.22
232	21244	Q1000	297.00	246.27	250.71	249.81	250.91	0.001275	2.16	163.28	100.00	0.44	4.44	-0.44	-0.44	-2393.89	19.81
232	21044	Q50	93.00	245.83	248.94	248.10	249.09	0.001462	1.70	54.84	35.11	0.43	3.11	0.88	0.88	-2393.89	22.00
232	21044	Q100	114.00	245.83	249.20	248.27	249.36	0.001430	1.78	64.16	37.67	0.43	3.37	0.63	0.63	-2393.89	23.47
232	21044	Q1000	297.00	245.83	250.58	249.36	250.71	0.000684	1.71	203.71	100.00	0.33	4.75	-0.76	-0.76	-2393.89	13.13
232	20844	Q50	113.00	245.38	248.53	247.82	248.74	0.002025	2.01	56.14	35.49	0.51	3.15	0.85	1.05	-2393.89	30.87
232	20844	Q100	138.00	245.38	248.79	248.00	249.01	0.001966	2.10	65.68	38.08	0.51	3.41	0.59	0.79	-2393.89	32.67
232	20844	Q1000	360.00	245.38	250.30	249.20	250.52	0.001080	2.24	190.23	100.00	0.41	4.92	-0.92	-0.72	-2393.89	19.57
232	20644	Q50	113.00	244.94	248.16	247.38	248.35	0.001784	1.92	58.80	36.22	0.48	3.22	1.35	1.73	-2393.89	27.90
232	20644	Q100	138.00	244.94	248.44	247.56	248.64	0.001706	1.99	69.18	38.98	0.48	3.50	1.07	1.45	-2393.89	29.18
232	20644	Q1000	360.00	244.94	249.94	248.76	250.27	0.001376	2.57	155.00	100.00	0.47	5.00	-0.43	-0.05	-2393.89	20.58
232	20444	Q50	113.00	244.49	247.87	246.92	248.03	0.001367	1.74	64.81	37.85	0.43	3.38	1.85	2.23	-2393.89	22.56
232	20444	Q100	138.00	244.49	248.17	247.11	248.33	0.001309	1.81	76.26	40.76	0.42	3.68	1.56	1.93	-2393.89	23.59
232	20444	Q1000	360.00	244.49	249.71	248.31	250.01	0.001161	2.47	150.86	56.14	0.44	5.22	0.02	0.39	-2393.89	30.03
232	20390	Q50	113.00	244.37	247.81	246.80	247.96	0.001253	1.69	66.91	38.40	0.41	3.44	1.69	1.72	-2393.89	21.04
232	20390	Q100	138.00	244.37	248.10	246.99	248.26	0.001203	1.75	78.66	41.34	0.41	3.73	1.40	1.42	-2393.89	22.05
232	20390	Q1000	360.00	244.37	249.66	248.19	249.94	0.001064	2.40	163.71	100.00	0.42	5.29	-0.16	-0.13	-2393.89	16.83
232	20244	Q50	145.00	244.05	247.45	246.73	247.70	0.002201	2.22	65.35	37.99	0.54	3.40	2.27	2.78	-2393.89	36.48
232	20244	Q100	179.00	244.05	247.73	246.94	248.01	0.002191	2.34	76.40	40.79	0.55	3.68	1.99	2.50	-2393.89	39.53
232	20244	Q1000	461.00	244.05	249.16	248.25	249.70	0.002143	3.28	144.82	55.08	0.59	5.11	0.56	1.07	-2393.89	54.27
232	20212	Q50	145.00	243.98	247.38	246.66	247.63	0.002203	2.22	65.33	37.98	0.54	3.40	2.29	2.72	-2393.89	36.50
232	20212	Q100	179.00	243.98	247.66	246.88	247.94	0.002191	2.34	76.40	40.79	0.55	3.68	2.01	2.44	-2393.89	39.54
232	20212	Q1000	461.00	243.98	249.09	248.18	249.63	0.002140	3.28	144.89	55.08	0.59	5.11	0.58	1.01	-2393.89	54.22
232	20044	Q50	145.00	243.60	247.02	246.27	247.26	0.002132	2.19	66.11	38.19	0.53	3.42	2.52	2.86	-2393.89	35.57
232	20044	Q100	179.00	243.60	247.30	246.50	247.58	0.002119	2.31	77.34	41.02	0.54	3.70	2.24	2.57	-2393.89	38.50
232	20044	Q1000	461.00	243.60	248.75	247.80	249.27	0.002053	3.23	146.98	55.44	0.58	5.15	0.79	1.13	-2393.89	52.41
232	19844	Q50	145.00	243.16	246.61	245.83	246.85	0.002033	2.16	67.28	38.49	0.52	3.45	3.28	3.51	-2393.89	34.23
232	19844	Q100	179.00	243.16	246.90	246.06	247.16	0.002019	2.27	78.73	41.36	0.53	3.74	2.99	3.22	-2393.89	37.03
232	19844	Q1000	461.00	243.16	248.36	247.36	248.87	0.001930	3.17	150.14	56.05	0.56	5.20	1.53	1.76	-2393.89	49.80
232	19773	Q50	145.00	243.00	246.47	245.67	246.70	0.001968	2.13	68.08	38.70	0.51	3.47	3.53	3.76	-2393.89	33.36
232	19773	Q100	179.00	243.00	246.76	245.90	247.02	0.001957	2.25	79.64	41.58	0.52	3.76	3.24	3.47	-2393.89	36.11
232	19773	Q1000	461.00	243.00	248.24	247.20	248.73	0.001864	3.14	151.96	56.35	0.55	5.23	1.77	1.99	-2393.89	48.40
232	19644	Q50	152.00	242.72	246.17	245.44	246.43	0.002236	2.26	67.25	38.48	0.55	3.45	3.71	3.90	-2393.89	37.65
232	19644	Q100	188.00	242.72	246.45	245.68	246.74	0.002247	2.40	78.47	41.30	0.55	3.73	3.43	3.62	-2393.89	41.14
232	19644	Q1000	486.00	242.72	247.88	247.00	248.46	0.002255	3.40	147.56	55.56	0.61	5.16	2.00	2.19	-2393.89	57.68
232	19444	Q50	152.00	242.28	245.71	245.00	245.97	0.002319	2.29	66.36	38.25	0.56	3.43	3.24	3.62	-2393.89	38.76
232	19444	Q100	188.00	242.28	245.98	245.24	246.28	0.002343	2.43	77.28	41.01	0.57	3.70	2.97	3.34	-2393.89	42.53
232	19444	Q1000	486.00	242.28	247.40	246.56	247.99	0.002351	3.44	145.47	55.18	0.62	5.12	1.55	1.92	-2393.89	59.69
232	19244	Q50	152.00	241.85	245.13	244.57	245.45	0.002907	2.49	61.09	36.85	0.62	3.28	3.46	3.52	-2393.89	46.44
232	19244	Q100	188.00	241.85	245.40	244.80	245.75	0.002930	2.64	71.19	39.49	0.63	3.55	3.20	3.26	-2393.89	50.88
232	19244	Q1000	486.00	241.85	246.78	246.14	247.46	0.002907	3.68	135.32	53.33	0.68	4.93	1.82	1.87	-2393.89	71.04
232	19133	Q50	152.00	241.61	244.71	244.29	245.08	0.003713	2.72	55.95	35.50	0.69	3.10	-2.19	3.98	-2393.89	56.33
232	19133	Q100	188.00	241.61	244.96	244.52	245.38	0.003710	2.88	65.37	38.07	0.70	3.35	-2.45	3.72	-2393.89	61.33
232	19133	Q1000	486.00	241.61	246.34	245.85	247.10	0.003540	3.88	127.15	51.82	0.74	4.73	-3.82	2.35	-2393.89	83.59
232	19044	Q50	155.00	241.41	244.39	243.95	244.76	0.003509	2.67	58.10	36.40	0.67	2.98	3.27	4.05	-2393.89	54.04
232	19044	Q100	191.00	241.41	244.66	244.17	245.06	0.003458	2.81	68.02	39.03	0.68	3.25	3.01	3.78	-2393.89	58.14
232	19044	Q1000	494.00	241.41	246.06	245.52	246.78	0.003302	3.77	132.74	53.08	0.72	4.65	1.60	2.38	-2393.89	79.60
232	18844	Q50	155.00	240.98	243.92	243.21	244.18	0.002197	2.22	69.67	40.43	0.54	2.94	2.91	3.95	-2393.89	36.61
232	18844	Q100	191.00	240.98	244.20	243.43	244.48	0.002196	2.36	81.09	43.16	0.55	3.22	2.63	3.68	-2393.89	39.87
232	18844	Q1000	494.00	240.98	245.66	244.76	246.19	0.002201	3.22	155.28	57.86	0.59	4.68	1.16	2.21	-2393.89	57.01
232	18644	Q50	155.00	240.54	243.48	242.77	243.74	0.002191	2.22	69.75	40.45	0.54	2.94	2.40	3.28	-2393.89	36.52
232	18644	Q100	191.00	240.54	243.76	242.99	244.04	0.002189	2.35	81.19	43.18	0.55	3.22	2.12	3.00	-2393.89	39.77
232	18644	Q1000	494.00	240.54	245.22	244.31	245.75	0.002204	3.22	155.20	57.85	0.59	4.68	0.66	1.54	-2393.89	57.08
232	18444	Q50	155.00	240.10	243.05	242.33	243.30	0.002171	2.21	69.98	40.51	0.54	2.95	2.09	3.32	-2393.89	36.25
232	18444	Q100	191.00	240.10	243.32	242.55	243.60	0.002171	2.35	81.44	43.24	0.55	3.22	1.81	3.04	-2393.89	39.51
232	18444	Q1000	494.00	240.10	244.78	243.87	245.31	0.002219	3.23	154.85	57.76	0.60	4.68	0.36	1.59	-2393.89	57.42
232	18232	Q50	155.00	239.64	242.59	241.87	242.84	0.002177	2.22	69.91	40.49	0.54	2.95	2.84	4.00	-2393.89	36.33
232	18232	Q100	191.00	239.64	242.86	242.08	243.14	0.002175	2.35	81.37	43.22	0.55	3.22	2.57	3.73	-2393.89	39.58
232	18232	Q1000	494.00	239.64	244.28	243.41	244.82	0.002316	3.27	152.71	57.40	0.61	4.64	1.15	2.31	-2393.89	59.47
232	18044	Q50	155.00	239.23	242.18	241.46	242.43	0.002164	2.21	70.06	40.52	0.54	2.95	2.21	2.35	-2393.89	36.17
232	18044	Q100	191.00	239.23	242.46	241.68	242.74	0.002165	2.34	81.52	43.26	0.54	3.23	1.93	2.07	-2393.89	39.42
232	18044	Q1000	494.00	239.23	243.79	243.00	244.36	0.002549	3.37	148.02	56.59	0.63	4.56	0.60	0.74	-2393.89	64.36
232	17941	Q50	155.00	239.01	241.95	241.23	242.21	0.002226	2.24	69.22	40.16	0.54	2.94	1.84	2.04	-2393.89	37.09
232	17941	Q100	191.00	239.01	242.22	241.45	242.51	0.002231	2.37	80.55	42.95	0.55	3.21	1.57	1.77	-2393.89	40.44
232	17941	Q1000	494.00	239.01	243.43	242.79	244.07	0.003039	3.55	139.91	55.24	0.69	4.42	0.36	0.56	-2393.89	74.31
232	17844	Q50	155.00	238.79	241.74	241.02	241.99	0.002168	2.21	70.01	40.51	0.54	2.95	1.15	1.57	-2393.89	36.23
232	17844	Q100	191.00	238.79	242.01	241.24	242.29	0.002172	2.35	81.41	43.24	0.55	3.22	0.88	1.30	-2393.89	39.53
232	17844	Q1000	494.00	238.79	243.01	242.56	243.74	0.003805	3.78	135.32	78.11	0.76	4.22	-0.12	0.30	-2393.89	63.66
232	17644	Q50	155.00	238.36	241.30	240.59	241.55	0.002207	2.23	69.63	40.50	0.54	2.94	1.06	1.06	-2393.89	36.68
232	17644	Q100	191.00	238.36	241.57	240.81	241.86	0.002211	2.36	80.99	43.24	0.55	3.21	0.79	0.79	-2393.89	40.01
232	17644	Q1000	494.00	238.36	242.53	242.13	243.00	0.002858	3.24	174.60	100.00	0.66	4.17	-0.17	-0.17	-2393.89	47.35
232	17444	Q50	155.00	237.92	240.86	240.15	241.11	0.002219	2.23	69.42	40.37	0.54	2.94	1.07	1.07	-2393.89	36.90
232	17444	Q100	191.00	237.92	241.12	240.37	241.41	0.002233	2.37	80.60	43.05	0.55	3.20	0.80	0.80	-2393.89	40.41
232	17444	Q1000	494.00	237.92	242.07	241.69	242.45	0.002430	2.97	190.26	100.00	0.60	4.15	-0.15	-0.15	-2393.89	43.29
232	17244	Q50	155.00	237.49	240.38	239.72	240.65	0.002390	2.29	67.58	39.90	0.56	2.89	1.11	1.11	-2393.89	39.14
232	17244	Q100	191.00	237.49	240.64	239.94	240.94	0.002417	2.44	78.32	42.51	0.57	3.15	0.84	0.84	-2393.89	43.03

HEC-RAS Plan: 120814 rev 5 River: DIV Reach: 232 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	L. Levee Frbrd	R. Levee Frbrd	Power Total	Shear Total
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)		(m)	(m)	(m)	(N/m s)	(N/m2)
232	17244	Q1000	494.00	237.49	241.59	241.27	241.96	0.002406	2.92	192.16	100.00	0.60	4.10	-0.11	-0.11	-2393.89	43.17
232	17172	Q50	155.00	237.33	240.18	239.56	240.47	0.002584	2.36	65.75	39.50	0.58	2.85	1.14	1.14	-2393.89	41.59
232	17172	Q100	191.00	237.33	240.44	239.79	240.76	0.002619	2.51	76.12	42.06	0.60	3.11	0.89	0.89	-2393.89	45.82
232	17172	Q1000	494.00	237.33	241.44	241.11	241.79	0.002280	2.84	196.37	100.00	0.58	4.11	-0.11	-0.11	-2393.89	41.64
232	17044	Q50	155.00	237.05	239.76	239.28	240.09	0.003267	2.57	60.38	38.06	0.65	2.71	1.29	1.29	-2393.89	50.11
232	17044	Q100	191.00	237.05	240.00	239.50	240.38	0.003321	2.74	69.79	40.46	0.67	2.95	1.05	1.05	-2393.89	55.38
232	17044	Q1000	494.00	237.05	241.10	240.82	241.48	0.002553	2.96	189.46	100.00	0.61	4.05	-0.05	-0.05	-2393.89	45.02
232	16844	Q50	155.00	236.61	239.02	238.64	239.38	0.003795	2.67	58.01	38.61	0.70	2.41	1.59	1.59	-2393.89	55.23
232	16844	Q100	191.00	236.61	239.25	238.86	239.66	0.003809	2.84	67.24	40.93	0.71	2.64	1.36	1.36	-2393.89	60.60
232	16844	Q1000	494.00	236.61	240.67	240.14	241.00	0.002081	2.76	201.58	100.00	0.56	4.06	-0.06	-0.06	-2393.89	38.78
232	16726	Q50	155.00	236.36	238.64	238.13	238.95	0.003227	2.47	62.64	41.48	0.64	2.28	1.71	1.71	-2393.89	47.28
232	16726	Q100	191.00	236.36	238.89	238.39	239.23	0.003176	2.62	72.99	43.90	0.65	2.53	1.47	1.47	-2393.89	51.20
232	16726	Q1000	494.00	236.36	240.47	239.63	240.77	0.001709	2.61	211.41	100.00	0.51	4.11	-0.11	-0.11	-2393.89	33.63
232	16644	Q50	155.00	236.18	238.44	237.83	238.70	0.002651	2.28	68.07	44.09	0.58	2.26	1.74	1.74	-2393.89	39.73
232	16644	Q100	191.00	236.18	238.69	238.04	238.99	0.002580	2.40	79.56	46.62	0.59	2.51	1.49	1.49	-2393.89	42.72
232	16644	Q1000	494.00	236.18	240.02	239.29	240.57	0.002893	3.28	150.43	59.92	0.66	3.84	0.16	0.16	-2393.89	70.32
232	16570	Q50	155.00	236.02	238.29	237.57	238.51	0.002110	2.08	74.67	46.85	0.52	2.27	1.72	1.72	-2393.89	32.67
232	16570	Q100	191.00	236.02	238.55	237.77	238.80	0.002052	2.19	87.23	49.46	0.53	2.53	1.46	1.46	-2393.89	35.14
232	16570	Q1000	494.00	236.02	239.87	239.00	240.35	0.002443	3.07	161.05	62.63	0.61	3.85	0.14	0.14	-2393.89	60.86
232	16444	Q50	155.00	235.74	238.07	237.26	238.26	0.001802	1.96	79.24	48.28	0.49	2.33	1.68	1.68	-2393.89	28.72
232	16444	Q100	191.00	235.74	238.34	237.46	238.55	0.001749	2.06	92.64	51.00	0.49	2.60	1.41	1.41	-2393.89	30.85
232	16444	Q1000	494.00	235.74	239.76	238.68	240.06	0.001528	2.51	216.34	100.00	0.49	4.02	-0.02	-0.02	-2393.89	30.68
232	16327	Q50	155.00	235.49	237.87	237.02	238.06	0.001653	1.90	81.67	48.82	0.47	2.38	1.61	1.61	-2393.89	26.86
232	16327	Q100	191.00	235.49	238.15	237.22	238.35	0.001600	2.00	95.61	51.60	0.47	2.66	1.34	1.34	-2393.89	28.77
232	16327	Q1000	494.00	235.49	239.59	238.43	239.88	0.001456	2.49	217.11	100.00	0.48	4.10	-0.10	-0.10	-2393.89	29.69
232	16244	Q50	155.00	235.31	237.75	236.83	237.92	0.001478	1.83	84.93	49.49	0.44	2.44	1.55	1.55	-2393.89	24.63
232	16244	Q100	191.00	235.31	238.04	237.03	238.22	0.001438	1.92	99.29	52.34	0.45	2.73	1.27	1.27	-2393.89	26.47
232	16244	Q1000	494.00	235.31	239.50	238.25	239.76	0.001261	2.37	228.53	100.00	0.45	4.19	-0.19	-0.19	-2393.89	26.90
232	16117	Q50	155.00	235.03	237.60	236.55	237.75	0.001201	1.70	91.27	50.70	0.40	2.57	1.43	1.43	-2393.89	20.99
232	16117	Q100	191.00	235.03	237.89	236.75	238.05	0.001186	1.80	106.18	53.56	0.41	2.86	1.14	1.14	-2393.89	22.81
232	16117	Q1000	494.00	235.03	239.38	237.97	239.61	0.001007	2.20	247.01	100.00	0.40	4.35	-0.35	-0.35	-2393.89	23.05
232	16044	Q50	155.00	234.87	237.53	236.39	237.66	0.001048	1.62	95.75	51.58	0.38	2.66	1.34	1.34	-2393.89	18.88
232	16044	Q100	191.00	234.87	237.81	236.59	237.97	0.001047	1.72	110.97	54.45	0.38	2.94	1.06	1.06	-2393.89	20.70
232	16044	Q1000	494.00	234.87	239.33	237.81	239.53	0.000883	2.10	257.94	100.00	0.38	4.46	-0.46	-0.46	-2393.89	21.05
232	16005	Q50	155.00	234.78	237.49	236.30	237.62	0.000962	1.57	98.66	52.14	0.36	2.71	1.29	1.29	-2393.89	17.67
232	16005	Q100	191.00	234.78	237.78	236.50	237.92	0.000969	1.67	114.04	55.01	0.37	3.00	1.00	1.00	-2393.89	19.48
232	16005	Q1000	494.00	234.78	239.30	237.72	239.49	0.000820	2.05	264.21	100.00	0.37	4.52	-0.51	-0.51	-2393.89	19.98
232	15844	Q50	155.00	234.43	237.38	235.95	237.48	0.000683	1.39	111.39	54.56	0.31	2.95	1.05	1.05	-2393.89	13.52
232	15844	Q100	191.00	234.43	237.67	236.15	237.78	0.000711	1.50	127.33	57.43	0.32	3.24	0.77	0.77	-2393.89	15.29
232	15844	Q1000	494.00	234.43	239.20	237.37	239.37	0.000643	1.91	283.13	100.00	0.33	4.77	-0.77	-0.77	-2393.89	16.94
232	15791	Q50	155.00	234.32	237.35	235.84	237.45	0.000610	1.34	115.89	55.34	0.30	3.03	0.96	0.96	-2393.89	12.38
232	15791	Q100	191.00	234.32	237.64	236.04	237.74	0.000642	1.45	131.97	58.17	0.31	3.32	0.68	0.68	-2393.89	14.12
232	15791	Q1000	494.00	234.32	239.17	237.26	239.34	0.000596	1.87	289.58	100.00	0.32	4.85	-0.85	-0.85	-2393.89	16.05
232	15741	Q50	155.00	234.21	237.33	235.73	237.41	0.000544	1.28	120.69	56.20	0.28	3.12	0.88	0.88	-2393.89	11.32
232	15741	Q100	191.00	234.21	237.61	235.93	237.71	0.000579	1.39	136.93	59.02	0.29	3.40	0.60	0.60	-2393.89	13.02
232	15741	Q1000	494.00	234.21	239.15	237.15	239.30	0.000536	1.81	300.25	100.00	0.30	4.94	-0.95	-0.95	-2393.89	14.92
232	15644	Q50	265.00	234.00	237.02	236.12	237.29	0.001806	2.30	115.34	55.24	0.51	3.02	0.97	0.97	-2393.89	36.58
232	15644	Q100	320.00	234.00	237.27	236.33	237.58	0.001915	2.48	129.15	57.69	0.53	3.27	0.73	0.73	-2393.89	41.58
232	15644	Q1000	808.00	234.00	238.72	237.81	239.17	0.001742	3.12	284.28	100.00	0.54	4.72	-0.73	-0.73	-2393.89	45.58
232	15600	Q50	265.00	233.90	236.95	236.01	237.21	0.001747	2.27	116.71	55.49	0.50	3.05	0.95	0.95	-2393.89	35.64
232	15600	Q100	320.00	233.90	237.19	236.23	237.50	0.001870	2.46	130.24	57.88	0.52	3.29	0.71	0.71	-2393.89	40.81
232	15600	Q1000	808.00	233.90	238.63	237.70	239.09	0.001777	3.16	280.93	100.00	0.55	4.73	-0.73	-0.73	-2393.89	46.29
232	15465	Q50	265.00	233.61	236.76	235.72	236.98	0.001465	2.09	131.21	78.77	0.46	3.15	3.24	0.84	-7860.59	23.74
232	15465	Q100	320.00	233.61	237.01	235.95	237.25	0.001472	2.23	150.62	79.99	0.47	3.40	2.99	0.60	-7860.59	26.87
232	15465	Q1000	808.00	233.61	238.47	237.38	238.86	0.001400	2.94	302.95	100.00	0.49	4.86	1.53	-0.86	-7860.59	39.43
232	15444	Q50	265.00	233.58	236.73	235.69	236.95	0.001501	2.11	129.38	78.74	0.46	3.15	3.27	0.85	-7806.49	24.01
232	15444	Q100	320.00	233.58	236.97	235.92	237.22	0.001511	2.25	148.70	79.95	0.47	3.39	3.03	0.61	-7806.49	27.26
232	15444	Q1000	808.00	233.58	238.43	237.37	238.83	0.001430	2.96	300.42	100.00	0.50	4.85	1.57	-0.85	-7806.49	40.01
232	15244	Q50	265.00	233.33	236.38	235.45	236.63	0.001739	2.22	122.90	78.24	0.50	3.05	3.62	0.96	-10025.15	26.57
232	15244	Q100	320.00	233.33	236.62	235.67	236.90	0.001734	2.35	141.91	79.45	0.50	3.29	3.38	0.71	-10025.15	30.02
232	15244	Q1000	808.00	233.33	238.12	237.11	238.54	0.001499	3.01	296.23	100.00	0.51	4.79	1.88	-0.79	-10025.15	41.35
232	15156	Q50	265.00	233.22	236.25	235.33	236.47	0.001585	2.13	131.08	78.14	0.47	3.03	3.75	0.98	-11909.14	25.73
232	15156	Q100	320.00	233.22	236.49	235.62	236.74	0.001561	2.25	150.45	79.37	0.48	3.27	3.51	0.73	-11909.14	28.55
232	15156	Q1000	808.00	233.22	238.02	236.87	238.40	0.001368	2.89	306.59	100.00	0.48	4.80	1.98	-0.79	-11909.14	38.90
232	15139	Q50	265.00	233.20	236.22	235.35	236.44	0.001589	2.14	130.61	78.10	0.48	3.02	3.78	0.98	-11081.81	25.73
232	15139	Q100	320.00	233.20	236.47	235.58	236.71	0.001566	2.26	149.99	79.33	0.48	3.27	3.53	0.74	-11081.81	28.58
232	15139	Q1000	808.00	233.20	237.99	236.85	238.38	0.001367	2.89	306.46	100.00	0.48	4.79	2.01	-0.79	-11081.81	38.88
232	15044	Q50	265.00	233.09	236.09	235.33	236.30	0.001460	2.05	137.35	78.02	0.46	3.00	3.91	0.99	-12090.13	24.78
232	15044	Q100	320.00	233.09	236.34	235.52	236.57	0.001432	2.16	157.01	79.27	0.46	3.25	3.66	0.74	-12090.13	27.26
232	15044	Q1000	808.00	233.09	237.89	236.62	238.25	0.001276	2.80	314.50	100.00	0.47	4.80	2.11	-0.80	-12090.13	37.13
232	15018	Q50	265.00	233.05	236.07	235.27	236.25	0.001336	1.98	142.18	78.08	0.44	3.02	3.93	0.99	-11751.14	23.41
232	15018	Q100	320.00	233.05	236.32	235.44	236.52	0.001320	2.09	161.90	79.33	0.44	3.27	3.68	0.74	-11751.14	25.83
232	15018	Q1000	808.00	233.05	237.86	236.52	238.21	0.001215	2.75	319.55	100.00	0.46	4.81	2.14	-0.81	-11751.14	35.90
232	14929	Q50	265.00	232.94	236.00	234.97	236.14	0.000931	1.73	160.80	78.29	0.37	3.06	4.00	0.95	-7819.42	18.35
232	14929	Q100	320.00	232.94	236.25	235.13	236.41	0.000954	1.86	180.51	79.54	0.38	3.31	3.75	0.70	-7819.42	20.71
232	14929	Q1000	808.00	232.94	237.79	236.20	238.10	0.001017	2.59	337.34	100.00	0.42	4.85	2.21	-0.85	-7819.42	31.69
232	14845	Q50	265.00	232.84	235.90	234.97	236.06	0.001064	1.81	154.02	78.31	0.39	3.06	4.10	0.94	-7973.10	20.10
232	14845	Q100	320.00	232.84	236.15	235.13	236.33	0.001078	1.94	173.60	79.55	0.40	3.31	3.85	0.69	-7973.10	22.52
232	14845	Q1000	808.00	232.84	237.69	236.20	238.01	0.001077	2.63	332.34	100.00	0.43	4.85	2.31	-0.85	-7973.10	32.98
232	14824	Q50	265.00	232.82	235.87	234.97	236.04	0.001111	1.85	151.49	78.27	0.40	3.05	4.13	0.94	-7981.24	20.68
232	14824	Q100	320.00	232.82	236.12	235.13	236.31	0.001122	1.97	171.04	79.51	0.41	3.30	3.88	0.69	-7981.24	23.14
232	14824	Q1000	808.00	232.82	237.67	236.21	237.99	0.001094	2.65	330.94	100.00	0.44	4.85	2.33	-0.85	-7981.24	33.32
232	14772	Q50	265.00	232.75	235.77	234.92	235.97	0.001393	2.02	138.90	78.10	0.45	3.02	4.23	0.98	-13810.37	23.93
232	14772	Q100	320.00	232.75	236.02	235.16	236.24	0.001380	2.14	158.40	79.34	0.45	3.27	3.98	0.73	-13810.37	26.53
232	14772	Q1000	808.00	232.75	237.58	236.29	237.93	0.001218	2.76	319.36	100.00	0.46	4.83	2.42	-0.83	-13810.37	35.88
232	14645	Q50	265.00	232.59	235.60	234.81	235.79	0.001342	1.98	141.77	78.07	0.44	3.01	4.40	0.99	-13262.18	23.49
232	14645	Q100	320.00	232.59	235.85	234.99	236.06	0.001326	2.10	161.45	79.32	0.44	3.26	4.15	0.74	-13262.18	25.93
232	14645	Q1000	808.00	232.59	237.44	236.07	237.77	0.001160	2.71	325.24	100.00	0.45	4.85	2.56	-0.84	-13262.18	34.63
232	14525	Q50	270.00	232.45	235.43	234.66	235.63	0.001405	2.02	141.61	77.86	0.45	2.98	4.57	1.01	-14144.09	24.59
232	14525	Q100	326.00	232.45	235.69	234.84	235.90	0.001382	2.13	161.42	79.12	0.45	3.24	4.31	0.76	-14144.09	27.05
232	14525	Q1000	821.00	232.45	237.29	235.93	237.63	0.001185	2.74	326.29	99.94	0.45	4.84	2.71	-0.85	-14144.09	35.53
232	14445	Q50	270.00	232.35	235.33	234.53	235.52	0.001329	1.97	144.74	77.90	0.44	2.98	4.67	1.02	-13564.77	23.72
232	14445	Q100	326.00	232.35	235.58	234.70	235.79	0.001311	2.09	164.70	79.17	0.44	3.23	4.42	0.76	-13564.77	26.10
232	14445	Q1000	821.00	232.35	237.21	235.78	237.54	0.001131	2.69	331.42	100.00	0.44	4.86	2.80	-0.86	-13564.77	34.36
232	14411	Q50	270.00	232.30	235.29	234.48	235.47	0.001317	1.97	145.29	77.93	0.43	2.99	4.71	1.02	-13711.75	23.59
232	14411	Q100	326.00	232.30	235.54	234.64	235.75	0.001299	2.08	165.29	79.20	0.44	3.24	4.46	0.76	-13711.75	25.95
232	14411	Q1000	821.00	232.30	237.17	235.72	237.50	0.001120	2.68	332.44	100.00	0.44	4.87	2.83	-0.86	-13711.75	34.10

HEC-RAS Plan: 120814 rev 5 River: DIV Reach: 232 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	L. Levee Frbrd	R. Levee Frbrd	Power Total	Shear Total
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)		(m)	(m)	(m)	(N/m s)	(N/m2)
232	14245	Q50	270.00	232.10	235.10	234.17	235.26	0.001075	1.83	155.26	78.02	0.40	3.00	4.90	0.99	-14900.07	20.54
232	14245	Q100	326.00	232.10	235.36	234.32	235.54	0.001082	1.95	175.32	79.30	0.40	3.26	4.64	0.74	-14900.07	22.90
232	14245	Q1000	821.00	232.10	237.01	235.41	237.31	0.000993	2.58	344.57	100.00	0.42	4.91	2.99	-0.91	-14900.07	31.41
232	14167	Q50	270.00	232.00	235.03	234.05	235.18	0.001038	1.80	157.81	78.13	0.39	3.03	4.97	0.98	-16248.77	20.02
232	14167	Q100	326.00	232.00	235.28	234.22	235.46	0.001050	1.92	177.82	79.40	0.40	3.28	4.72	0.72	-16248.77	22.37
232	14167	Q1000	821.00	232.00	236.94	235.29	237.23	0.000967	2.55	348.55	100.00	0.41	4.94	3.06	-0.93	-16248.77	30.72
232	14045	Q50	270.00	231.85	234.92	233.87	235.06	0.000883	1.69	166.55	78.35	0.36	3.07	5.08	0.93	-8532.32	17.91
232	14045	Q100	326.00	231.85	235.17	233.98	235.33	0.000909	1.81	186.42	79.61	0.37	3.32	4.83	0.68	-8532.32	20.26
232	14045	Q1000	821.00	231.85	236.84	235.06	237.12	0.000881	2.46	358.81	100.00	0.39	4.98	3.17	-0.98	-8532.32	28.82
232	13922	Q50	270.00	231.70	234.81	233.72	234.95	0.000877	1.69	166.85	78.56	0.36	3.11	5.19	0.89	-14506.52	17.77
232	13922	Q100	326.00	231.70	235.06	233.88	235.22	0.000909	1.82	186.46	79.80	0.37	3.36	4.94	0.64	-14506.52	20.20
232	13922	Q1000	821.00	231.70	236.73	234.95	237.01	0.000869	2.45	360.69	100.00	0.39	5.03	3.27	-1.03	-14506.52	28.49
232	13845	Q50	270.00	231.61	234.76	233.54	234.88	0.000777	1.59	174.69	78.75	0.34	3.15	5.24	0.85	-13482.88	16.24
232	13845	Q100	326.00	231.61	235.00	233.70	235.15	0.000817	1.73	194.13	79.97	0.35	3.39	5.00	0.60	-13482.88	18.64
232	13845	Q1000	821.00	231.61	236.67	234.79	236.94	0.000817	2.39	369.24	100.00	0.38	5.06	3.33	-1.07	-13482.88	27.15
232	13823	Q50	270.00	231.58	234.76	233.30	234.86	0.000600	1.41	189.00	78.89	0.30	3.20	5.24	0.82	-14044.02	13.61
232	13823	Q100	326.00	231.58	235.00	233.46	235.13	0.000646	1.55	208.47	80.11	0.31	3.44	5.00	0.58	-14044.02	15.88
232	13823	Q1000	821.00	231.58	236.67	234.58	236.92	0.000715	2.25	384.19	100.00	0.36	5.11	3.33	-1.09	-14044.02	24.79
232	13667	Q50	270.00	231.39	234.60	233.55	234.74	0.000912	1.74	164.01	79.05	0.37	3.21	5.40	0.79	-19599.66	18.10
232	13667	Q100	326.00	231.39	234.83	233.72	235.00	0.000959	1.88	182.60	80.22	0.38	3.44	5.17	0.55	-19599.66	20.84
232	13667	Q1000	821.00	231.39	236.51	234.80	236.79	0.000879	2.48	359.15	100.00	0.40	5.12	3.49	-1.12	-19599.66	28.70
232	13585.76	Q50	270.00	231.26	234.53	233.50	234.63	0.001691	1.39	193.85	100.00	0.32	3.27	5.47	5.47	-40391.14	31.21
232	13585.76	Q100	326.00	231.26	234.77	233.62	234.89	0.001690	1.50	217.51	100.00	0.32	3.51	5.23	5.23	-40391.14	34.83
232	13585.76	Q1000	821.00	231.26	236.45	234.50	236.68	0.001667	2.13	385.05	100.00	0.35	5.19	3.55	3.55	-40391.14	58.89
232	13353.13	Q50	270.00	230.98	234.15	233.10	234.24	0.001665	1.38	195.25	100.00	0.32	3.17	5.85	5.85	-36420.19	30.75
232	13353.13	Q100	326.00	230.98	234.38	233.22	234.49	0.001668	1.49	218.88	100.00	0.32	3.40	5.62	5.62	-36420.19	34.39
232	13353.13	Q1000	821.00	230.98	236.06	234.09	236.29	0.001653	2.12	386.91	100.00	0.34	5.08	3.94	3.94	-36420.19	58.34
232	13068.94	Q50	270.00	230.56	233.65	232.65	233.75	0.001800	1.42	190.55	100.00	0.33	3.09	6.35	6.35	-41892.05	32.52
232	13068.94	Q100	326.00	230.56	233.89	232.77	234.00	0.001783	1.52	214.33	100.00	0.33	3.33	6.11	6.11	-41892.05	36.09
232	13068.94	Q1000	821.00	230.56	235.58	233.64	235.82	0.001689	2.14	384.10	100.00	0.35	5.02	4.42	4.42	-41892.05	59.30
232	12680.44	Q50	270.00	229.92	233.01	231.92	233.10	0.001535	1.35	199.64	100.00	0.31	3.09	6.99	6.99	-35541.54	29.14
232	12680.44	Q100	326.00	229.92	233.25	232.05	233.36	0.001537	1.46	223.88	100.00	0.31	3.33	6.75	6.75	-35541.54	32.57
232	12680.44	Q1000	821.00	229.92	234.97	232.91	235.19	0.001526	2.08	395.60	100.00	0.33	5.05	5.03	5.03	-35541.54	55.32
232	12447.06	Q50	270.00	229.68	232.65	231.55	232.75	0.001522	1.35	200.35	100.00	0.30	2.97	7.35	7.35	-33927.09	28.93
232	12447.06	Q100	326.00	229.68	232.90	231.68	233.01	0.001524	1.45	224.69	100.00	0.31	3.22	7.10	7.10	-33927.09	32.32
232	12447.06	Q1000	821.00	229.68	234.62	232.55	234.83	0.001521	2.07	396.44	100.00	0.33	4.94	5.38	5.38	-33927.09	55.09
232	12265.30	Q50	270.00	229.16	232.37	231.30	232.46	0.001607	1.37	197.22	100.00	0.31	3.21	7.63	7.63	-41802.15	30.02
232	12265.30	Q100	326.00	229.16	232.61	231.42	232.72	0.001598	1.47	221.62	100.00	0.32	3.45	7.39	7.39	-41802.15	33.39
232	12265.30	Q1000	821.00	229.16	234.33	232.29	234.55	0.001559	2.09	393.75	100.00	0.34	5.17	5.67	5.67	-41802.15	56.00
232	12077.51	Q50	270.00	228.68	232.08	230.97	232.17	0.001495	1.34	201.59	100.00	0.30	3.50	7.92	7.92	-44830.82	28.53
232	12077.51	Q100	326.00	228.68	232.32	231.09	232.43	0.001496	1.44	226.08	100.00	0.31	3.74	7.68	7.68	-44830.82	31.88
232	12077.51	Q1000	821.00	228.68	234.05	231.96	234.27	0.001496	2.06	398.66	100.00	0.33	5.47	5.95	5.95	-44830.82	54.41
232	11679.54	Q50	270.00	228.85	231.49	230.37	231.58	0.001464	1.34	202.19	100.00	0.30	2.64	8.51	8.51	-41614.92	27.83
232	11679.54	Q100	326.00	228.85	231.74	230.50	231.84	0.001463	1.44	226.68	100.00	0.31	2.89	8.27	8.27	-41614.92	31.03
232	11679.54	Q1000	821.00	228.85	233.47	231.37	233.68	0.001430	2.06	399.96	100.00	0.33	4.62	6.53	6.53	-41614.92	51.82
232	11388.99	Q50	270.00	227.85	231.04	229.97	231.14	0.001578	1.36	198.66	100.00	0.31	3.19	8.96	8.96	-43672.27	29.56
232	11388.99	Q100	326.00	227.85	231.29	230.09	231.40	0.001564	1.46	223.46	100.00	0.31	3.44	8.71	8.71	-43672.27	32.80
232	11388.99	Q1000	821.00	227.85	233.04	230.96	233.26	0.001510	2.06	398.26	100.00	0.33	5.19	6.96	6.96	-43672.27	54.62
232	11068.55	Q50	270.00	227.64	230.60	229.39	230.68	0.001287	1.28	210.94	100.00	0.28	2.96	9.40	9.40	-46406.01	25.67
232	11068.55	Q100	326.00	227.64	230.84	229.51	230.94	0.001305	1.38	235.60	100.00	0.29	3.20	9.16	9.16	-46406.01	28.96
232	11068.55	Q1000	821.00	227.64	232.59	230.39	232.79	0.001362	2.00	410.26	100.00	0.32	4.95	7.41	7.41	-46406.01	50.91
232	10685.24	Q50	270.00	227.31	230.03	228.98	230.13	0.001639	1.38	195.91	100.00	0.31	3.02	9.97	9.97	-44458.84	30.48
232	10685.24	Q100	326.00	227.31	230.27	229.10	230.38	0.001625	1.48	220.36	100.00	0.32	3.26	9.73	9.73	-44458.84	33.82
232	10685.24	Q1000	821.00	227.31	232.02	229.97	232.24	0.001543	2.08	394.67	100.00	0.33	5.01	7.98	7.98	-44458.84	55.67
232	10463.14	Q50	270.00	225.73	229.68	228.59	229.77	0.001565	1.35	199.34	100.00	0.31	4.70	10.32	10.32	-36264.48	29.35
232	10463.14	Q100	326.00	225.73	229.92	228.71	230.03	0.001556	1.46	223.99	100.00	0.31	4.94	10.08	10.08	-36264.48	32.65
232	10463.14	Q1000	821.00	225.73	231.68	229.59	231.90	0.001493	2.05	399.99	100.00	0.33	6.70	8.32	8.32	-36264.48	54.11
232	10042.23	Q50	270.00	225.03	228.86	227.97	228.98	0.001843	1.63	185.43	100.00	0.35	3.83	11.14	11.14	-41724.52	32.46
232	10042.23	Q100	326.00	225.03	229.12	228.10	229.25	0.001775	1.72	211.10	100.00	0.35	4.09	10.88	10.88	-41724.52	35.43
232	10042.23	Q1000	821.00	225.03	230.93	228.97	231.16	0.001528	2.29	392.46	100.00	0.35	5.90	9.07	9.07	-41724.52	54.79
232	9853.63	Q50	270.00	225.41	228.52	227.33	228.61	0.001309	1.29	209.77	100.00	0.28	3.11	11.48	11.48	-38352.04	26.00
232	9853.63	Q100	326.00	225.41	228.79	227.45	228.88	0.001299	1.38	235.92	100.00	0.29	3.38	11.21	11.21	-38352.04	28.87
232	9853.63	Q1000	821.00	225.41	230.62	228.32	230.82	0.001266	1.96	419.55	100.00	0.30	5.21	9.38	9.38	-38352.04	48.34
232	9618.39	Q50	270.00	224.40	228.18	227.07	228.28	0.001460	1.35	201.88	100.00	0.30	3.78	11.82	11.82	-37987.21	28.08
232	9618.39	Q100	326.00	224.40	228.45	227.20	228.56	0.001412	1.44	228.77	100.00	0.30	4.05	11.55	11.55	-37987.21	30.60
232	9618.39	Q1000	821.00	224.40	230.31	228.07	230.51	0.001285	2.01	414.27	100.00	0.31	5.91	9.69	9.69	-37987.21	48.68
232	9449.62	Q50	270.00	224.33	228.00	226.62	228.07	0.000996	1.19	227.73	100.00	0.25	3.67	12.00	12.00	-39093.22	21.47
232	9449.62	Q100	326.00	224.33	228.27	226.74	228.35	0.001004	1.28	254.90	100.00	0.26	3.94	11.73	11.73	-39093.22	24.10
232	9449.62	Q1000	821.00	224.33	230.13	227.62	230.30	0.001074	1.86	440.92	100.00	0.28	5.80	9.87	9.87	-39093.22	43.06
232	9195.67	Q50	466.00	224.24	226.96	226.54	227.33	0.007418	2.70	172.72	100.00	0.66	2.72	13.04	13.04	-45651.54	121.75
232	9195.67	Q100	563.00	224.24	227.03	226.71	227.53	0.009480	3.13	179.84	100.00	0.75	2.79	12.97	12.97	-45651.54	161.80
232	9195.67	Q1000	1373.00	224.24	227.91	227.91	229.25	0.015280	5.13	267.87	100.00	1.00	3.67	12.09	12.09	-45651.54	381.94
232	8914.46	Q50	466.00	224.18	225.65	225.41	225.69	0.003737	1.04	556.05	1242.28	0.41	1.55	0.99	-0.01	-41808.28	16.40
232	8914.46	Q100	563.00	224.18	225.72	225.46	225.76	0.003487	1.08	647.15	1256.28	0.40	1.62	0.92	-0.08	-41808.28	17.61
232	8914.46	Q1000	1373.00	224.18	226.23	225.72	226.29	0.002217	1.22	1289.05	1266.31	0.35	2.13	0.41	-0.59	-41808.28	22.11
232	8684.37	Q50	466.00	223.75	225.24	224.64	225.26	0.000907	0.58	773.29	939.27	0.21	1.88	-0.60	0.05	-40948.45	7.32
232	8684.37	Q100	563.00	223.75	225.33	224.69	225.35	0.000883	0.62	970.86	1338.47	0.21	1.97	-0.69	-0.04	-40948.45	6.27
232	8684.37	Q1000	1373.00	223.75	225.89	225.01	225.92	0.000937	0.88	1747.60	1498.69	0.23	2.53	-1.25	-0.60	-40948.45	10.71
232	8261.57	Q50	466.00	223.14	224.52	224.17	224.57	0.002759	1.01	502.85	732.21	0.36	1.92	-0.62	0.40	-33999.04	18.58
232	8261.57	Q100	563.00	223.14	224.67	224.22	224.72	0.002238	1.02	618.61	782.33	0.33	2.07	-0.77	0.25	-33999.04	17.35
232	8261.57	Q1000	1373.00	223.14	225.23	224.57	225.30	0.002097	1.34	1258.70	1172.46	0.35	2.63	-1.33	-0.31	-33999.04	22.06
232	7533.61	Q50	466.00	221.35	223.86	223.34	223.87	0.000365	0.53	1259.21	1628.44	0.14	2.51	-0.32	0.45	-54761.62	2.76
232	7533.61	Q100	563.00	221.35	223.87	223.41	223.88	0.000507	0.63	1278.27	1628.90	0.17	2.52	-0.33	0.44	-54761.62	3.90
232	7533.61	Q1000	1373.00	221.35	224.48	223.54	224.50	0.000482	0.78	2363.45	1901.35	0.17	3.13	-0.94	-0.17	-54761.62	5.87
232	7033.29	Q50	466.00	220.75	223.34	222.66	223.42	0.002018	1.39	416.01	469.00	0.35	2.59	0.03	0.31	-59802.25	17.54
232	7033.29	Q100	563.00	220.75	223.46	222.77	223.49	0.000711	0.87	1010.01	1432.56	0.21	2.71	-0.09	0.19	-59802.25	4.91
232	7033.29	Q1000	1373.00	220.75	224.07	223.37	224.10	0.000687	1.04	1976.59	1706.46	0.21	3.32	-0.70	-0.42	-59802.25	7.79
232	6531.49	Q50	466.00	220.73	222.82	222.13	222.86	0.001326	1.00	629.22	946.63	0.27	2.09	-0.32	0.54	-50668.09	8.65
232	6531.49	Q100	563.00	220.73	222.96	222.22	223.00	0.001205	1.02	773.07	1070.74	0.26	2.23	-0.46	0.40	-50668.09	8.53
232	6531.49	Q1000	1373.00	220.73	223.55	222.79	223.60	0.001249	1.29	1614.18	1601.15	0.28	2.82	-1.05	-0.19	-50668.09	12.35
232	6282.70	Q50	466.00	220.13	222.51	221.84	222.55	0.001173	1.03	574.45	602.50	0.26	2.38	0.35	1.37	-58997.00	10.96
232	6282.70	Q100	563.00	220.13	222.66	221.92	222.70	0.001177	1.10	670.81	704.19	0.27	2.53	0.20	1.22	-58997.00	10.99
232	6282.70	Q1000	1373.00	220.13	223.24	222.39	223.29	0.001163	1.32	1595.61	1530.83	0.28	3.11	-0.38	0.64	-58997.00	11.89
232	6008.30	Q50	466.00	219.20	222.21	221.53	222.24	0.001058	0.92	600.03	603.08	0.25	3.01	0.10	0.58	-58425.82	10.32
232	6008.30	Q100	563.00	219.20	222.32	221.59	222.37	0.001253	1.06	724.51	1109.27	0.27	3.12	-0.01	0.47	-58425.82	8.02
232	6008.30	Q1000	1373.00	219.20	222.90	222.02	222.96	0.001262	1.31	1530.47	1479.34	0.29	3.70	-0.59	-0.11	-58425.82	12.80
232	5760.79	Q50	466.00	219.35	221.93	221.16	221.96	0.000891	0.85	646.17	596.75	0.22	2.58	0.00	1.38	-56870.77	9.46
232	5760.79	Q100	563.00	219.35	222.02	221.22	222.05	0.000960	0.91	867.68	1160.64	0.24	2.67	-0.09	1.29	-56870.77	7.03

HEC-RAS Plan: 120814 rev 5 River: DIV Reach: 232 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Max Chl Dpth	L. Levee Frbrd	R. Levee Frbrd	Power Total	Shear Total
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)		(m)	(m)	(m)	(N/m s)	(N/m2)
232	5760.79	Q1000	1373.00	219.35	222.53	221.63	222.58	0.001246	1.26	1519.06	1318.31	0.28	3.18	-0.60	0.78	-56870.77	14.07
232	5546.47	Q50	466.00	219.32	221.78	221.07	221.80	0.000870	0.83	849.76	1266.75	0.22	2.46	-0.01	0.56	-53999.42	5.72
232	5546.47	Q100	563.00	219.32	221.86	221.16	221.89	0.000889	0.87	957.47	1280.93	0.23	2.54	-0.09	0.48	-53999.42	6.52
232	5546.47	Q1000	1373.00	219.32	222.35	221.62	222.39	0.000973	1.10	1841.21	1909.58	0.25	3.03	-0.58	-0.01	-53999.42	9.20
232	5273.51	Q50	466.00	218.85	221.48	220.82	221.51	0.001169	0.94	624.21	686.94	0.26	2.63	0.14	0.28	-44741.36	10.41
232	5273.51	Q100	563.00	218.85	221.51	220.88	221.56	0.001562	1.10	649.57	722.42	0.30	2.66	0.11	0.25	-44741.36	13.77
232	5273.51	Q1000	1373.00	218.85	222.01	221.29	222.05	0.001447	1.29	1686.47	2005.00	0.30	3.16	-0.39	-0.25	-44741.36	11.94
232	5069.47	Q50	466.00	219.32	221.35	220.66	221.36	0.000442	0.59	1173.72	1621.71	0.16	2.03	-0.32	0.03	-54985.77	3.14
232	5069.47	Q100	563.00	219.32	221.32	220.73	221.33	0.000761	0.76	1112.23	1618.01	0.21	2.00	-0.29	0.06	-54985.77	5.13
232	5069.47	Q1000	1373.00	219.32	221.82	221.09	221.84	0.000678	0.88	2278.24	2324.93	0.21	2.50	-0.79	-0.44	-54985.77	6.51
232	4284.70	Q50	466.00	218.70	220.36	219.98	220.40	0.002500	1.06	535.92	825.15	0.35	1.66	0.06	0.18	-63258.06	15.92
232	4284.70	Q100	563.00	218.70	220.46	220.03	220.48	0.000698	0.60	1165.67	1602.07	0.19	1.76	-0.04	0.08	-63258.06	4.97
232	4284.70	Q1000	1373.00	218.70	220.98	220.42	221.00	0.000721	0.80	2054.21	1910.76	0.20	2.28	-0.56	-0.44	-63258.06	7.59
232	3909.61	Q50	466.00	217.98	220.10	219.74	220.12	0.000990	0.78	866.31	1403.99	0.23	2.12	-0.10	0.07	-60846.97	5.98
232	3909.61	Q100	563.00	217.98	220.18	219.79	220.20	0.000968	0.81	986.08	1425.35	0.23	2.20	-0.18	-0.01	-60846.97	6.56
232	3909.61	Q1000	1373.00	217.98	220.69	220.01	220.72	0.000961	1.01	1832.03	2086.22	0.24	2.71	-0.69	-0.52	-60846.97	8.27
232	3463.10	Q50	466.00	217.38	219.61	219.07	219.62	0.000666	0.58	1042.86	1617.87	0.18	2.23	-0.12	0.20	-65294.83	4.21
232	3463.10	Q100	563.00	217.38	219.69	219.11	219.70	0.000675	0.61	1170.80	1622.25	0.19	2.31	-0.20	0.12	-65294.83	4.77
232	3463.10	Q1000	1373.00	217.38	220.21	219.41	220.23	0.000616	0.76	2255.04	2080.28	0.19	2.83	-0.72	-0.40	-65294.83	6.54
232	2964.04	Q50	466.00	216.68	219.20	218.82	219.23	0.001329	0.92	769.39	1382.07	0.27	2.52	-0.05	0.99	-49574.19	7.26
232	2964.04	Q100	563.00	216.68	219.30	218.87	219.32	0.001221	0.93	908.02	1522.50	0.26	2.62	-0.15	0.89	-49574.19	7.14
232	2964.04	Q1000	1373.00	216.68	219.91	219.19	219.94	0.000848	1.00	1934.94	1756.98	0.23	3.23	-0.76	0.28	-49574.19	9.15
232	2617.84	Q50	466.00	216.74	218.96	218.27	218.97	0.000448	0.54	1151.27	1541.95	0.16	2.22	-0.37	-0.94	-51417.02	3.28
232	2617.84	Q100	563.00	216.74	219.06	218.35	219.08	0.000448	0.57	1313.02	1585.50	0.16	2.32	-0.47	-1.04	-51417.02	3.63
232	2617.84	Q1000	1373.00	216.74	219.70	218.69	219.72	0.000436	0.73	2390.59	1790.70	0.17	2.96	-1.11	-1.68	-51417.02	5.70
232	1935.04	Q50	466.00	216.47	218.63	217.84	218.64	0.000371	0.49	1156.42	1315.38	0.14	2.16	-0.41	0.53	-55540.17	3.20
232	1935.04	Q100	563.00	216.47	218.73	217.89	218.74	0.000389	0.52	1282.30	1329.85	0.15	2.26	-0.51	0.43	-55540.17	3.67
232	1935.04	Q1000	1373.00	216.47	219.34	218.22	219.36	0.000465	0.74	2130.96	1439.21	0.17	2.87	-1.12	-0.18	-55540.17	6.74
232	1593.07	Q50	466.00	215.86	218.43	217.90	218.45	0.001208	0.77	723.50	966.73	0.25	2.57	-0.21	1.08	-43669.35	8.86
232	1593.07	Q100	563.00	215.86	218.52	217.96	218.54	0.001227	0.82	808.04	967.26	0.25	2.66	-0.30	0.99	-43669.35	10.04
232	1593.07	Q1000	1373.00	215.86	219.08	218.29	219.14	0.001321	1.11	1357.01	970.72	0.28	3.22	-0.86	0.43	-43669.35	18.08
232	1054.43	Q50	466.00	215.95	217.80	217.21	217.82	0.001031	0.77	825.86	1331.75	0.23	1.85	-0.16	3.19	-39553.34	6.27
232	1054.43	Q100	563.00	215.95	217.88	217.27	217.90	0.001048	0.81	932.16	1348.37	0.24	1.93	-0.24	3.11	-39553.34	7.10
232	1054.43	Q1000	1373.00	215.95	218.42	217.68	218.45	0.001071	1.05	1705.04	1521.88	0.25	2.47	-0.78	2.57	-39553.34	11.76
232	719.50	Q50	466.00	216.08	217.42	216.92	217.44	0.001137	0.81	855.27	1574.23	0.24	1.34	-0.04	0.38	-60477.34	6.05
232	719.50	Q100	563.00	216.08	217.51	216.97	217.53	0.001066	0.83	999.46	1632.04	0.24	1.43	-0.13	0.29	-60477.34	6.40
232	719.50	Q1000	1373.00	216.08	218.09	217.34	218.12	0.000802	0.93	2079.23	2015.86	0.22	2.01	-0.71	-0.29	-60477.34	8.11
232	232.37	Q50	466.00	215.20	217.10	216.33	217.11	0.000433	0.58	1145.27	1633.56	0.16	1.90	-0.04		-59296.16	2.98
232	232.37	Q100	563.00	215.20	217.20	216.41	217.21	0.000433	0.61	1302.83	1636.56	0.16	2.00	-0.14		-59296.16	3.38
232	232.37	Q1000	1373.00	215.20	217.82	216.74	217.84	0.000433	0.77	2333.33	1682.27	0.17	2.62	-0.76		-59296.16	5.89

F. Preliminary Design Drawings

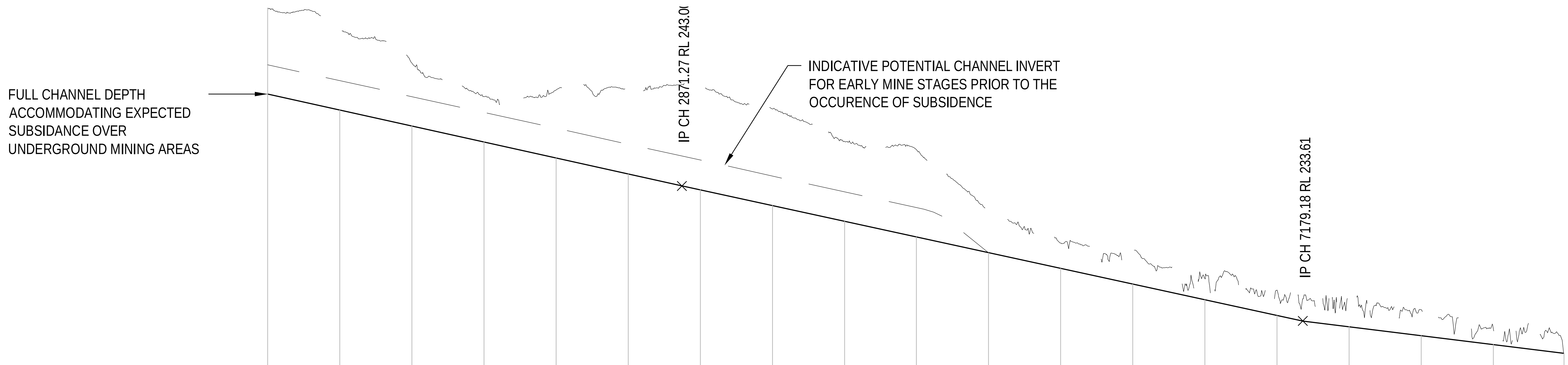
SK004 Case Study Diversion Drain Long Section

SK005 Conceptual Diversion Drain Cross Sections

SK008 North Carmichael Levee Longitudinal Section

SK009 Haul Road Crossing Longitudinal Section

SK010 South Carmichael Levee Longitudinal Section



DATUM RL. 225.00

VERTICAL ALIGNMENT	L=2871.27m G=-0.22%						L=4307.91m G=-0.22%									L=1809.96m G=-0.12%			
LEVEL DIFFERENCE CUT - / FILL +	-5.97	-5.55	-4.37	-3.16	-4.72	-5.75	-7.25	-6.72	-5.56	-6.06	-2.88	-1.75	-2.38	-1.48	-1.75	-2.18	-1.80	-1.10	0.03
DESIGN SURFACE LEVEL	249.381	248.270	247.159	246.048	244.936	243.825	242.719	241.629	240.539	239.449	238.359	237.268	236.178	235.088	233.998	233.211	232.593	231.976	231.374
EXISTING SURFACE LEVEL	255.35	253.82	251.52	249.21	249.66	249.58	249.97	248.35	246.10	245.50	241.24	239.02	238.56	236.57	235.75	235.39	234.39	233.08	231.35
CHAINAGE	0.00	500.00	1000.00	1500.00	2000.00	2500.00	3000.00	3500.00	4000.00	4500.00	5000.00	5500.00	6000.00	6500.00	7000.00	7500.00	8000.00	8500.00	8990.01

CASE STUDY DIVERSION DRAIN
LONG SECTION

SCALE 1:30000 HORIZONTAL
SCALE 1:300 VERTICAL

NOTE:

1. DURING DETAILED DESIGN, ENERGY DISSIPATION MEASURES INCLUDING RIP RAP SHOULD BE IMPLEMENTED WHERE REQUIRED.
   SEE SECTION 9.3 OF THE REPORT FOR DETAILS OF DIVERSION DRAIN VELOCITY AND WIDTH.

PRELIMINARY

rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
CASE STUDY DIVERSION DRAIN
LONG SECTION

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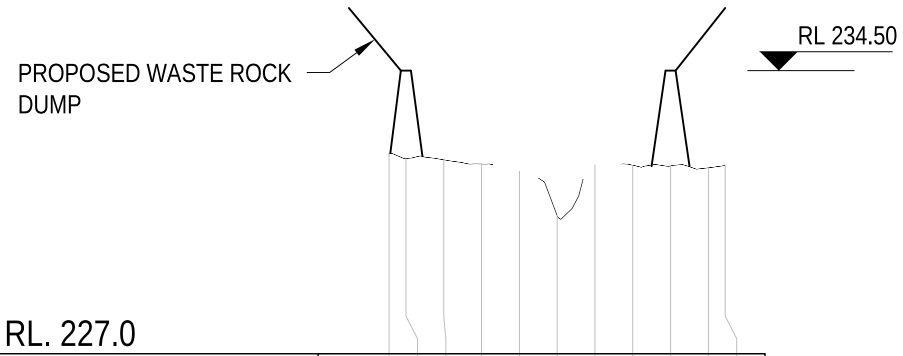
scale	- for A3	job no.	41-24415
date	DEC 2011	rev no.	A

approved (PD) SK004

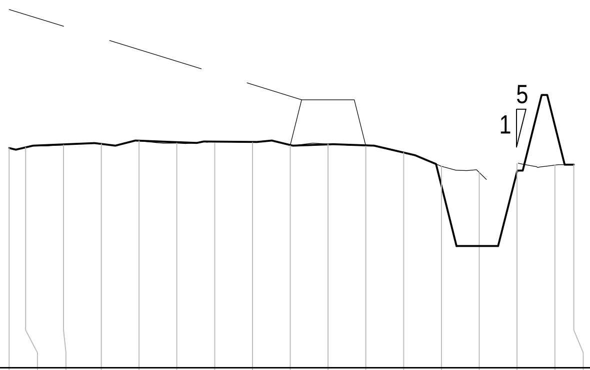


DATUM RL. 227.0

EXISTING SURFACE LEVEL	232.314	232.174	232.137	232.029	231.835	230.663	232.004	231.996	231.979	231.927	231.983
CHAINAGE	-88.93	-80	-60	-40	-20	0	20	40	60	80	88.93

CROSS SECTION OF NATURAL CHANNEL THROUGH WASTE ROCK DUMP HECRAS 13069

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200



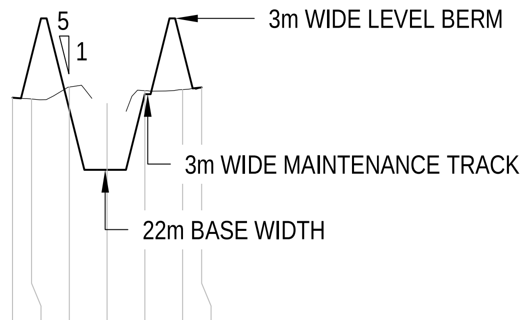
DATUM RL. 230.0

DESIGN LEVEL	235.82	235.84	235.919	235.931	236.016	235.976	235.991	235.981	235.9	235.919	235.893	235.701	234.825	233.225	235.192	236.425	235.381
EXISTING SURFACE LEVEL	235.82	235.84	235.902	235.93	236.01	235.953	235.95	235.966	235.895	235.927	235.879	235.702	235.339	235.171	235.41	235.371	235.381
CHAINAGE	-248.737	-240	-220	-200	-180	-160	-140	-120	-100	-80	-60	-40	-20	0	20	40	50

CROSS SECTION CH 7500 HECRAS STATION 15156

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200

NOTE:
PLEASE SEE THE PRELIMINARY FLOOD MITIGATION & CREEK DIVERSION DESIGN REPORT, SECTION 9.3, FOR DETAIL OF CASE STUDY DIVERSION DRAIN

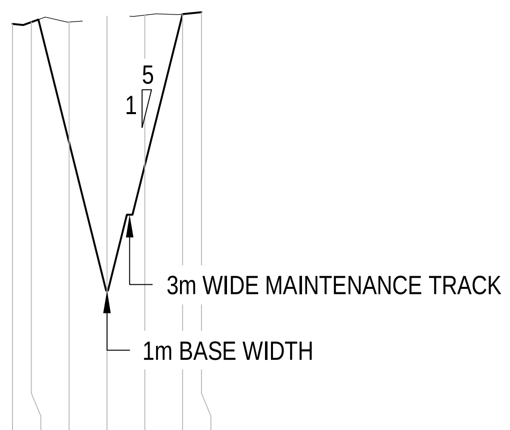


DATUM RL. 230.0

DESIGN LEVEL	235.903	236.998	235.598	233.998	235.998	237.198	236.175
EXISTING SURFACE LEVEL	235.903	235.869	236.184	235.751	236.09	236.119	236.175
CHAINAGE	-50	-40	-20	0	20	40	50

CROSS SECTION CH 7000 HECRAS STATION 15644

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200



DATUM RL. 239.0

DESIGN LEVEL	249.764	249.811	246.619	242.719	246.019	250.019	250.071
EXISTING SURFACE LEVEL	249.764	249.811	249.813	249.968	249.994	250.019	250.071
CHAINAGE	-50	-40	-20	0	20	40	50

CROSS SECTION CH 3000 HECRAS STATION 19644

HORIZONTAL SCALE 1:4000
VERTICAL SCALE 1:200

PRELIMINARY

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A	INITIAL ISSUE		

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CARMICHAEL COAL MINE SURFACE WATER STUDY
CASE STUDY DIVERSION DRAIN
CROSS SECTIONS

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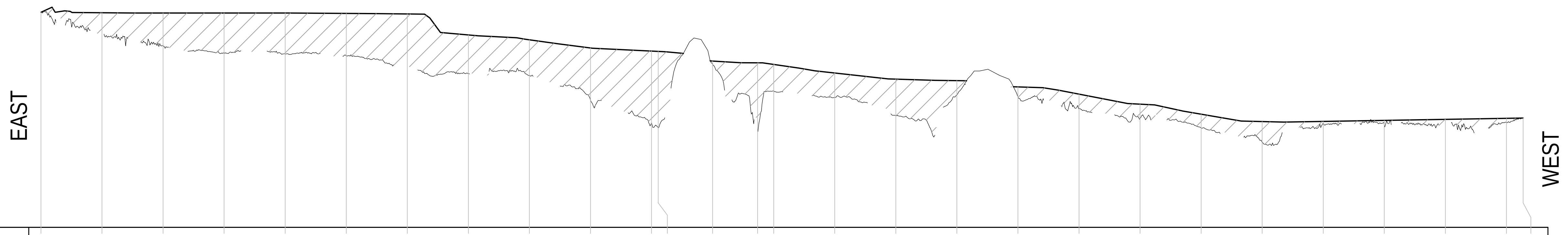
scale - for A3 job no. 41-24415
date DEC 2011 rev no. A

approved (PD) SK005



DATUM RL. 214.00

LEVEL DIFFERENCE CUT - / FILL +	0.00	2.03	2.69	3.31	3.35	3.47	4.33	3.15	2.92	4.26	5.88	6.07	0.26	5.55	2.17	1.99	2.98	1.16	0.80	1.20	1.16	1.12	1.69	0.17	0.36	0.35	0.34	-0.00
DESIGN SURFACE LEVEL	231.579	231.538	231.519	231.517	231.513	231.484	231.438	229.721	229.325	228.662	228.407	228.224	227.587	227.422	227.316	226.610	226.113	225.993	225.476	224.889	224.063	223.249	222.644	222.653	222.739	222.824	222.910	222.933
EXISTING SURFACE LEVEL	231.58	229.51	228.83	228.20	228.16	228.01	227.11	226.57	226.40	224.41	222.53	222.15	227.33	221.88	225.14	224.62	223.13	224.83	224.67	223.69	222.90	222.12	220.96	222.48	222.38	222.47	222.57	222.93
CHAINAGE	0.00	500.00	1000.00	1500.00	2000.00	2500.00	3000.00	3500.00	4000.00	4500.00	5000.00	5054.48	5500.00	5868.08	6000.00	6500.00	7000.00	7500.00	8000.00	8500.00	9000.00	9500.00	10000.00	10500.00	11000.00	11500.00	12000.00	12136.78

LONGITUDINAL SECTION - NORTH CARMICHAEL LEVEE

HORZ 1:35000 VERT 1:350

PRELIMINARY

rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
NORTH CARMICHAEL LEVEE
LONG SECTION

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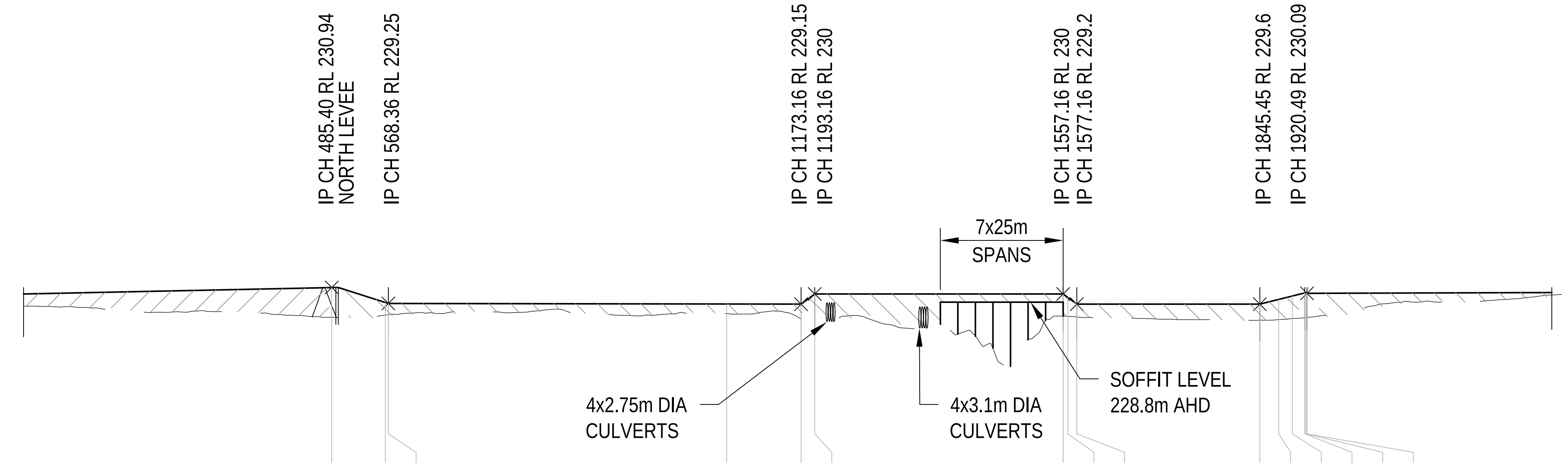
scale - for A3 job no. 41-24415
date month 2011 rev no. A

approved (PD) DEC 2011 SK008

Plot Date: 21 August 2012 - 1:55 PM Plotted by: Shayne Johnson Cad File No: G:\41\24415\CADD\Drawings\41-24415-SK008.dwg



DATUM RL. 205.00

VERTICAL ALIGNMENT

L	G
L=451.54m	G=0.21%
L=73.4m	G=-3.19%
L=604.8m	G=-0.02%
L=20m	G=7.5%
L=364m	G=0%
L=20m	G=-7.5%
L=268.29m	G=0%
L=3.31m	G=-1.48%
L=358.81m	G=0.03%

CHAINAGE	LEVEL DIFFERENCE CUT - / FILL +	DESIGN SURFACE LEVEL	EXISTING SURFACE LEVEL
0.00			228.51
485.40	4.38	230.944	226.57
564.00	1.83	228.745	226.91
568.36	2.28	229.250	226.97
1064.00	1.38	228.519	227.13
1173.16	2.82	229.15	226.33
1193.16	4.07	230.000	225.93
1557.16	3.25	230.000	226.75
1564.00	2.77	229.487	226.72
1577.16	2.57	229.20	226.63
1845.45	3.43	229.60	226.17
1873.10	2.95	229.190	226.24
1893.08	3.30	229.688	226.39
1911.19	3.64	230.140	226.50
1913.06	3.59	230.113	226.52
1920.49	3.55	230.090	226.54
2280.00			229.92

LONGITUDINAL SECTION - HAUL ROAD CROSSING

HORZ 1:9000 VERT 1:900

PRELIMINARY

rev	description	app'd	date
A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY

HAUL ROAD CROSSING LONG SECTION

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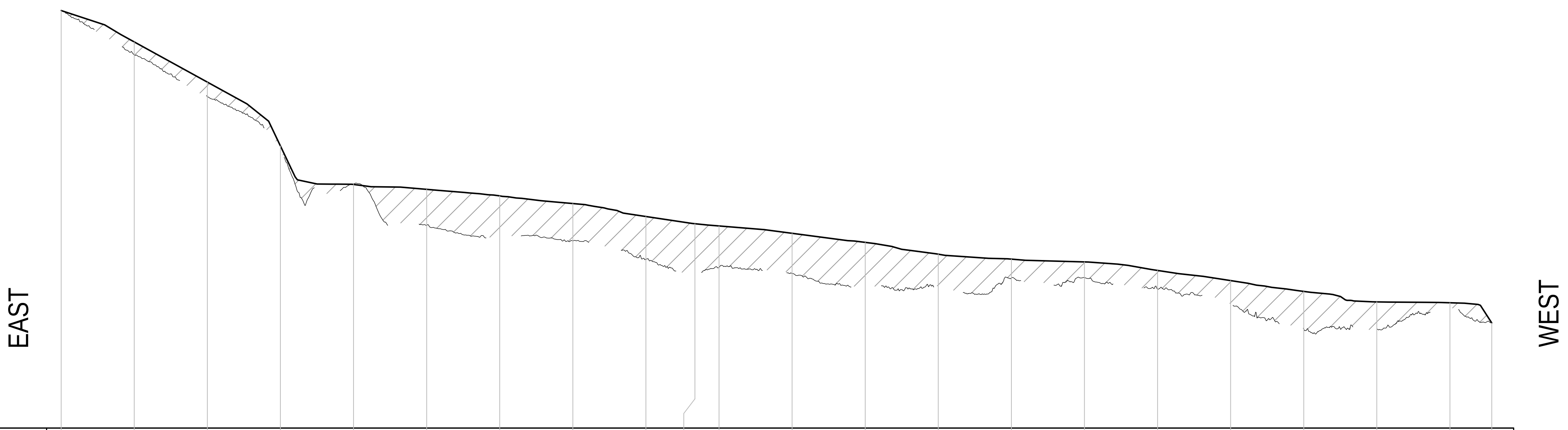
scale - for A3 job no. 41-24415
date JAN 2012 rev no. A
approved (PD) SK009



DATUM RL. 213.00

LEVEL DIFFERENCE CUT - / FILL +	-0.01	0.89	1.01	0.18	-0.01	2.46	2.70	2.56	2.92	3.40	2.84
DESIGN SURFACE LEVEL	241.584	239.443	236.691	232.319	229.687	229.350	228.905	228.375	227.484	226.970	226.839
EXISTING SURFACE LEVEL	241.59	238.56	235.68	232.14	229.70	226.89	226.21	225.82	224.57	223.57	224.00
CHAINAGE	0.00	500.00	1000.00	1500.00	2000.00	2500.00	3000.00	3500.00	4000.00	4335.32	4500.00

LEVEL DIFFERENCE CUT - / FILL +	2.75	3.00	2.24	1.28	1.07	1.29	1.58	2.56	1.88	0.31	-0.00
DESIGN SURFACE LEVEL	226.337	225.719	224.910	224.569	224.378	223.798	223.098	222.358	221.645	221.579	220.198
EXISTING SURFACE LEVEL	223.59	222.72	222.67	223.29	223.30	222.51	221.52	219.79	219.77	221.27	220.20
CHAINAGE	5000.00	5500.00	6000.00	6500.00	7000.00	7500.00	8000.00	8500.00	9000.00	9500.00	9785.88

LONGITUDINAL SECTION - SOUTH CARMICHAEL LEVEE

HORZ 1:40000 VERT 1:400

PRELIMINARY

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A	INITIAL ISSUE		

ADANI MINING PTY LTD
CARMICHAEL COAL MINE SURFACE WATER STUDY
SOUTH CARMICHAEL LEVEE
LONG SECTION

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A	Leila Macadam	Paul Priebbenow	P. Priebbenow	Paul Priebbenow	P. Priebbenow	3/01/2012
B	Daniel Copelin	Peter Dunn		Paul Priebbenow	P. Priebbenow	22/08/2012
0	Daniel Copelin			Paul Priebbenow	P. Priebbenow	28/08/2012

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