WATER MANAGEMENT PLAN

MP 3.4.1.8

Version E

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Version History

Version	Version Date	Details	Authors	Authorised/Approved for Issue	
				Name (Position)	Date
A	2003	Site/Surface Water Management Plan (inc. GWMP)	ACOL	Peter Barton	09/09/2003
B	2005	Site Water Management Plan	ACOL	Peter Horn	30/08/2005
C	2006	Site Water Management Plan, Part 2 UG Revision	ACOL	Tracey Rock	19/08/2006
D	29/02/2012	Water Management Plan (RPS Aquaterra ref. S56E/006g)	RPS Aquaterra / ACOL	Lisa Richards (Environment & Community Relations Manager) Michael Moore (Approvals Manager)	
E	25/07/2012	Water Management Plan (RPS Aquaterra ref. S56E/006g)	RPS Aquaterra / ACOL	Lisa Richards (Environment & Community Relations Manager) Michael Moore (Approvals Manager)	25/07/2012

External Approval Register

Organisation	Nominated Representative	Version	Date Issued	Date Approved
DoP	H. Reed	A	July 2003	2003
DECC	N. Pulver	A	09/09/2003	
SSC	Ken Horner	A C	26/10/2003 31/05/2006	
NSW DPI - Fisheries	Scott Carter	A C	09/09/2003 31/05/2006	
DWE	Fergus Hancock	C	31/05/2006	
DP&I	Howard Reed	E	11/03/2012	10/08/12

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ABBREVIATIONS

A

ACOL Ashton Coal Operations Pty Limited

ACP Ashton Coal Project

AEMR Annual Environmental Management Report

AHD Australian Height Datum

ARI Average Recurrence Interval (measured in years, to determine flood size and likelihood)

AS Australian Standard

B

BCD Bowmans Creek Diversion

BCDMP Bowmans Creek Diversion Management Plan

C

CCC Community Consultative Committee

CHPP Coal Handling and Preparation Plant

CMRA 1982 Coal Mines Regulation Act 1982 (NSW)

D

DECC Department of Environment and Climate Change (now OEH)

DECCW Department of Environment, Climate Change and Water (now OEH)

DA Development Consent DA 309-11-2001

DRE Division of Resources and Energy (within DTIRIS)

DoP Department of Planning (now DP&I)

DPI NSW Department of Primary Industries (division of DTIRIS)

DP&I Department of Planning and Infrastructure

DTIRIS Department of Trade and Investment, Regional Infrastructure and Services (Trade & Investment)

E

EA Environmental Assessment

EC electrical conductivity

EEA Eastern Emplacement Area

EIS Environmental Impact Statement

EMP Environmental Management Plan

EMS Environmental Management System

EoP End of Panel (Report)

EP Extraction Plan

EP&A Act 1979 Environmental Planning Assessment Act 1979 (NSW)

EPA Environment Protection Authority (part of OEH)

EPL Environment Protection Licence

F

G

GM General Manager

GDE Groundwater Dependent Ecosystem

H

ha hectares

I

J

K

kg kilograms

kL kilolitres

km kilometres

L

LB Lower Barrett (coal seam)

LGA Local Government Area

L/s litres per second

LW longwall

M

m metres

m/s metres per second

mg/l milligrams per litre

ML megalitres

ML mining lease

mm millimetres

Mm^3 million metres cubed

MOP Mining Operation Plan

Mt million tonnes

Mtpa million tonnes per annum

N

NA not applicable

NEOC North East Open Cut

NOW NSW Office of Water

NSW New South Wales

O

OC open cut

OEH Office of Environment and Heritage, Division of the NSW Department of Premier and Cabinet (formerly DECCW)

OGM Organic Growth Medium

P

PG Pikes Gully (coal seam)

pH measure of acidity (<7) or alkalinity (>7) of a (water) sample

POEO Act Protection of the Environment Operations Act 1997 (NSW)

PWD Process Water Dam

Q

R

RL Reduced Level (relative height (m) compared to Australian Height Datum (AHD))

ROM run-of-mine

S

SD Settling Dam

SHECMS Safety Health Environment Community Management System

SMP Subsidence Management Plan

SoC Statement of Commitments

SSC Singleton Shire Council

T

t tonne

TARP Trigger Action Response Plan

tph tonnes per hour

TDS Total Dissolved Solids

TSS Total Suspended Solids

U

UG underground

ULD Upper Liddell (coal seam)

ULLD Upper Lower Liddell (coal seam)

V

W

WMP Water Management Plan

WMS Water Management System

Y

yr year

Z

Other

µS/cm micro Siemens per centimetre (units of measurement for electrical conductivity)

1 INTRODUCTION

1.1 Background

Ashton Coal Operations Pty Limited (ACOL) operates the Ashton Coal Project (ACP) approximately 14km west of Singleton in the Hunter Valley, NSW (**Figure 1**). ACOL is a wholly owned subsidiary of Yancoal Australia Limited (Yancoal), which is the majority (90%) joint venture owner of the mine.

The ACP comprises an open cut mine, an underground mine, a coal handling and preparation plant (CHPP), rail loading facilities, run-of-mine (ROM) and product coals stockpiles, and various surface support infrastructure and facilities. Development consent (DA 309-11-2001) for the ACP was granted by the Minister for Planning in October 2002. The ACP is approved to produce up to 5.45Mtpa of ROM coal up to February 2024.

Construction of the open cut mine commenced in 2002, and ceased coal production in September 2011. The mine void will be used for rejects and tailings emplacement for the remaining life of the underground mine.

The underground mine is a longwall operation which is approved to mine coal from the Pikes Gully (PG), Upper Liddell (ULD), Upper Lower Liddell (ULLD) and Lower Barrett (LB) coal seams (in descending order). Development of the underground mine commenced in the PG seam in 2005. The general longwall layout comprises eight longwall panels (LW1, LW2, LW3, LW4, LW5, LW6A & 6B, LW7A & 7B and LW8). In 2012, longwall extraction in the PG seam will be completed and the longwall miner will be relocated to the ULD seam.

This Water Management Plan (WMP) has been prepared by RPS Aquaterra on behalf of ACOL to address the requirements of condition 4.7 to Schedule 2 of DA 309-11-2001, in consultation with the NSW Office of Water (NOW), the Office of Environment and Heritage (OEH), the Division of Resources and Energy (DRE) within the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS), and Singleton Shire Council (SSC).

The purpose of the WMP is to outline how all water resources onsite will be managed, measured, monitored and reported.

1.2 Context

This WMP forms part of the Environmental Management Strategy for the mine and is an integral part of ACOL's Safety Health Environment and Community Management System (SHECMS).

The WMP includes a Site water balance; erosion and sediment control plan; Bowmans Creek diversion management plan, surface and ground water monitoring plans; and surface and ground water response plans.

When approved, the WMP will replace the following existing individual ACP environmental management plans:

- Erosion and Sediment Control Plan;
- Surface Water Management Plan; and
- Groundwater Management Plan.

1.3 Scope

This WMP covers the management of surface water and groundwater related impacts associated with mining at the ACP. Specifically, the WMP includes:

- objectives for water management;
- statutory requirements;
- a brief summary of the existing environment;
- baseline monitoring data;
- predicted impacts and mitigation;
- impact assessment criteria including response trigger levels;
- site water balance;
- site water management procedures and uses;
- an erosion and sediment control plan;
- surface water and groundwater monitoring program;
- Trigger Action Response Plans;
- Bowmans Creek Diversion Management Plan;
- requirements for reporting and review;
- roles of staff and contractors; and
- relevant mine personnel and emergency contacts.

The water related impacts of the ACP are described and assessed in the following principal technical assessment documents:

- 2001 Environmental Impact Statement (2001 EIS), prepared by HLA Enviro-sciences Pty Ltd;
- 2009 Environmental Assessment (2009 EA) for the Bowmans Creek Diversion Project; and
- 2012 ULD Seam Extraction Plan Groundwater Impact Assessment report (2012 ULD EP), prepared by RPS Aquaterra.

1.4 Objectives

The primary objective of the WMP is to manage and minimise the impact of mining operations on surface water and groundwater resources. The objectives of the WMP are to:

- detail water sources, their use and management on and off site;
- identify erosion and sediment control risks;
- describe measures taken to manage erosion and sediment contamination onsite;
- identify potential contamination risks to surface water and groundwater;
- detail surface water and groundwater quality and quantity (flow/level) in terms of baseline data, identification of trigger levels, and a monitoring program for ongoing assessment;
- specify response protocols for exceedances in surface water and groundwater assessment criteria;

- provide measures to manage and mitigate adverse impacts to watercourse baseflows, privately-owned water supplies, groundwater dependant ecosystems and riparian vegetation;
- provide for the management of the Bowmans Creek diversion; and
- comply with conditions of development consent DA 309-11-2001.

The monitoring program outlined in this WMP has been designed to provide a reliable database for comparing the actual operational impacts and performance of the ACP with those predicted in the 2001 EIS and updated in the 2009 EA, as well as all other relevant supporting documentation as listed in condition 1.2 of Schedule 2 within DA 309-11-2001.

The implementation of the WMP will assist ACOL in its water system planning and in the management and mitigation of mine related surface and groundwater impacts.

1.5 Plan Development and Consultation

Water efficiency and security are a priority for ACOL (and Yancoal) to ensure high operational performance and environmental protection, through responsible practices.

Sustainable water management is defined as "*enough water, of sufficient quality, at the right time, and at the right place to meet the ongoing needs of this and future generations and of the ecosystem as a whole*" (MCMPR, 2006). Further guidance on the overall plan is derived from the Australian Government Department of Resources, Energy and Tourism handbook, *Leading Practice Sustainable Development Program for the Mining Industry – Water Management* (DRET, 2008).

The WMP has been prepared in accordance with relevant statutory requirements, DA conditions and commitments, and various water management related guidelines, which are further described in **Sections 2** and 7, and **Appendix A**.

Improved understanding of the Bowmans Creek alluvium has been achieved since the preparation of the 2001 EIS (HLA-Envirosciences, 2001) through additional groundwater, subsidence and surface water monitoring and specialist studies conducted for the preparation of the 2009 EA (Evans & Peck Pty Ltd, 2009). In particular, significant attention has been given to the design of the diversion channels, which will have similar hydraulic and geomorphic characteristics to the existing creek. This understanding has been further enhanced through additional assessment and modelling of groundwater impacts for the Upper Liddell Seam Extraction Plan (ULD EP).

The development of this WMP has also been guided by a review of existing ACOL environmental management plans, Mining Operations Plan (MOP), Annual Environmental Management Reports (AEMR), 2001 EIS and 2009 EA. A reassessment of erosion and sediment controls, surface water and groundwater at the Site has also been conducted.

During 2010 and 2011, ACOL consulted extensively with NOW on the water licensing requirements for the existing ACP and proposed future developments (including the approved Bowmans Creek diversion), under the provisions of both the *Water Act 1912* and *Water Management Act 2000*.

Formal consultation on this WMP has been carried out with DP&I, NOW, OEH, DRE and SSC, and revisions made where appropriate. Written correspondence where available from these agencies is included in **Appendix B**.

As indicated, the WMP will replace existing Water Management Plans in place for the ACP.

2 STATUTORY REQUIREMENTS

2.1 Legislation

This WMP has been prepared with reference to the following:

- *Water Act 1912* (WA 1912);
- *Water Management Act 2000* (WMA 2000);
- *Water Sharing Plan for the Hunter Regulated River Water Source 2003* (WSPHRRWS 2003)*;*
- *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* (WSPHUAWS 2009);
- *Protection of the Environment and Operations Act 1997* (POEO Act)*; and*
- *Environmental Planning and Assessment Act 1979* (EP&A Act).

2.2 Approvals and Licences

The current statutory approvals and environmental licence relevant to water management at the ACP are listed in **Table 2.1**. Details of their relevant conditions are included within **Appendix A** of this document.

Table 2.1 ACOL statutory approvals and licences

Reference	Approval Description	Date Approved	Legislation	Authority
DA 309-11-2001	Development Approval (as modified)	11/10/2002	Section 80 EP&A Act 1979	DP&I
EPL 11879 (latest variation)	Environmental Protection Licence for Mining Lease 1533	17/11/2005	POEO Act 1997	OEH

Water access (WAL), aquifer access (AAL) and bore (BL) licences held by ACOL under the WMA and WA (respectively) are listed in **Table 2.2** below. All water extractions are metered and reported in the AEMR.

Table 2.2: Water licences

Licence No.	Bore/extraction reference	Extraction limit (ML/yr)
Surface Water		
WAL 29565	Bowmans Creek – Water Access	266
WAL 29566	Bowmans Creek – Aquifer Access	100
20SL042214	Bowmans Creek (Irrigation)	14
WAL 997	Glennies Creek (High Security)	11
WAL 8404	Glennies Creek (High Security)	80
WAL 15583	Glennies Creek (General Security)	354
WAL 1358	Glennies Creek (Supplementary)	4
WAL 1120	Hunter River (High Security)	3
WAL 1121	Hunter River (General Security)	335

Licence No.	Bore/extraction reference	Extraction limit (ML/yr)
WAL 6346	Hunter River (Supplementary)	15.5
Groundwater		
20BL169508	Mining	100
20BL169937	Mining (restricted at 230ML)	230 (combined total)
20BL171364	Mining (restricted at 100ML)	

A full list of licensed monitoring bores and piezometers is provided in **Appendix C**.

2.3 Monitoring Standards, Guidelines and Plans

The following guidelines, standards, policies and plans have been referred to where relevant.

Table 2.3: Relevant guidelines and standards for erosion, sediment and water management

Element	Standard / Guideline
Erosion and Sediment Control	• (Draft) *Guidelines for Establishing Stable Drainage Areas on Rehabilitated Minesites* (DLWC, 1999) • *Managing Urban Stormwater: Soils and Construction Volume 1 Edition 4* (Landcom, 2004) • *Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and quarries* (DECC, 2008)
Water – General	• EPA Environmental Guideline, *Use of Effluent by Irrigation*, 2004 • *Hunter-Central Rivers Catchment Action Plan 2006-2015* (Hunter-Central Rivers Catchment Management Authority (CMA), 2007) • *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, 2000 (ANZECC/ARMCANZ, 2000) • *Australian Guidelines for Water Quality Monitoring and Reporting* (ANZECC/ ARMCANZ, 2000) • NATA accredited laboratory analysis of collected water samples • *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales* (DECCW, 2004) • AS/NZS 5667.1:1998 *Water Quality – Sampling – Guidance on the Design of Sampling Programs, Sampling Techniques, and the Preservation and Handling of Samples* • Environmental Protection Licence conditions for testing/monitoring
Groundwater	• *NSW Groundwater Policy Framework – General* (DLWC, 1997) • *NSW Groundwater Quality Protection Policy* (DLWC, 1998) • *NSW Groundwater Dependent Ecosystem Policy* (DLWC, 2002) • *MDBC Groundwater flow modelling guideline* (Middlemis/MDBC, 2001) • AS/NZS 5667.11:1998 *Water Quality – Sampling – Guidance on Sampling of Groundwaters* • (Draft) *Groundwater Monitoring Guidelines for Mine Sites Within the Hunter Region* (DLWC, 1999)

3 EXISTING ENVIRONMENT

3.1 Climate

The climate of the region is temperate with hot summers and cool winters. The average daily maximum temperature ranges from 31.7ºC in January to 17.4ºC in July (Jerrys Plains).

3.1.1 Rainfall and Evaporation

Rainfall data from the Jerrys Plains weather station, situated approximately 14km to the southwest of the ACP, is summarised in **Table 3.1**. The Table lists the mean monthly rainfall and mean annual rainfall, based on more than 100 years of rainfall data since 1884.

Evaporation data (pan evaporation records) are available from Scone, approximately 65km north-west of ACP, and regional mapping of average values across the mine site. There is an excess of evaporation over rainfall in all months as shown in **Table 3.1**; however rainfall and potential evaporation are close to being in balance in the winter months (June and July). It is important to note that this evaporation data relates to open water surfaces and bare soil, rather than to land surfaces with vegetation.

Table 3.1: Long-term average monthly rainfall at Jerrys Plains and evaporation at Scone (mm)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall*	77.0	72.4	58.3	44.5	40.9	48.1	43.5	36.4	41.7	52.1	60.3	68.2	643.7
Evaporation#	220	174	155	105	68	48	56	84	117	155	183	220	1606
Balance	-143	-101	-97	-61	-27	0	-12	-47	-75	-103	-123	-152	-962

Source: Bureau of Meteorology (BOM August 2011)

Note: Rainfall – BOM Jerrys Plains Meteorological Station; Evaporation – BOM Scone SCS Meteorological Station

3.2 Topography

The surface topography of the ACP generally dips to the west and is gently undulating over most of the area and is presented in **Figure 2**. Surface elevation varies between approximately 100m Australian Height Datum (AHD) along the eastern ridge to around 50m AHD near the Hunter River end of Bowmans Creek.

The underground mining area is located in an area containing rounded hills on the eastern portion, which slope steeply towards Glennies Creek (to the east), and more gently to Bowmans Creek in the west, where it flattens along the low-lying valley floor. The topography rises again on the western side of Bowmans Creek. In the south there are some steeper slopes leading down to the alluvial flats adjacent to the Hunter River.

3.3 Soils

HLA-Envirosciences (2001) identified the soils within the ACP area as belonging to the Bayswater, Hunter and Roxburgh Landscapes of the Singleton 1:250 000 Sheet (mapped by the Soil Conservation Service of NSW), as follows:

- The Bayswater soils cover the majority of the ACP area, particularly the undulating low hills. They predominately include Yellow Solodic Soils on slopes with alluvial soils in drainage lines. Some drainage lines have some Brown and Yellow Earths and Prairie Soils. Red, Brown and Yellow Podsolic Soils occur on the slopes, whereas intergrades are comprised of Yellow Podsolic Soils-Red-Brown Earth;

- The Hunter soils are predominantly formed in alluvium and include Brown Clays and Black Earths on prior stream channels and on tributary flats, with Red Podsolic Soils and Lateric Podsolic Soils on older terraces; and
- The Roxburgh soils include Yellow Podsolic Soils, which occur on the upper to mid slopes with Red Solodic Soils on the more rounded hills. Lithosols occur on the crests. Brown Podsolic Soils occur on slopes on conglomerate with associated flat pavements.

3.4 Hydrology

3.4.1 Watercourses

The ACP is, as shown on **Figure 2**, situated between Betty's Creek in the north, the Hunter River in the south, Glennies Creek in the east and Bowmans Creek and its associated floodplain in the west. Bowmans Creek and Glennies Creek are tributaries of the Hunter River, while Bettys Creek is a tributary of Bowmans Creek. The ACP operates as two distinct elements – the North East Open Cut (NEOC), including CHPP, coal stockpiles, rail loading and support facilities; and the underground mine.

3.4.2 Existing Surface Water and Drainage

The NEOC pit is no longer being mined; however the ACP coal handling and processing facilities, which are still utilised, are situated adjacent to the western side of the pit. Final rehabilitation of the available spoil area is almost complete, with a final void and residual spoil area for future capping remaining. Over the life of the underground operation, tailings and rejects will be emplaced within the final void prior to capping and final rehabilitation. A catchment plan for the NEOC is shown in **Figure** 3. The entire NEOC is managed as a zero effluent discharge area. The surface drainage and cover is managed to minimise the generation of sediment and ensure that all runoff from disturbed catchments is directed to sediment settling dams and return water dams.

The area above the underground mine consists mostly of grassland and drainage is towards natural rivers (see **Figure 2**). Most of the area above the underground mine drains westward towards Bowmans Creek, which flows south, prior to joining the Hunter River. Other smaller areas of the site drain east into Glennies Creek (which also flows south to join the Hunter River), and south directly to the Hunter River. The landscape above the underground mine is impacted by mine subsidence and appropriate measures to manage the surface drainage, erosion and sediment are included in this WMP.

3.4.3 Groundwater Hydrology

Two distinct aquifer systems occur within the ACP area:

- A semi-confined porous fractured rock aquifer system in the consolidated Permian age sedimentary strata (Permian coal measures), with groundwater flow mainly in fractures and cleats within the coal seams; and
- A shallow unconfined granular aquifer system in the unconsolidated sediments of the alluvium associated with Bowmans Creek, Glennies Creek and Hunter River.

Some 'perched' groundwater occurs locally within the upper weathered zone of the Permian coal measures; however the extent of these perched aquifers is limited.

The main aquifers are the alluvial deposits, which extend along the low-lying areas of Bowmans and Glennies creeks and the Hunter River. The water table in the alluvium is recharged by direct rainfall, runoff from the adjacent slopes and flooding (along channel reaches and across associated floodplains). With the exception of short periods of peak flood flow, the water table in the alluvium tends to remain above the creek and river levels. Under these conditions, water discharges from the alluvium into the channels, providing baseflow. Mining activities that reduce the water table can potentially reduce the contribution of baseflow from the alluvium aquifers, as quantitatively determined in groundwater model studies for the ACP (e.g. Aquaterra, 2009c). The amount of this reduction is manageable via licensed allocations and accounting. However, the rainfall recharge to the alluvium is high favouring rapid post-subsidence recovery of the water table. Further, the replenishment and ingress to the underlying hard rock is limited, favouring horizontal drainage into the water channel. The process is monitored and discussed in more detail through the various 'End of Panel' (EoP) Reports, such as Aquaterra (2010c).

The other aquifers of significance are the underlying Permian coal measures. These are semi-confined, low-yielding and saline. The distribution of hydraulic properties and associated pore properties is heterogeneous in places causing saline water to rise to the surface in a few isolated pockets from the Permian age rocks. This low volume saline water is flushed away by the active creeks but the salinity has been observed to increase in some ponded parts of the Bowmans Creek during dry periods, especially in the reach just north of the eastern creek diversion. Dewatering of the groundwater within the Permian coal measures as a result of mining has had the effect of reducing the piezometric pressures within the semi-confined strata and beneficially reducing the vertical rise of saline water to surface creeks with beneficial outcomes for water quality

4 SITE WATER BALANCE

As part of the Water Management Plan, measured data is to be used in application of ACOL's calibrated Water Balance Model at regular intervals (6 months). This will provide an ongoing means of validating the model and ensuring that the water balance remains efficient and manageable relative to available water licences and ACOL's policy of zero effluent discharge. Modifications to accommodate any significant changes in planned future developments that may affect the water balance will be undertaken when relevant.

The water balance comprises of several components depicting water sources, water storage and water use. These components are included in a water balance model which accounts for variability and reuse within the flow system. The water balance components and the associated water security as previously studied by Worley Parsons (2009c) are summarised below.

4.1 Water Sources

Water sources that are available for use at the ACP are listed in **Table 4.1**. The combined quantities of water available as controlled and uncontrolled sources are summarised further below in **Table 4.3.**

Table 4.1: Water sources

Raw (primary) water sources	Worked (used/recycled) water sources
• Licenced surface water extraction (Hunter River, Glennies Creek, Bowmans Creek). • Licenced groundwater extraction (Unconfined granular aquifer system of the unconsolidated sediments in the alluvium associated with the Bowmans Creek, Glennies Creek and Hunter River; and the porous fractured rock aquifer system in the Permian age sedimentary strata making up the coal measures). • Rain interception. • Clean surface runoff. • Town water supply (some trucked in potable).	• Site stormwater – runoff from roads, disturbed areas and partly rehabilitated areas. • Stockpile and overburden dump runoff and seepage. • CHPP discharge (tailings fine slurry/water). • Contaminated water – runoff from workshop/hardstand areas. • Treated effluent. • Mine inflow water (dewatered from OC and UG workings). • UG mine water transferred from Glennies Creek Coal Mine.

4.2 Site Water Use and Storage Facilities

Water is used on site for coal washing, dust suppression, potable applications (bathhouse/drinking), underground operations and irrigation. A summary of the typical flow regime, water storages and uses for the ACP is presented in **Table 4.2.** The dams presented in the Table and their associated catchment areas are all part of the water management system for the NEOC which is presented in **Figure 3**. Catchments overlying the underground mining area, which include rehabilitated subsidence areas can be regarded as having no "worked surface water" that needs to be managed within the water circuit affecting ponds and voids used to achieve zero effluent discharge. The inputs and outputs to the underground mining area as affected by the hydrogeology of the overlying materials are however accounted for in the water balance. The water circuit is depicted schematically in **Figure 4**.

Table 4.2: Water storage and flow regime

Storage			Catchment		Inflows	Out flows
ID	**Capacity/ Extraction limit**	**Purpose**	**ID**	**Area (Ha)**	**Source**	**Destination**
Raw Water						
Hunter River*	353.5ML/yr	• Available water licences, used predominately in CHPP and OC.	-	-	-	• Tank Farm. • Process Water Dam (PWD).
Glennies Creek*	449ML/yr	• Available water licences, used to supply the UG operations as a priority and for make-up water for coal washing and dust suppression.	-	-	-	• Tank Farm. • PWD.
Bowmans Creek*	380ML/yr	• Includes both irrigation (14ML) and industrial use licences (266ML water access and 100ML aquifer access).	-	-	-	• Tank Farm. • PWD. • Irrigation, agricultural use.
Tank Farm	-	• Receives water from Bowmans Creek, Glennies Creek and Hunter River. • Supplies clean water to the UG, Ravensworth Void 4 Floc Station and Potable water treatment plant. • Has the ability to supply the Settling Dam (SD). • Fire water.	-	-	• Bowmans Creek / Glennies Creek / Hunter River.	• Underground mine. • Potable water. • Ravensworth Void 4 Floc Station. • SD when required.
Potable Water	-	• Potable water treatment plant located at the Tank Farm.	-	-	• Tank Farm. • Town water.	• General site use.
Worked Water						
Dam 56	55.6ML	• Sediment control dam for the Eastern Rehabilitation Area (EEA).	D56	37.8	• EEA runoff. • Glennies Creek Mine.	• PWD. • Barrett/Hebden Pit.
Arties Pit Sump	30ML	• Runoff water catchment for UG pit top. • UG dewatering staging dam.	ARP	10.8	• Surface water runoff. • UG.	• SD.

<table>
<tr><th colspan="3">Storage</th><th colspan="2">Catchment</th><th>Inflows</th><th>Out flows</th></tr>
<tr><th>ID</th><th>Capacity/ Extraction limit</th><th>Purpose</th><th>ID</th><th>Area (Ha)</th><th>Source</th><th>Destination</th></tr>
<tr><td>Process Water Dam (PWD)</td><td>36ML</td><td>Central point for all water sources.
Provides water feed to the CHPP. Almost all water onsite has the ability to feed to this dam including clean water supplies from Hunter River and Glennies Creek and Bowmans Creek.
The combined PWD and SD have an emergency flood capacity of 89ML total storage.
This control enables pumping of excess stormwater, as a further precaution, to be initiated during large storms to maintain the buffer storage and contain all dirty water on site by pumping it to the Ravensworth Void 4 Tailings dam and or open pit areas.</td><td rowspan="2">PSD</td><td rowspan="2">133.2</td><td>Dam 56.
Barrett/Hebden Pit.
SD.
Hunter River and Glennies Creek when required.</td><td>CHPP make-up water.
Dust suppression and wash-down water in and around CHPP.</td></tr>
<tr><td>Settling Dam (SD)</td><td>22.5ML</td><td>CHPP, Workshop and OC surface water runoff catchment.
Supply water to CHPP.
Emergency flood storage when combined with the PWD.
This dam shares a dividing wall with the PWD. At high levels the SD and PWD can become a single storage. The SD provides sediment settling to prevent silting of the PWD and decreases TSS for CHPP feed water.</td><td>Disturbed surface water runoff (inc. CHPP, coal stockpiles, haul roads).
UG dewatering.
Arties.
Tailings dewatering.
Oil separator.</td><td>PWD.</td></tr>
<tr><td>NEOC (Barrett/ Hebden Pit)</td><td>Variable – open cut pit</td><td>Mining in the NEOC has now ceased and the void is available for excess emergency mine water storage and/or rejects.
Provides emergency flood/stormwater storage.
When the Ravensworth Void 4 (Tailings Dam) reaches capacity, fine rejects slurry from the CHPP will be discharged directly into the open cut void.</td><td>BHP</td><td>54.7</td><td>Groundwater and surface water inflows.
Storm event storage – inflows from Dam 56 and PWD.
Future CHPP discharge.</td><td>PWD.</td></tr>
</table>

Storage			Catchment		Inflows	Out flows
ID	Capacity/ Extraction limit	Purpose	ID	Area (Ha)	Source	Destination
OC Dust Suppression Tank	-	• Worked water pumped to a tank used for watering OC roads and infrastructure areas.	-	-	• PWD.	-
Underground Mine	-	• Raw water consumer, to be supplied clean river water. • Produces mine water, which is made up of inflows from groundwater and associated alluvial inflows and water that is supplied for UG use (e.g. LW and dust suppression).	-	-	• Clean water supply Glennies Creek / Hunter River/ Bowmans Creek. • Groundwater inflows. • Associated alluvial inflows.	• SD.
Ravensworth Void 4 (Tailings Dam)	~3.5Mm^3 (*Capacity not fixed. Available storage relative to quantity of tailings deposited*)	• Tailings are pumped from the CHPP to Void 4 via two dedicated pipelines. • Water can be pumped directly to Void 4 for temporary storage. • Decant (return) water is pumped back from the tailings void.	-	-	• CHPP – available in the fine rejects slurry discharge. • Stormwater.	• Decant (return) water to SD/PWD.
CHPP	-	• Largest demand for water at the ACP. • Consumes water for coal washing. • Generates water in tailings.	-	-	• PWD.	• Ravensworth Void 4 (Tailings Dam).
Ravensworth Underground Mine (RUM)	-	• An inactive, in principle agreement to pump water to RUM. This water would come from the PWD and is offset by a surface water licence held by RUM.	-	-	• Unknown.	• Unknown.
Glennies Creek Underground Mine	900ML/yr	• Agreement to receive mine water from the Intergra UG operations for reuse onsite.	-	-	• Integra.	• Dam 56.

Note * Restrictions on water extraction apply according to WSP rules as detailed in **Sections 6.2.1** and **7.2.1**.

4.3 Water Balance Model

The water balance for the ACP was reviewed in 2009, as part of the Bowmans Creek Diversion development consent modification application (Worley Parsons, 2009c). Model results are presented in **Table 4.3**. The model was calibrated against three years of site data (2006-2007). It allowed for future water management planning and is used to undertake the six-monthly site water balance reconciliation, which is reported in the AEMR.

A water balance is calculated simply as *change in storage = inputs – outputs*. Worley Parsons (2009) used the following data for calculations:

- Catchment areas from periodic mine survey data;
- Daily rainfall data from the real time rain gauge established at the repeater station (on the ridge line adjacent to and east of the NEOC);
- Pan evaporation data from Scone and Cessnock sites;
- Water conveyance data from flow and pump monitoring points including underground and open cut mine water flows, pumping from stormwater detention ponds in the various catchments, and imported water from off-site sources and water use such as CHPP water supply and dust suppression, and water supply for underground mine equipment;
- Water levels in water storage ponds or the main mine catchment storages; and
- Coal production, CHPP through-put and coal export data.

The balance varies in accordance with production and mine development, the climate, and water recycling/saving strategies implemented by ACOL to manage and conserve water within the compliance requirements of various government agencies.

The communication of the water balance (including data used to calculate it) to various operational teams within the ACP is an important aspect of Site water management, which enables the efficient use of water,

The Water Balance in Table 4.3 indicates that the available amount of water from controlled water sources (3.4ML/day) is more than the total demand for a secure water supply (3.3ML/day). The demands for less secure (uncontrolled water sources) varies between 0.2ML/day and 1.8ML/day while the availability from uncontrolled water sources varies between 1.5ML/day and 3.1ML/day. A small possibility exists that allocations of uncontrolled water from some licensed sources (creeks) could be zero during severe drought conditions while uncontrolled water recovered from under mining is more reliable.

Table 4.3 Worley Parsons water balance modelling results (excerpt)

Year	2011 to 2024
Water Demands (ML/Day)	
Dust Suppression	0
CHPP	3.0
Evaporation Losses	0.3
Total Demand	***3.3***
Controlled Water Sources (ML/day)	
Water received from Glennies Creek Mine	1.2
Licenced Extraction*	Up to 2.2
Total Controlled Water Source	***3.4***
Year	**2011 to 2024**

Uncontrolled Water Sources (ML/day)	
Net water make from underground mine	1.2 to 1.6
Annual Rainfall	**Surface Runoff (ML/day)**
10th Percentile	0.3
Average	0.9
90th Percentile	1.5
Total Uncontrolled Water Source	***1.5 to 3.1***
Annual Rainfall	**Required Controlled Water Source (ML/day)**
10th Percentile	1.4 to 1.8
Average	0.8 to 1.2
90th Percentile	0.2 to 0.6

Note: * Licenced extraction volumes subject to annual allocations that can be as low as 0% during dry periods.

Source: Worley Parsons, 2009c, *Bowmans Creek Diversion Environmental Assessment – Water Balance Modelling*, pg. 4.

4.4 Water Security

As a result of onsite water recycling, transfer of excess mine water from neighbouring mines and licensed water entitlements there is an adequate and secure water supply for the ACP under predicted worst case dry weather conditions based on the water balance information.

Site water management ensures that there is sufficient water for all stages of development during dry conditions and sufficient storage for periods of heavy rainfall without the need to discharge water from site. The Worley Parsons (2009c) assessment concluded that:

- The additional groundwater source from underground operations would increase the drought security of the ACOL operation;
- The increased inflow rates from the underground operations are insignificant when compared to the volumes of surface runoff predicted during major rainfall event. As such, underground mining would not adversely affect the capacity of the Mine Water System (MWS) to retain mine water runoff during major rainfall events; and
- The ability to harvest underground inflows of up to 3.4ML/day and the potential to store surplus stormwater from process areas in open pits such as the Hebden Pit provides the flexibility to maintain a balance between inflows and outflows during dry, average and wet periods.

If necessary, ACOL will adjust the scale of mining operations to match the water supply as per condition 4.1 to Schedule 2 of DA 309-11-2001.

5 SITE WATER MANAGEMENT

5.1 Water Management System

Key water management system (WMS) components are interconnected (via pipelines and drains) to provide water to operations and enable worked water to be redistributed between storages. A schematic flow diagram depicting these interactions is shown in **Figure 4**. By monitoring and managing dam available/spare capacity, the requirement for discharge during storm events is avoided.

Significant water management infrastructure (pumps, dams, pipes, tanks and drains) to move and store both raw and worked water throughout the Site is shown on **Figure 5**.

The WMS is updated as the Mine develops and any variations are reported in the AEMR.

5.1.1 Off-site Water Transfers

When required, ACP utilises mine water received via a pipeline from Glennies Creek Coal Mine underground operations under agreement. This water is transferred to Dam 56 before being pumped to the PWD and used as CHPP make-up water in preference to raw water.

Water, in the form of tailings, is piped off lease for disposal in one of the old Ravensworth voids (Ravensworth Void 4 (Tailings Dam)), under agreement with the landowner (Macquarie Generation). The decant water is pumped via a return line back to the PWD for re-use.

5.2 Surface Water Management

The strategy for managing water onsite includes:

- Clean water is kept separate from worked water flows where practicable;
- Minimising volumes of worked water by diverting clean water from up-slope areas;
- Collecting runoff from disturbed areas using drains and bunds and directing this to onsite storage dams;
- Maximising use of saline groundwater inflows to the Mine;
- Using excess worked water to irrigate mine rehabilitation areas, where quality permits. Water contained in remote sedimentation dams will also be used for irrigation of rehabilitated areas, where required. However, ACOL has been successful in its use of natural vegetation that does not require irrigation;
- Storing worked water for dust suppression or for coal processing purposes;
- Locating water management facilities in areas that minimise impacts to natural ecosystems and archaeological sites, where practical;
- Maintaining a sufficient operating free-board in Emergency Flood Storage Dams to accommodate the runoff for the design event. A visual marker indicates the required operating freeboard for each dam onsite, which is monitored regularly. Pumps are activated to transfer water to either the PWD as required, or if necessary the NEOC void; and
- Implementing contingency measures to prevent the accidental discharge of worked water.

5.2.1 Zero Effluent Discharge Policy

The management of worked water onsite prevents it from being discharged as per ACOL's commitments in the 2001 EIS and 2009 EA. However, this does not prevent potential future licenced releases under the *Hunter River Salinity Trading Scheme* (HRSTS), where the necessary salt credits can be obtained.

ACOL is not licensed (under the POEO Act) to discharge water into nearby streams, and has a commitment to retain a 100 year ARI, 72-hour duration storm event without the need for discharge.

5.2.2 Raw Water Management

Raw water is defined as "water that has not passed through a task" (DRET, 2008). Raw water includes water extracted under licence from watercourses and bores, or town water and clean surface runoff. Clean water required for underground use comes from the Tank Farm.

Bunding and drains along the boundaries of the NEOC minimises an exchange of water between the NEOC area and the surrounding road network and rail corridor. Worked water is channelled to onsite return water dams and clean water from external areas flows along natural and grassed flow lines to Betty's Creek and Bowmans Creek.

5.2.2.1 Clean Runoff

Catchments which are either rehabilitated, undisturbed (natural) or relatively undisturbed provide clean surface runoff.

The only remaining clean surface water runoff areas inside the ACOL mine lease, are above the underground mine area south of the New England Highway and small areas of rehabilitation that flow to external catchments. These flows will continue to be discharged via their 'natural' watercourses to Glennies Creek, Bowmans Creek and the Hunter River. Flows in natural drainage lines are monitored as mining progresses to ensure that potential erosion issues associated with subsidence (such as nick point development and surface cracking) are addressed promptly. Details of the specific subsidence management controls are contained within Subsidence Management Plans / Extraction Plans.

Gas drainage wells, situated above the underground operations, are raised above surface level to ensure clean water is diverted around the area.

Disturbed areas are minimised where possible and revegetated as soon as practicable to enable the creation of clean stormwater. As areas of rehabilitation advance, the quality of rehabilitation and runoff from will be assessed and where appropriate, clean runoff from completed rehabilitation areas will be allowed to leave site as clean surface water runoff.

5.2.2.2 Minimising Raw Water Use

ACOL operates the ACP as a nil discharge site. This means that the source of water and its onsite use are specifically managed to ensure there is no offsite discharge requirement. In practice this is achieved by strategically managing onsite water sources to ensure adequate onsite supply is maintained; recycling and re-using worked water, wherever possible; and ensuring all water used for mining and operational processes is fit-for-purpose. That is, the process water supply is drawn in order of preference from poorest quality onsite water sources, with supplementary supplies first being drawn from off-site excess mine water from neighbouring mines. Additional make up water is obtained using licensed surface water entitlements as a last resort, or where higher quality water is specifically required. This ensures that the draw of water from licensed creek/river entitlements is minimised to the greatest extent possible.

The following initiatives have been implemented to generally minimise onsite water use and to limit the requirement for drawing water from offsite raw water sources:

- Where possible, water is stored in tanks and transferred via pipelines rather than drains to minimise evaporation losses.

- All water used/pumped around site is metered, such that any unusual usage can be investigated.
- Pipelines are regularly inspected to identify any leakages.
- All water used in the coal washery for dust suppression is applied by fine sprays.
- All water spillage within the coal washery area is captured and returned to the Process water dam for reuse. .
- Dust suppression of exposed earthen areas is undertaken utilising controlled application strategies, including:
  - Spot spraying along haul roads rather than blanket saturation of the road surface. This is not only effective for the conservation of water but the safety of the haul roads.
  - Sending water carts to areas requiring watering thereby focusing their utilisation to key areas.
  - Using water carts on an as needed basis, depending on the weather and dust conditions.

These water use management and minimisation strategies are consistent with industry best practice.

5.2.3 Worked Water Management

Worked water is classified as “water that has passed through a task once” (DRET, 2008) and includes runoff from disturbed, contaminated or partly rehabilitated areas, waste and mine inflow water.

5.2.3.1 Disturbed Area Surface Runoff

Disturbed area runoff is generated from rainfall on the Eastern Emplacement Area (EEA), inclusive of partly rehabilitated areas. Even though this water generally has a low salinity level and the rehabilitation and on site drainage management methods minimise sediment movements, the water is always managed using the zero effluent discharge policy.

Stormwater flows on the upper catchment surface of the EEA are collected in two separate ponds. Pond overflows during peak storm events discharge this water at a controlled rate via the rock-lined drop structures and contour banks which are designed to attenuate stormwater around the EEA. Runoff from the EEA slopes is collected in perimeter drainage channels, which drain to Dam 56 in the east and the NEOC void to the west.

5.2.3.2 Mine Water

Mine water is water with varying concentrations of salts, generated from catchments where coal is mined or handled. These include the NEOC, the underground mine, coal stockpiles, the CHPP and haul roads.

The general arrangement of the drainage structures and sedimentation ponds is based on collecting and storing all runoff from mining and production areas. All rainfall on these areas is drained to various small sedimentation ponds/sumps from where it either drains under gravity or is pumped to the PWD. The drain feeding from the ROM stockpile and the CHPP is fitted with a sediment trap to reduce the quantity of fines entering the SD.

Excess groundwater from the underground operation is pumped to either the Arties Pit Sump or PWD. Inflow to the underground mine workings is determined by a mass balance of inputs, outputs and losses. Pumped inflows and abstractions are continuously measured, and water use onsite is estimated using a water balance model which is updated every six months.

Mine water is also transferred from Glennies Creek Coal Mine (underground) to ACOL. This water is then re-used for processes in preference to better quality water from external water sources, wherever the water quality is fit for the intended purpose.

5.2.3.3 Contaminated Water

Contaminated water is surface water that potentially contains hydrocarbons or other chemical pollutants. Hardstand, refuelling, workshop and lubricating areas are where this water could be generated.

Overflow/underflow baffles to restrict oil and hydrocarbon discharges are installed on drainage lines from the workshop and vehicle washdown bay. Water that is potentially contaminated is treated by an oil separator before being directed to the SD.

All site hydrocarbon storage areas are appropriately bunded (using impervious materials and include a wall height of 250mm, graded floor and collection sump) and inspected regularly. Bunds are of sufficient capacity to contain 110% of the volume of the tank (or 110% volume of the largest tank where a group of tanks are installed). Site bunding either does not have a drain valve incorporated in the bund structure, or has the drain valve locked.

No hydrocarbon storage areas are positioned where a spill could leave the site. In remote site areas, away from bunded fuel storage and refuelling areas, self-bunded fuel storage tanks are used in conjunction with spill containment kits.

5.2.3.4 Treated Effluent

Onsite effluent treatment using an enviro-cycle tank is used for bathhouse and toilet facilities.

Suitable quality effluent is used to irrigate selected approved re-vegetation areas. The irrigation of the effluent is in accordance with the EPA Environmental Guideline, *Use of Effluent by Irrigation*, 2004.

5.2.4 Dam Design and Construction

Dams have been constructed in accordance with design criteria to accommodate inflow from a 1:10 year, 24-hour storm event. Dam capacities and catchment areas for the site are detailed **Table 4.2** Freeboard exists for larger events of 1:100 year, 72-hour ARI to be accommodated by making use of pumps to redistribute water between dams and move excess water into the NEOC void and or the Ravensworth Void 4 Tailings Dam. Spillways are designed with the outlet located as far as possible from the inlet to minimise the potential for short-circuiting during events which exceed design capacity.

Dam 56 has an emergency overflow into an unnamed tributary of Betty's Creek. The risk of spillage is however negated through the above mentioned redistribution of water as well as operating strategies to lower the freeboard during wet periods when access to uncontrolled water sources is more reliable.

5.3 Groundwater Management

The strategy for groundwater management is to minimise groundwater inflows to the open cut and underground mine. It involves the adherence to mining practices that minimise the potential for interconnection between aquifers or enhancement of permeability in barriers between the open cut and underground workings and surface watercourses (and their associated alluvial aquifers).

The underground mining of the Upper Liddel Seam (ULD) will be done in two stages. Considerable mitigation is achieved as mentioned above through the planned positions of the longwalls which avoid or minimise subsidence in the vicinity of the Glennies Creek and Hunter River Alluvium. Stage 1 is planned so that Bowmans Creek Alluvium is largely avoided during the extraction of ULD LWs 1 to 4.

The Bowmans Creek contains several meanders and two clay lined river diversions were designed so that Stage 2 mining of the ULD (which involves extraction of ULD LWs 5 to 8) could be planned so that no subsidence occurred below the diversions and the remaining active channel reaches. The diversion lining will minimise the risk of losses of baseflow water originating from upstream areas but some reductions are expected in the remaining alluvial areas. ACOL is committed to accounting for these reductions through licensed water allocations as discussed below.

5.3.1 Baseflow

ACOL will account for the reduction (**Table 6.1** in **Section 6.2.1**) of groundwater contributions to the alluvium and baseflow for the Bowmans Creek, the Glennies Creek and the Hunter River as follows:

- An internal underground water seepage account has been established within the ACOL balance sheet for licensed water draw from the Hunter Regulated and Unregulated River System. The internal underground water seepage account will be managed in accordance with the rules of the relevant Water Sharing Plans. Water assigned to the account is to be from the appropriate water source;
- As requested and agreed to by NOW, in relation to existing and future Glennies Creek baseflow reductions, to ensure adequate water can be sourced for this purpose, ACOL has purchased significant volumes of high security water to cover the seepage requirement even under periods of reduced allocation. This high security water is prioritised for this purpose;
- ACOL will account for the reduction under existing Water Access Licences, to the Minister administering the *Water Management Act* 2000, for the reduction in baseflows in Bowmans Creek for the duration of underground mining in accordance with the amount of reduction (the amount will vary over the life of the mine). By the end of ULD extraction, the cumulative net baseflow impacts are predicted to be 9.31ML/y for Glennies Creek, 27ML/y for Bowmans Creek and 7.3ML/y for the Hunter River. These predictions will continue to be assessed as mining progresses; and
- ACOL shall also ensure that in any licensing period enough water has been allocated to the internal underground water seepage account to cater for the seepage inflows to the underground workings.

At the conclusion of underground mining operations, ACOL will permanently surrender existing Water Access Licences with an appropriate share component to the Minister administering the Water Management Act 2000 for any future ongoing loss of baseflows in Bowmans Creek, Glennies Creek or the Hunter River. The actual volumes will be based on the difference between the pre mining baseflow gain and the baseflow loss after recovery. The final values to be used will be negotiated with NOW at various stages of the mine’s life as new information becomes available and model calibration and projections are refined.

Mitigation of subsidence effects to Bowmans Creek flows will be achieved through the diversion of two sections of the Creek. In areas other than those made redundant by the diversion, impacts will be managed by maintaining a setback between the underground workings and any point vertically beneath the high bank of active Bowmans Creek by at least 40m.

Impacts to the Hunter River alluvium will be managed by maintaining a setback to the southern limits of LWs 2 to 7 by a distance of at least 200m from the alluvium. The mine plan will be reviewed in response to actual subsidence and geotechnical behaviour associated with mining in the deeper seams based on monitoring experience.

The ULD LW1 to LW8 mine plan is offset to the west of the PG LW1 to 8 mine plan, by 60m. This offset will minimise any additional baseflow losses from Glennies Creek by the extractions of ULD LW1 and subsequent LWs, by maintaining the permeability characteristics of the hard rock within the barrier between LW1 and Glennies Creek.

6 SUMMARY OF PREDICTED IMPACTS

6.1 Overview

6.1.1 ACP Site Impacts and Management

As indicated, the ACP consists of two main water monitoring and management areas, namely the NEOC area (inclusive of CHPP, coal stockpiles and support infrastructure) and the underground mining area. The approach to water management, in both areas is not identical. Some aspects of this WMP apply holistically to the entire ACP, while other water monitoring and management aspects have been tailored to cater for the particular issues expected to be encountered in each area.

The primary difference lies in the strategies developed to maintain water quality. For example, in the open cut area and surrounds attention is given to onsite containment and reuse to avoid the need for treating and discharging water off site.

In contrast, the runoff from the area above the underground mine is classified as clean water runoff and allowed to discharge naturally to surrounding surface water sources. Here the focus is to ensure that mine subsidence effects are appropriately managed and remediated to ensure that water quality and sediment loads in surface drainages are maintained at levels equal to or better than pre-mining conditions. Of further importance to the underground mining area, is the management of the interaction between surface water and groundwater.

ACOL has approved water management plans that have dealt with the development of the ACP, inclusive of the NEOC. The suitability of, and the effective implementation of these plans has been demonstrated through ACOL's ability to manage its site water to maintain zero effluent discharge. This WMP draws on and continues to apply the details presented in the previous plans, 2001 EIS and 2009 EA, where appropriate.

This WMP also incorporates strategies to address additional requirements of the DA associated with more recent development modifications and the need to include specific water management measures associated with the planned longwall extraction of the ULD Seam.

The water management strategy for the underground area and ULD Seam extraction has been broadly divided into two components, Stage 1 which addresses ULD Seam longwall panels 1 to 4 (ULD LW1-4) and Stage 2 which addresses ULD Seam longwall panels 5 to 8 (ULD LW5-8). This WMP focuses in more detail on the ULD Stage 1 area, with only broader context provided for the ULD Stage 2 area. Prior to mining the ULD Stage 2 area, the WMP will be reviewed and updated to incorporate additional monitoring and management measures for the Stage 2 area, where required.

A separate management plan has been prepared for the construction and initial rehabilitation phase of the Bowmans Creek diversions and this is included as **Appendix E** to this plan for completeness.

6.1.2 Underground Area

As the longwall miner progresses along the panel and coal is removed, the overlying strata collapses into the mined void. This causes subsidence and fracturing of the overlying strata.

6.1.2.1 Surface Drainage

Subsidence above longwall panels causes localised changes in surface topography. The natural surface drainage patterns can be affected and remedial works are needed to close and seal fractures as well as restore effective surface drainage patterns. The subsidence is therefore projected and monitored. The affected areas are rehabilitated and landscaped to minimise the risk of ingress of surface runoff into subsidence fractures, restore surface drainage and minimise the risk of uneven surfaces to livestock. Potential impacts on surface and groundwater resources are also managed as explained below.

6.1.2.2 Subsidence Effects in the Alluvium

Subsidence due to longwall mining can cause a temporary or permanent increase in the hydraulic conductivity and water storage capability of the overlying strata. However, the extent of change in aquifer properties can, to some extent, decrease due the gravimetric pressure caused by the increase in rock mass with depth.

Ingress of water into mined voids and subsidence fractures causes a decrease in natural piezometric pressure within the coal seams and other overlying strata, resulting in the development of a dewatering cone above the underground workings (this drawdown cone can recover over time subject to post mining conditions). The water table is reduced across the surface of the cone which extends outwards and can intercept alluvial aquifers alongside creeks and rivers potentially causing diffuse discharge of water from these sources toward the drawdown cone.

Subsidence in some cases can cause the extent of lowering of the base of the alluvium to be more than the corresponding level to which the water table will recover. The result is a beneficial gain in the saturated thickness and storage of the aquifer. The final level of recovery of the water table may in some cases be slightly less than prior to subsidence and a reduction in creek baseflow could occur. Baseflow reduction can also occur if subsidence fractures are affecting the integrity of the channel floor or create or enhance any connectivity between the alluvium aquifer and underlying mine workings or other underlying aquifers.

The level of detail for groundwater monitoring needs to be increased in the vicinity of areas likely to be affected. The monitoring results need to be evaluated at regular (weekly or fortnightly) intervals, compared to forecasts based on modelling and reported appropriately (e.g. in an End of Panel (EoP) Report). Subsidence can also impact on the groundwater monitoring network, which will need to be revised on a case by case basis to meet the requirements for monitoring of future mining and groundwater recovery.

> ***Note**: The amounts of drawdown and impacts on aquifer storage and baseflow reduction are predicted using groundwater models. At the ACP, the detailed monitoring network has provided extensive amounts of data so that the calibration of groundwater models can be updated at appropriate times for reliable use in predicting the water related impacts of mining. The quantities involved are generally small and manageable based on monitoring and experience to date in mining the overlying PG Seam as well as the model projections for extractions in the ULD Seam.*

6.2 Subsidence Impacts on Surface Water

The potential water impacts of coal extraction, and the associated mitigation and remediation measures needed to accommodate the impacts described in this WMP are summarised below.

6.2.1 Surface Water Resource Impacts

The result is a very small reduction in baseflow to Bowmans Creek, Glennies Creek and Hunter River (RPS Aquaterra, 2011a) associated with a projected minor amount of groundwater drawdown within the alluvium.

The Stage 1 mine area will not undermine Bowmans Creek, Glennies Creek, the Hunter River or their associated saturated alluvium and will therefore have negligible direct effect on the water resources within these water sources (RPS Aquaterra, 2011a). In contrast, Stage 2 (ULD LW5-8) mining will occur below Bowmans Creek alluvium. (Note at no stage will longwall extraction occur beneath Bowmans Creek as diverted).

The ULD Seam underlies the PG Seam and generally outcrops to the east of Glennies Creek. The layout of ULD LWs has been offset to the west of the PG LWs by about 60m to reduce the effects of subsidence due to multi-seam mining and to minimise the potential for increased interaction between ULD LW1, Glennies Creek and its connected alluvium. At its closest, the ULD LW1 tail gate is at least 170m west of Glennies Creek and its connected alluvium (see **Figure 6**). Given this separation distance and seam outcrop location (east of the creek), it is not expected that ULD LW1 will be hydraulically connected to Glennies Creek or its alluvium. Hence ULD LW1 is predicted to have minimal effect on the creek.

The proposed ULD LW1 start line is located in the vicinity of the edge of the Hunter River alluvium, but within hard rock generally greater than 100m below the surface, with longwall extraction planned to progress north away from the alluvium where the topography rises. The ULD LW4B void will be offset by at least 70m east of Bowmans Creek, including the eastern Creek diversion (see **Figure 6**). This offset will ensure the longwall void will be more than 40m (in a horizontal direction) from the high bank of the Creek. The reduced panel width also minimises the risk of subsidence fractures affecting the integrity of the Bowmans Creek channel floor. The depth of cover above ULD LW4B at its closest point to the creek is generally greater than 125m.

The decreased amounts of baseflow as a result of the ULD LWs 1 to 4 together with cumulative impacts from other (non-Ashton) mining activities are shown in **Table 6.1**.

Table 6.1: Projected reduction in baseflow amounts after selected stages of mine development

Impacts on Baseflow	Total by end of PG LW8	Total by end of ULD LW 1-4	Increment due to ULD LW 1-4	Total by end of ULD LW 5-8 since PG LW 8	Increment due to ULD LW 5-8 and after ULD LW 1-4
Baseflow impacts to Glennies Creek	2.60L/s	2.90L/s	0.30L/s	3.00L/s	0.01L/s
Baseflow impacts to Bowmans Creek	0.45L/s	0.59L/s	0.14L/s	0.86L/s	0.27L/s
Baseflow impacts to Hunter River	0.07L/s	0.13L/s	0.06L/s	0.23L/s	0.10L/s

ACOL has committed to secure appropriate water licences to account for reduced baseflow caused by the ACP to these surface water sources (see **Table 2.2**).

Further, from year six of the WSPHUAWS (i.e. from July 2015) new rules will commence governing when water can be taken from the managed water sources (Bowmans Creek) under low flow conditions (i.e. 'cease to pump' rules). This will mean that ACOL may need to return some water to Bowmans Creek under cease to pump conditions to account for water that may be removed from the creek as a result of the operation during these periods. To satisfy this future requirement, ACOL will utilise its Regulated River licences to transfer water from the Hunter River or Glennies Creek to Bowmans Creek, whenever the WSP 'cease to pump' conditions apply to Bowmans Creek. Alternately where available ACOL may utilise water stored on site to transfer to Bowmans Creek under these conditions. The amount of returned water will be equal to or greater than the reduction caused by the mine and at equal or better quality.

6.2.2 Flooding and drainage

Surface drainage and flood prone areas must be managed to accommodate surface subsidence effects on flood extents and risks associated with subsidence. Typical risks include ingress to underground aquifers and mining areas, disruption of surface drainage patterns, surface ponding and alteration of extent of areas inundated during flooding. The level and extent of subsidence associated with mining the ULD seam is shown on **Figure 7** and described further in SCT, 2011. The 1:100 year flood levels for the Hunter River, Glennies Creek and Bowmans Creek are shown on **Figure 8**.

Almost the entire area for proposed Stage 1 mining of the ULD Seam (ULD LWs 1 to 4) lies outside the 1:100 year Hunter River, Glennies Creek and Bowmans Creek flood levels. The Stage 1 mining activities are unlikely to affect the extent of inundation due to flooding.

The ULD coal seams in the Stage 1 mining area dip naturally towards the south west commencing at about 150m below the surface at ULD LW1 and depths increase with distance away from Glennies Creek. Subsistence fractures at these depths are not expected to be rapid conduits of any ponded water, water in drainage lines and flood risks are not expected to be problematic, even in the unlikely event of the area overlying the Stage 1 extraction zone becoming submerged.

ULD LW4B lies just east of the oxbow on the Bowmans Creek and is also very close to the 1:100 year flood line, however, the land surface to be affected by its subsidence lies just beyond the edge of the flood line and is more than 40m back from the Creek. As part of the remediation presented in this WMP, any subsidence fractures in or in close proximity to flood prone areas, will be rehabilitated as soon as possible after subsidence; even though the risk of flood related impacts to deep seated underground workings is small.

For Stage 2, the extraction will occur at much greater depths and mining is planned to occur in hard rock, well below alluvium soils and flood prone areas along Bowmans Creek. Subsidence fractures are projected to be less permeable with increasing depths of mining. Despite this the Creek is being diverted in two areas and mining will not occur directly below these diverted sections nor the sections along which the creek will continue to flow. A similar approach of mining below the flood prone areas, but not directly below the main channel, was implemented during extractions of the PG Seam which overlies the ULD. During the PG extraction the subsidence fractures at the soil surface were rehabilitated to minimise risks of direct ingress of surface runoff (overland flow and local drainage lines) and no significant underground inflows were attributed to water arising from surface runoff despite above the above average rainfall early in 2011.

As the ULD longwalls (Stage 1 and 2) will be offset 60m to the west of the PG panels, the landscaping required in maintaining natural surface drainage will be less onerous than that which would have occurred without the offset. However, during subsidence, the offset and natural dip of the strata may cause a small amount of horizontal shift towards the west. Some horizontal subsidence fractures may therefore be wider and more noticeable at the soil surface on the upslope or eastern side of the subsidised zones. Such fractures will be more prone to ingress of surface runoff.

As part of the implementation of the WMP together with the Extraction Plan, these fractures will be repaired as soon as possible after subsidence events, and particularly in areas prone to flooding and fracture zones crossing drainage lines. This will reduce risks of ingress of surface water to mine workings and also reduce other associated risks such as those to livestock.

During Stage 2 (ULD LWs 5 to 8) and also the successive stages of mining below the alluvium, the extent and depth of natural flooding could increase in some areas in response to subsidence. The excess material from constructing the Bowmans Creek Diversion is therefore being deposited at strategically located stockpile sites in these areas. These stockpiles will be appropriately covered with topsoil and natural vegetation. These emplacements will assist in either curtailing the extent of flooding or reducing the depth of inundation.

Flooding in Glennies Creek occurs predominantly across its eastern banks while the proposed mining is west of the Creek. Higher elevations on the western side where ULD LW1 is located, ensures that the mining area is not affected by flooding in the Glennies Creek. Subsidence zones above this longwall are about 300m away from the creek and its alluvium soils. Flood risks are negligible but fractures must be in-filled giving priority to sections that cross drainage lines.

The Hunter River is incised along the area to the south of ULD LWs 2 to 4. These longwall areas are all located north of the Hunter River's 1:100 year flood line and the overlying surface is well above the floodline. Fractures will be rehabilitated as a precaution against flooding but mostly to prevent ingress from overland flow, minor drainage lines, maintain drainage paths and prevent unnecessary ponding.

6.2.3 Subsidence and Surface Drainage Lines

The post-ULD seam subsidence topography is shown on **Figure 7** and will, to a large extent, preserve the primary drainage directions of the original topography.

The topography above ULD LWs 1 to 4 remains at elevations higher than the creeks, and surface runoff can be directed towards the creeks without unnecessary ponding. Landscaping may be needed in low lying areas to reduce ponding and also to ensure continued drainage along existing drainage paths as far as practicable. The approximate positions of the post-subsidence drainage lines, after landscaping to maintain drainage are shown on **Figure 7**. The re-establishment of natural surface vegetation will be undertaken for soil conservation purposes.

The drainage across the Stage 2 extraction area (ULD LWs 5 to 8) will be affected by subsidence but the flow from upstream areas will be routed through the lined Bowmans Creek Diversion. The BCD planning also allows for the creation, for environmental purposes, of some billabongs. These will accommodate localised drainage into subsided areas of the existing creek which includes some existing ponds. They will be sustained by such drainage and allowance is made for flood water and ecological water requirements to be diverted through or over purpose built block banks located at the entrances of the river diversions.

The planned billabongs, block bank structures and flood mitigating stockpiles are described in the EA for the Bowmans Creek Diversion (Evans & Peck Pty Ltd, 2009). Appendix E presents a separate WMP, which deals specifically with the construction stage of the BCD.

6.2.4 Surface Water Quality

Since it is not proposed to discharge mine water under normal operating circumstances, no impacts on water quality in Bowmans Creek, Glennies Creek or the Hunter River are expected, during the operating life of the Mine.

The water quality of natural surface runoff (overland flow and local drainage lines) from the subsided area should not be affected in any significant manner by the underlying longwall mining, provided that:

- subsidence fractures are rehabilitated;
- surface drainage lines are maintained;
- ponding is prevented, as far as practicable; and
- natural vegetation is preserved for soil conservation purposes.

The natural soil water flux should be maintained through these remedial measures without disruption to the natural soil water and hydro-salinity flux.

The quality of the receiving waters is monitored to confirm that no adverse impacts are occurring. The water quality monitoring network and programs are discussed in **Section 9.**

The PG Seam, which overlies the ULD extraction area, has been completely dewatered and extractions in the underlying ULD seams will tend to continue to maintain reduced potentiometric pressures in the overlying semi confined Permian Strata. This reduces the likelihood of saline water rising upwards, towards the surface water. The drainage is essentially in the opposite (downward) direction in the area above ULD LWs 1 to 4. This is discussed further in **Section 6.3**.

The overall mine design also includes provisions to ensure that any accidental discharge of worked water or fine tailings will be contained by strategically located bunding and pits, and pressure-loss activated cut-off switches on pumps.

6.3 Groundwater Impacts

6.3.1 Groundwater Levels

The impacts of mining on groundwater (largely due to dewatering, and the impacts of subsidence fracturing on aquifer properties) can affect the interaction between the porous rock aquifer system and the overlying alluvium, often incurring losses from alluvium and baseflow in water courses.

RPS Aquaterra (2012) modelled the cumulative as well as incremental impacts of progressive underground mining on drawdown in the alluvium and baseflow, amongst other parameters. The mine schedule applicable to the ULD is shown in **Figure 9**. The drawdown amounts projected by the end of mining the PG Seam, end of mining ULD LWs 1 to 4 and end of mining ULD LWs 5 to 8 are summarised in **Table 6.2**

Table 6.2: Summary of projected drawdown amounts for selected areas and stages of mining

Groundwater level impact	Total by end of PG LW5-8	Total by end of ULD LW1-4	Increment due to ULD LW1-4 (since PG LW8)	Total by end of ULD LW5-8	Combined increment due to ULD LW5-8 and ULD 1-4 (since PG LW8)
Glennies Creek Alluvium					
East of southern portion of ULD LW1	0.05m	0.11m	0.06m	0.16m	0.11m
East of central portion ULD LW1	0.14m	0.18m	0.04m	0.20m	0.06m
Hunter River Alluvium					
South of ULD LW4	0.00m	0.01m	0.01m	0.01m	0.01m
Bowmans Creek Alluvium					
In the vicinity of the oxbow meander west of ULD LW4B	0.32m	0.45m	0.13m	0.73m	0.41m

6.3.2 Aquifer Properties

The impacts of subsidence fracturing on vertical and horizontal hydraulic conductivity and storage characteristics is reflected in the manner in which water levels respond to subsidence events and through ingress to mine workings.

To the east of ULD LW1 the permeability characteristics of the PG seam and overburden along the alignment of PG TG1 (in an area referred to as the 'barrier') are predicted to be maintained. This will minimise any additional baseflow losses from Glennies Creek, caused by the extraction of ULD LW1 (and subsequent LWs), by maintaining the permeability characteristics of the hard rock within the barrier between ULD LW1 and Glennies Creek. An unexpected or significant increase in the permeability characteristics of the barrier might indicate an impact to Glennies Creek that is greater than predicted.

6.3.3 Groundwater Quality

Modelling indicates there will be no upward migration of saline water due to the creation of voids through mining and subsidence giving rise to a loss of pore pressure in the semi-confined Permian horizons. It is therefore projected that the ACP will result in an improvement in water quality. There are also significant in-situ barriers between the mine workings and the Hunter River and Glennies Creek alluvium, which reduce the risk of groundwater moving from underground workings to surface water bodies. The risk is considered to remain negligible, even during the post mining recovery period. The large vertical separation between the mine workings and Bowmans Creek alluvium and the strong downward gradients also prevents the unlikely impact on the water quality of the alluvium.

6.3.4 Groundwater Users

There are no non-ACOL registered bores in surrounding areas that will be impacted by the underground mine. The reason for this is that most of the drawdown due to the underground mine occurs in close proximity to the mined area.

The positions of registered bores within a 4km radius of the underground mining area are shown on **Figure 10**.

Based on model predictions and monitoring observations during longwall mining of the PG Seam, drawdown impacts due to the underground operation are not expected to propagate over longer distances towards private registered bores in surrounding regions.

6.3.5 Groundwater Dependent Ecosystems

The River Red Gums (RRGs) are the only identified groundwater dependent ecosystems (GDEs) in the vicinity of underground mining (**Figure 10**). Small stands of RRGs are located on:

- Bowmans Creek, outside the mining lease and within 1km from the Hunter River confluence (Marine Pollution Research Pty Ltd, 2009); and
- Glennies Creek to the east of LW1, including a small stand growing on the east bank near the midway point of LW1 and a single RRG tree on the east bank located near the northern section of LW1 (ERM, 2009).

None of these GDEs are predicted to be impacted by underground mining in the PG or ULD seams (Aquaterra, 2009c and RPS Aquaterra, 2012). Ecological investigations demonstrate that there are no GDEs within the parts of the Glennies Creek or Bowmans Creek alluvium that are predicted to be affected the extraction of ULD LWs 1 to 8.

7 IMPACT ASSESSMENT CRITERIA

7.1 Methodology – Water Quality Trigger Levels

Guidelines for assessing water resource (surface water and groundwater) suitability as presented in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* 2000 (ANZECC/ARMCANZ, 2000) provide a generic approach for the development of low and high risk trigger values.

Trigger levels are "*the concentrations (or loads) for each water quality parameter, below which there exists a low risk that adverse biological (or ecological) effects will occur. They are the levels that trigger some action; either continued monitoring in the case of low risk situations or further ecosystem-specific investigations in the case of high risk situations*" (ANZECC/ARMCANZ, 2000).

Some analytes (pH, EC, TDS and/or hardness) are easily and regularly monitored using electronic data loggers or low cost in situ measurements. These are well suited for continuous or frequent monitoring. Site-specific trigger values (the desirable range or upper limit only) have been developed for these key analytes and are presented in **Appendix C**. When a sample (or median in a set of samples) exceeds the 80th percentile (20th or 80th in the case of pH), the trigger provides an 'early warning' mechanism to alert the Environmental Coordinator of a potential or emerging change that will need to be followed up.

The ANZECC/ARMCANZ (2000) default trigger values are presented below in **Table 7.1** for reference for a limited number of analytes (as available in the Guidelines) for the surface water quality data analysis in **Appendix C**, and the groundwater quality data analysis in **Appendix E**. Trigger values have been selected for 'slightly to moderately disturbed ecosystems' as the environment at the ACP contains some cleared catchments, partly intact riparian vegetation and the ecosystem integrity is largely retained. Baseline ranges are still relevant however to understand natural conditions.

Table 7.1: ANZECC (2000) trigger values for water chemistry

Parameter	Units	95% Protection of freshwater species [a]	South east Australia freshwater ecosystems
pH	pH Units		6.5 – 8.5[b]
Electrical Conductivity (EC)	µS/cm		200 – 300[c]
Aluminium	mg/L	0.055	
Ammonia (Total)	mg/L	0.9[d] (at specific pH of 8)	
Arsenic	mg/L	0.024 (As III) / 0.013 (As V)	
Boron	mg/L	0.37	
Cadmium	mg/L	0.0002	
Chromium	mg/L	0.0033 (Cr III)[e] / 0.001 (Cr VI)	
Copper	mg/L	0.0014	
Lead	mg/L	0.0034	
Manganese	mg/L	1.9	
Mercury	mg/L	0.00006	
Nickel	mg/L	0.011	
Nitrate as N	mg/L	0.7	
PAH (Naphthalene)	mg/L	0.016	

Parameter	Units	95% Protection of freshwater species [a]	South east Australia freshwater ecosystems
Selenium	mg/L	0.011	
Turbidity	NTU		6 – 50[c]
Zinc	mg/L	0.008	
Total Nitrogen	mg/L		0.5[b]
Total Phosphorus	mg/L		0.05[b]

Notes **a** Taken from trigger values for toxicants for freshwater – 95% protection of species, slightly-moderately disturbed ecosystems (ANZECC/ARMCANZ, 2000, Table 3.4.1).

b Taken from default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed freshwater aquatic ecosystems – Lowland rivers (ANZECC/ARMCANZ, 2000, Table 3.3.2).

c Taken from default trigger values for conductivity (EC, salinity), turbidity and suspended particulate matter (SPM) for south-east Australia for slightly disturbed freshwater aquatic ecosystems – Lowland rivers (ANZECC/ARMCANZ, 2000, Table 3.3.3).

d Temperature and pH is to be taken into consideration when using this trigger value for ammonia as per ANZECC/ARMCANZ (section 8.3.7.2, 2000).

e Indicative trigger value according to Section 8.3.7 ANZECC/ARMCANZ (2000) Guidelines, Volume 2.

The hardness of the water is taken into consideration when comparing site water quality results to the above trigger values for metals (cadmium, chromium (III), copper, lead, nickel and zinc) as per ANZECC/ARMCANZ (Table 3.4.3, 2000). The calculated hardness-modified trigger values for each surface water monitoring location are presented in **Table 7.2**.

Table 7.2: Calculated trigger values for metals affected by water hardness (mg/L)

Site	Median Hardness	Cadmium	Chromium (III)	Copper	Lead	Nickel	Zinc
SM1	39.5	0.0003	0.0041	0.0018	0.0048	0.0139	0.0101
SM2	88.5	0.0005	0.0080	0.0035	0.0134	0.0276	0.0201
SM3	234	0.0012	0.0178	0.0080	0.0462	0.0630	0.0459
SM4	248	0.0013	0.0187	0.0084	0.0497	0.0662	0.0482
SM5	247	0.0013	0.0186	0.0084	0.0495	0.0660	0.0480
SM6	218	0.0012	0.0168	0.0076	0.0422	0.0594	0.0432
SM7	90	0.0005	0.0081	0.0036	0.0137	0.0280	0.0204
SM8	93	0.0005	0.0083	0.0037	0.0143	0.0288	0.0209
SM9	219.5	0.0012	0.0169	0.0076	0.0426	0.0597	0.0434
SM10	209.5	0.0011	0.0162	0.0073	0.0401	0.0574	0.0417
SM11	92	0.0005	0.0083	0.0036	0.0141	0.0285	0.0207
SM12	159	0.0009	0.0130	0.0058	0.0283	0.0454	0.0330
SM13	207.5	0.0011	0.0161	0.0072	0.0396	0.0569	0.0414
SM14	213.5	0.0011	0.0165	0.0074	0.0411	0.0583	0.0424

As the monitoring record lengths increase, the statistical properties of the data sets reflect the natural variability more meaningfully. If the record lengths and monitoring frequency increase and provide more data over time (24 data points in two years), the criteria based on ANZECC/ARMCANZ (2000) may be superseded in some instances.

Annual audits present a means of detecting anomalous trends but it is not practical to keep updating trigger values on an annual basis. The approach adapted for this WMP and recommended for future WMPs is to revise the trigger values after five year periods or prior to any EA aimed at significant new developments so that the updated information would constitute a new baseline condition prior to the new development. Annual audits will however provide a means of checking if significant local changes justify more detailed studies and interim revisions of trigger values or the monitoring network. Results of any updated trigger values and the creation of reference sites will be discussed with NOW prior to implementation.

7.2 Surface Water Impact Assessment Criteria

7.2.1 Surface Water Resource

Surface water impact assessment for reductions in baseflow to Bowmans Creek, Glennies Creek and the Hunter River are projected from calibrated groundwater models. The actual flows in the creeks are monitored through observations of stream flow as detailed in **Section** 0.

Reductions in baseflow associated with ACP operations are regarded as an indirect take of water associated with lowering of alluvial water table levels due to the effects of mining and will be accounted for against water licenses held by ACOL. The availability of water for licensed take and the conditions under which licensed allocations can be taken are regulated through the Water Sharing Plans for the Hunter Regulated River Water Source (HRRWSWSP) and the Hunter Unregulated and Alluvial Water Sources (HUAWSWSP).

The predicted impacts on baseflow due to PG seam and ULD seam extraction have been summarised earlier in **Table 6.2**. The table shows that the combined impacts on baseflow in Bowmans Creek, Glennies Creek and the Hunter River are all relatively small. These quantities are easily accommodated with existing ACOL water licences presented earlier in **Table 2.2**.

The modeled predictions are based on average climatic conditions. Actual responses may vary with climatic conditions and any changes in the planned mining schedules. Observations reported in (RPS Aquaterra, 2012) of PG mining induced drawdown amounts in the alluvium and the associated implications for baseflow reductions were less than those predicted by modelling for average climatic conditions. This is largely due to rapid water level recoveries in the alluvium following above rainfall and recharge amounts in 2011. The observed and predicted impacts are summarised in **Table 7.3**

Baseflow impacts to Glennies Creek are monitored via inflow rates recorded at TG1A (eastern most heading of LW1), which is specifically monitored to allow assessment of the seepages from the Glennies Creek area (Creek and alluvium). A sudden increase in observed seepages measured at TG1A which exceeds the predicted Glennies Creek seepage rate for three consecutive months (**Table** 7.3**)** at any stage during the mine life has been established to be the most appropriate trigger.

For the Hunter River and Bowmans Creek, the baseflow impacts cannot be measured directly from seepages underground. Instead, a sudden drawdown in the Bowmans Creek or Hunter River alluvium that is greater than the predicted drawdown might indicate a baseflow impact that is also greater than predicted. Likewise a sudden increase of mine inflows (and corresponding decrease of inflow EC) may also indicate a baseflow impact that is greater than what was predicted. The impact assessment criteria for monitoring baseflow impacts as a result of groundwater drawdown and mine inflows are further discussed under **Sections 7.3.2** and **7.3.5**.

Table 7.3: Modelled baseflow impacts

Baseflow impact	Total modelled impact at end of PG LW8[1]	Impacts observed to date PG LW 1-7B	Total cumulative modelled impact ULD LW 1-4[1]	Additional modelled impact ULD LW 1-4[2]
Glennies Creek	2.6 L/s	~1.5 L/s	2.9 L/s	0.3 L/s
Bowmans Creek	0.45 L/s	Nil due to alluvium water levels rapid recovery	0.59 L/s	0.14 L/s
Hunter River	0.07 L/s	No impact	0.13 L/s	0.06 L/s

Notes: **1** Total impacts are cumulative impacts from all mining in the area.

2 Additional impacts refer only to impacts predicted to occur as a result of ULD longwall operations.

7.2.2 Surface Water Quality

The trigger levels (20th and 80th percentiles) for key water quality parameters (pH, EC, TDS, TSS and hardness) to monitor the affects the ACP on surrounding surface water sources have been updated for this WMP. The revised trigger levels as shown in **Appendix C** are based on data from sampling conducted between September 2003 and December 2011, where there were a sufficient number of data points (observations) within two years to do so (SM3 – SM14).

Other analyte results (from comprehensive laboratory analysis) for all monitoring sites were taken from a limited number of samples collected between August 2007 and August 2011. As there are fewer than 24 data points over a two year period for the remainder of the analytes, the range can be used to further understand the hydro-chemical state of each watercourse.

The monitoring network is described in **Section 8.2** and **Section 9.1** and surface water monitoring locations are presented on **Figure 11**.

*Note: In **Appendix C** table when quantities of a substance fall below the Limit of Reporting (LOR) a '<' symbol is applied to the number by the laboratory. When analysing results the '<' symbol was removed, as a 'less than a number' has no value and cannot be evaluated. Hence in these instances some values are potentially over estimated.*

7.3 Groundwater Impact Assessment Criteria

Subsidence associated with longwall mining has the potential to affect the local hydrogeological system, which needs to be evaluated and managed over time, including:

- Impacts on baseflow to Bowmans Creek, Glennies Creek and the Hunter River (addressed under **Section 7.2** above);
- Impacts on groundwater levels within the Permian hard rock strata and particularly in the alluvium associated with Bowmans Creek, Glennies Creek and the Hunter River;
- Changes to hydraulic conductivity (permeability) in the 'barrier' between LW1 and Glennies Creek;
- Changes to groundwater quality in the alluvium; and
- Inflow of water to the underground mine and the management of that mine water.

7.3.1 Groundwater Levels

Groundwater levels in the alluvium would provide an indication of potential risks of excessive baseflow reduction amounts if observed values suddenly deviate beyond, or are sustained below, the model's projected drawdown amounts relative to the baseline water levels.

Triggers to initiate an investigation into groundwater levels in the Bowmans Creek, Glennies Creek and Hunter River alluvium are based on comparisons of predicted and observed drawdown amounts (relative to baseline water levels) during and subsequent to mining various seams. It is important to note that baseline levels also fluctuate according to natural seasonal climatic variations.

Groundwater levels in alluvium are influenced by rainfall and surface water levels, and this can be monitored by correlation of data from monitoring bores and surface water gauging stations. Any punctuated decline in groundwater levels outside that seen as natural seasonal variation in alluvium may signal loss of baseflow. The predicted drawdown amounts relative to baseline conditions for the ULD Seam Extraction Plan for selected illustrative bores are presented in **Table 7.4**.

Aside from RA27 which monitors the Hunter River alluvium, all piezometers which monitor the Glennies Creek and Hunter River alluvium are expected to respond to mining. A drawdown greater than the predicted drawdown may suggest an impact on the alluvium (and associated baseflows) that are greater than predicted. Therefore a sudden drawdown in measured water level amounting to 115% of the predicted drawdown will be used to initiate an investigation of monitoring results. In areas where the alluvium is not predicted to be impacted, a sudden water table decline by 0.5m outside that seen as natural seasonal variation is considered to be the most appropriate trigger.

Table 7.4: Predicted drawdown from baseline groundwater level (m) for specified monitoring bore locations

Mining Period	Bowmans Creek Alluvium								Glennies Ck Alluvium		Hunter River Alluvium	
	RM6	RM7	RM8	RA18	RA30	T2A	T3A	T4A	WML120A	WML129	RA27	WMLP277
PG LW1-8	0.57	0.41	1.22	1.28	0.88	0.55	0.72	0.66	0.19	0.02	0.00	0.03
ULD LW1-4*	0.25	0.12	0.43	0.78	0.75	0.60	0.93	1.03	0.04	0.05	0.00	0.05
ULD LW1-8*	0.95	0.35	0.26	0.78	0.04	2.93	3.31	3.99	0.05	0.09	0.00	0.27

Notes * From end of PG Seam mining.

7.3.2 Aquifer Properties

The permeability characteristics of the PG Seam and overburden along the alignment of PG TG1 are predicted by groundwater modelling to be maintained.

The criteria to determine that an impact has occurred in the 'barrier' includes a sudden or significant increase in mine inflow compared to predicted levels listed in **Error! Reference source not found.** and/or an increase in hydraulic conductivity being demonstrated through the hydraulic testing of standpipes in the 'barrier', which will be repeated following the advancement of ULD LW1.

Baseline permeability data exists for pre- and post PG LW1 for WML181-186, WML120A, WML129. Further 'barrier' bores (WML261, WML262, WML301 and WML302) have been installed to monitor the effects of ULD extractions.

7.3.3 Groundwater Quality

A groundwater impact investigation would be initiated in the case where a sudden observable variation or trend change occurs from baseline salinity (EC) or pH in any monitored bore. Baseline groundwater quality statistics can be found in **Section 8.3.2** and in **Appendix E**. An observable variation from baseline salinity or other parameter by 50% in comparison to baseline conditions, sustained over 3 months may indicate an impact which is greater than predicted and there this represents a suitable trigger.

7.3.4 Groundwater Dependant Ecosystems

The River Red Gums that were identified in the vicinity of underground mining are located next to Bowmans Creek and Glennies Creek (**Figure 10**), in areas where the alluvium is not expected to be impacted by mining. Despite this, groundwater monitoring near these areas will be carried out to detect any unforseen impacts to the alluvium in these areas. A sudden water table decline by 0.5m outside that seen as natural seasonal variation is considered to be the most appropriate trigger.

7.3.5 Groundwater Inflows

Mining in the NEOC is complete; however there is still some dewatering occurring for the purpose of reject emplacement. During the operational phase, approximately 0.5ML/d (6L/s) on average was pumped from the open cut pit. This comprises rainfall captured by the mine catchment, including rainfall infiltration to the in-pit waste, as well as groundwater inflows. Total groundwater inflows to the open cut are estimated to be only a small proportion of the total, probably less than 25% of the total or 0.13ML/d (1.5L/s).

The rate of groundwater inflows into the underground mine is expected to peak at approximately 570ML/yr, at which point it will fluctuate as the mine deepens.

The groundwater inflow rates for the ULD EP (RPS Aquaterra, 2011a) are presented in **Table 7.5.** These rates are less than those predicted in the 2009 EA.

An inflow rate significantly different from the predicted inflow rate over the short term (days to months) would not itself be cause for concern. This is because the predicted inflow rates are averages, and the actual inflow rates may vary considerably from day to day, according to the stage of longwall development. Therefore, a trigger value of 50% in excess of predicted inflow rate sustained for three consecutive months at any stage during the mine life, or a sudden inrush that is outside of the anticipated trend, have been established as the most appropriate trigger. Further, a sudden decrease in TDS may indicate an impact on the alluvium greater than what was predicted in the EA.

Table 7.5: Modelled mine inflows

Date	Approximate panel start	PG modelled mine inflow (m^3/d)	ULD modelled mine inflow (m^3/d)	Total (m^3/d)	Total (L/s)
30/09/2006		380.4		380.4	4.4
31/12/2006		343.9		343.9	4.0
31/03/2007	PG LW1	417.5		417.5	4.8
30/06/2007		377.9		377.9	4.4
30/09/2007		533.5		533.5	6.2
31/12/2007		522.3		522.3	6.0
31/03/2008		479.8		479.8	5.6
31/05/2008	PG LW2	598.5		598.5	6.9
31/07/2008		708.7		708.7	8.2
30/09/2008	PG LW3	803.7		803.7	9.3
30/11/2008		685.6		685.6	7.9
31/01/2009		897.7		897.7	10.4
31/03/2009	PG LW4	767.5		767.5	8.9
31/12/2009		1100.4		1100.4	12.7
31/12/2010	PG LW5 & LW6A	1268.6		1268.6	14.7
31/12/2011	PG LW7A & LW7B	1085.1	162.7	1247.8	14.4
31/03/2012	ULD LW1	876.2	482.8	1359.0	15.7
30/06/2012	ULD LW2	836.4	401.7	1238.1	14.3
30/09/2012		790.2	776.1	1566.3	18.1
31/12/2012	ULD LW3	737.0	551.1	1288.1	14.9
31/03/2013		658.5	811.9	1470.4	17.0
30/06/2013		625.1	619.7	1244.7	14.4
30/09/2013	ULD LW4A	569.0	927.2	1496.2	17.3
31/12/2013	ULD LW4B	531.0	745.3	1276.3	14.8

8 BASELINE MONITORING DATA

8.1 Baseline Surface Water Flows

Flows in Glennies Creek are regulated by releases from Glennies Creek Dam, whereas flows in Bowmans Creek are unregulated and surface flows periodically cease during drier summer months and in droughts. Flows in Bowmans Creek are monitored by the Foybrook monitoring station (NSW Office of Water Flow Gauge 210130), which provides long-term water flow data.

The ACP does not directly affect the runoff into Glennies Creek or the Hunter River. However, a number of localised drainage lines that direct overland flow to Bowmans Creek and Betty's Creek have been modified by the development of the mine (i.e. the open cut pit, emplacement areas, haul roads, coal processing plant, water storages and associated infrastructure areas). In addition, surface water catchment flow patterns above the underground mine have been (and will continue to be) affected by mine subsidence. Most of the affected drainage lines direct flow toward Bowmans Creek but these will be sealed and rehabilitated at visible subsidence cracks. The flows in the minor drainage lines are not expected to change significantly and are not measured.

Attention is however given to quantifying the interaction between surface and groundwater as affected by induced changes in baseflow contributions from the alluvium to the Creeks and the Hunter River. The open cut and underground mines have created a cone of depression (drawdown cone) in the groundwater levels around the mine, which may induce diffuse vertical leakage from the stream channels and associated alluvial aquifers, within the affected area. Increased hydraulic connectivity is expected to develop between the underground mine and the Bowmans Creek alluvial aquifer as the mine progresses to deeper seams. This is expected to lead to increased inflows of alluvial groundwater into the mine. Ensuing potential losses in Bowmans Creek stream flow will be mitigated with the implementation of two lined diversion channels, which will re-route the Creek to areas not undermined by longwall panels (see **Appendix F**).

Monitoring of stream bed stability and stream health for Bowmans Creek commenced in May 2006, prior to mining in that area.

In the absence of enhanced hydraulic connectivity between the underground mine and overlying alluvial groundwater sources, there will be no direct loss of stream flow due to the mining itself. Losses from the alluvium and the associated impacts on baseflow as a result of subsidence are derived from a combination of calibrated groundwater model outputs supported by groundwater monitoring in the alluvium. Baseline monitoring of streamflow at Foybrook is ongoing and being performed by the NSW Office of Water and the data is obtained from their website. This gauge is located between the Bowmans Creek's eastern and western diversions. Additional future baseline monitoring sites for stream flow gauging are planned for localities upstream and downstream of these diversions at sites FG1 and FG2 as presented on **Figure 11.**

The key flow statistics for the observed daily flow include a mean daily discharge of 51.7ML/day; a maximum of 17825ML/day and a minimum of zero. The 90th percentile is 70.17ML/day and the 10th percentile is 0.89ML/day.

8.2 Baseline Surface Water Quality

The baseline monitoring has been undertaken on a continual basis and has provided a foundation for understanding the main characteristics and trends of the quantities and qualities of the water observed at the ACP from the start of mining to date. In addition, it has provided a means of determining the trigger values for water quality investigations as discussed in **Section 7.2**.

A summary (observed range, median, and mean) of the surface water quality monitoring results for Betty's Creek, Bowmans Creek, Glennies Creek and the Hunter River is provided in **Appendix C** for monitoring data collected between 2003 and 2011. Monitoring point locations are described in **Section** 0 and shown on **Figure 11**.

The baseline data indicate that EC levels within the Hunter River and Glennies Creek are generally low. This is associated with the constant surface water supply that is released into those two rivers by upstream dams. Water in those dams is fed by rainfall runoff with a low salinity.

The pattern in EC fluctuations in Bowmans Creek reflects the climatic conditions quite strongly, and particularly higher EC during periods of no or reduced rainfall runoff, and lower EC at times of high runoff. The higher ECs during times of low runoff are influenced by groundwater baseflow discharges, either locally or from higher up the catchment, during very low flow periods. Outside of drought periods, EC levels reduce significantly due to surface runoff and the presence of 'fresher' groundwater within the alluvium. During high flows and floods, the Foybrook monitoring station (NSW Office of Water Flow Gauge 210130) on Bowmans Creek shows that EC values reduce dramatically, to around 200 to 300µS/cm.

8.3 Groundwater Baseline Data

A baseline monitoring program that commenced during the 2001 EIS studies has continued through to the present time and is ongoing. The monitoring program comprises the recording of groundwater levels and periodic sampling for water quality analysis from monitoring bores. The 2001 EIS baseline monitoring bore network has subsequently been expanded with regional and local bores installed as part of ongoing investigations and to comply with development consent and water licence conditions. Additional monitoring bores have been placed in the PG Seam overburden, and in the Bowmans Creek, Glennies Creek and Hunter River alluvium, to monitor impacts on the alluvium. The groundwater monitoring bore network is shown on **Figure 12** and described in **Section 9.3** and **Appendix D**.

The statistical analysis of groundwater monitoring data enables a characterisation of the existing groundwater system.

8.3.1 Groundwater Levels

The groundwater level range for selected bores is detailed in **Table 8.1**. These are bores that monitor groundwater levels in the Bowmans Creek, Glennies Creek and Hunter River alluvium. It is important to note that baseline levels fluctuate according to natural seasonal climatic variations. The baseline data ranges from November 2000 to August 2011. Shorter periods of record can be extracted if needed so that specific stages of mine development can be compared to water quality at that time.

Some bores have been specifically located for long term monitoring in the alluvium as shown in **Table** 8.1.

Table 8.1: Baseline groundwater level in selected alluvium monitoring bores (m)

Range	Bowmans Creek Alluvium								Glennies Ck Alluvium	Hunter Rr Alluvium
	RM6	RM7	RM9	RA30	RA18	T2-A	T3-A	T4-A	WML129	RA27
Highest level recorded (mAHD)	56.8	57.2	57.26	62.59	56.84	56.02	60.37	50.57	51.95	50.51
Mean (mAHD)	55.70	56.08	56.74	61.01	56.41	55.43	50.98	49.92	50.79	49.48
Lowest level recorded (mAHD)	55.11	55.33	55.3	59.95	55.98	55.12	50.35	49.26	43.14	48.89

8.3.2 Groundwater Quality

Groundwater quality varies according to its source and interaction with other water sources:

- alluvial groundwater in the floodplains of Bowmans Creek, Glennies Creek and the Hunter River is generally of a quality suitable for stock and domestic use;
- shallow coal measures groundwater, colluvial groundwater and some of the alluvial groundwater is brackish to saline in quality and is not used for consumptive purposes; and
- groundwater in the coal measures is saline and is not used for consumptive use, apart from mine purposes.

A summary assessment of the natural variation of groundwater quality is provided in **Table 8.2**, and groundwater monitoring (from the time of bore installation to date or destruction of the bore due to mining) minimums, maximums, mean and median results are presented in **Appendix E**.

*Note: In **Appendix E** table when quantities of a substance fall below the Limit of Reporting (LOR) a '<' symbol is applied to the number by the laboratory. When analysing results the '<' symbol was removed, as a 'less than a number' has no value and cannot be evaluated. Hence in these instances some values are potentially over estimated.*

Table 8.2: Baseline groundwater quality data summary 2007 - 2011

Aquifer screened	Piezometers	pH (pH units)		Electrical Conductivity (µS/cm)	
		Mean	Range	Mean	Range
Bowmans Creek Alluvium	RM04, RM06, RM07, RM09, RM10, PB1, RA10, RA14, RA15, RA18, RA30, WML110C, WML112C, WML113C, WML115C, WML275, T1-A, T2-A, T3-A, T4-A, T5, T6, T7, T10	7.23	6.44 - 10.04	1622	722 - 9920
Hunter River Alluvium	RA27, WML277, WML278, WML279, WML280	6.97	6.76 - 7.14	2091	1375 - 2540
Glennies Creek Alluvium	WML120B, WML129, WML239, WML240, WML241, WML243, WML247, WML249, WML252, WML253, WML256, WML261, WML262	7.05	6.53 - 7.79	3202	300 - 16300
Colluvium	RM02, RA8, RA16	6.91	6.52 - 7.87	6682	1300 - 13860
Pikes Gully Seam	WML119, WML120A, WML181, WML182, WML183, WML184, WML185, WML186	6.87	5.29 - 7.78	2088	86 - 8820

Aquifer screened	Piezometers	pH (pH units)		Electrical Conductivity (µS/cm)	
Upper Liddell Seam	WML261, WML262, WML172, GM1	7.64	6.81 - 8.99	4304	200 - 9370
Arties Seam	WML301, WML302	7.23	6.35 - 8.03	3432	648 - 6350
Shallow Permian Coal Measures	RSGM1, RM05, RA02, G1, G2, G3A, T1-P, T2-P, T3-P, T4-P, GM2, GM3A, WML108B, WML111B, WML112B, WML113B, WML115B.	7.36	6.35 - 11.97	5611	320 - 18200

9 MONITORING PROGRAM

Monitoring at the ACP is conducted to ensure the WMP is operating as designed and meets target criteria, licence conditions and commitments made during the development application process (condition 1.2 to Schedule 2 of the DA). In addition, it enables the collation of baseline data and provides an ongoing means of determining water quality, level and flow information.

Local conditions at most sites tend to vary and insights into the characteristics of the water quality are best understood through monitoring and interpretation of data. The monitoring network has been purposefully upgraded over time in response to the growth and development at the mine.

The data is utilised to identify trends, assess impacts on water sources, water users, stream health, overall performance of the WMS and associated infrastructure and to compare pre- and post-mining conditions.

All samples are allocated a sample number along with the date and time of sampling, location, person who collected the sample and comments on flow conditions (for streams and underground flows).

Site data obtained from the monitoring program is maintained in an up-to-date electronic format, which is utilised to analyse and report on water characteristics. The results are kept onsite from the outset of monitoring at the ACP to date. Monitoring records can be produced in a clear format for reporting and are available upon request by relevant authorised compliance officers. Hard copy records are archived after five years.

9.1 Water Quality Monitoring Parameters

The analysis undertaken to determine water quality in surface water storages, watercourses and groundwater bores is detailed in **Table 9.1**.

Table 9.1: Water quality monitoring parameters

Analysis undertaken
Screening Analysis: • pH, Electrical Conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), Total Hardness (CaCO3) and Oil and Grease
Surface Water Comprehensive Analysis: • Physical Parameters – pH, EC, TDS, TSS, Total Hardness ($CaCO^3$) and turbidity • Major Ions – Ca, Mg, Na, K, Cl, SO_4, HCO_3 and CO_3 • Dissolved Metals – Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se and Zn • Nutrients/other – Ammonia, Nitrate and Fluoride
Groundwater Comprehensive Analysis EC, pH, temp, TDS, Na, K, Ca, Mg, F, Cl, SO4, HCO3, NO3, Total N, Total P, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Total Alkalinity, Total Cyanide, Turbidity.

9.2 Surface Water Monitoring

Surface water quality and flows are monitored at the Site in a range of locations both internal and external to the active operations. This monitoring is to:

- provide pre-mining baseline flow and quality data and provide a comparison with post-mining conditions;
- identify potential physical and/or chemical water quality impacts external to the mining area related to mining;
- identify and confirm trends;
- assess potential long term mining impacts on stream flow and or quality;
- provide a holistic view of overall stream health; and
- ensure that the onsite WMS has adequate capacity for the ongoing supply of the operation, storage capacity and to prevent discharges from site.

A rigorous suite of water quality parameters are measured from samples collected (when possible) at all of the surface water monitoring sites.

The water quality and flows in major streams, and water quality, flows and storage volumes in the major water storages are monitored at the locations shown in **Figure 11** and listed in **Table 9.2** for the range of parameters shown in **Table 9.1**.

Aquatic and ecological monitoring is undertaken as per the Flora and Fauna (Biodiversity) Management Plan.

Table 9.2: Surface Water Monitoring Program

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
Stream Monitoring						
SM1	Betty's Creek (upstream)	Background Provides upstream point for comparison to identify any downstream impacts of mine infrastructure area and/or longwall panels.		Flood event[3.] • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website (www.waterinfo.nsw.gov.au), compare to flood frequency projections). • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate as indicator of flow relative to gauge SM3 on Bowmans creek and the downstream flow gauge at 210130. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.
SM2	Betty's Creek (confluence with Bowmans Creek)	Impact of mine surface infrastructure area.		Flood event[3.] • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe) • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website, compare to flood frequency projections) • Photo points • Field analysis of EC and pH once access is safe	• Water level – read gauge plate • Stream flow (gauge plate as an indicator of flow to be correlated with downstream flow gauge 210130 as well as sites SM1 and SM3) • Areas of increased flooding (large events or unusual ponding) • Visual observation of changes to stream banks and surrounding areas • Observable water quality issues • Water quality screening analysis	• Water Quality – comprehensive analysis • Photo points

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM3	Bowmans Creek (upstream)	Background Provides upstream point for comparison to identify any downstream impacts of mine infrastructure area and/or longwall panels.		Flood event[3] • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website, compare to flood frequency projections). • Visual observation of areas of increased flooding or unusual ponding or visible areas with surface flooding. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is an indicator of flow to be correlated with downstream flow gauge 210130). • Areas of increased flooding (large events or unusual ponding). • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM4	Bowmans Creek (Highway)	Impact of mine infrastructure area/upstream of longwall panels. Also to identify if the PWD is discharging worked water into the creek system.		Flood event[3.] • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website, compare to flood frequency projections). • Areas of increased flooding or unusual ponding or visible areas with surface flooding or the unlikely occurrence of unexpected surface water drainage to underground. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is an indicator of flow to be correlated with downstream flow gauge 210130). • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM5	Bowmans Creek	Impact of longwall panels/upstream of Narama Mine Dam Discharge.		Flood event[3] or level exceeds channel bank and flooding extends over longwall mining areas. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website). • Compare trigger level flood line maps to visible extent of flooding if access is safe and note discrepancies. If comparable to ARI flood event, compare observed extent of flooding to flood maps and note discrepancies. • Areas of increased flooding or unusual ponding. • Visual check in surrounding longwall areas for unlikely flow losses from drainage lines and ponded / flooded areas as indicated by visible ingress of water into subsidence cracks that need urgent repair. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is an indicator of flow to be correlated with flow gauge 210130). • Areas of increased flooding or unusual ponding. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM6	Bowmans Creek (above Hunter River confluence)	Cumulative Impact of project and other mines		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high and Bowmans creek is flooding then flood extent could be affected if flooding also occurs in Hunter River. Check for Hunter River flood conditions by contacting SES and checking BOM websites for floods information and forecasts for Hunter River flooding). • Areas of increased flooding extent relative to maps of floodlines and longwall subsidence zones. • Visual check in surrounding longwall areas for (unlikely) flow losses from drainage lines and ponded / flooded areas as indicated by visible areas of ingress of water to subsidence cracks that need urgent repair. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is indicator of flow to be correlated with flow gauge 210130 for periods when Hunter River is not flooding). • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM7	Glennies Creek (upstream)	Location is downstream of Integra mine. Position provides a basis and provides upstream basis for ongoing comparison to downstream conditions in vicinity of ACOL. Particularly relevant is the water quality and low flow conditions of the Creek during droughts. Downstream flooding extents are unlikely to be impacted on by ACOL operations as no subsidence is expected in the vicinity of the Creek. Flood conditions at this site and the downstream sites are therefore monitored as a precaution and basis for comparison to downstream sites		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high and flow is rapid, check BOM web site for flood forecasts and flood conditions and check with SES for floods information and releases of flood water from upstream dams as these may enhance flooding. • Areas of increased flooding or unusual ponding adjacent to Creek compare extent to maps of flood lines. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level –comment on visible flow conditions. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM8	Glennies Creek	Impact of longwalls and cumulative impact of project and other mines. Any unusual change in relative differences between this site and measurements at other site shown of Figure 13 could indicate an unlikely sudden loss of water from Glennies Creek and the alluvium to the underground mine. GP2 shown on Figure 13 is located at this site (SM8) and SM8 is shown on Figure 11.		Flood event[3] or water level exceeds channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high and flow is rapid, check BOM web site for flood forecasts and flood conditions and check with SES for floods information and releases of flood water from upstream dams). • Areas of increased flooding (if any) relative to maps of flood lines and subsidence zones. • Photo points. • Field analysis of EC and pH once access is safe. Longwall Mining. For short term periods when longwall mining of ULD LW1 occurs adjacent to this site then fortnightly monitoring will be done at this site and at other sites shown on Figure 13. These include GP1, GP2, GP3 and GP4. • Water Quality comprehensive analysis to be done once during the longwall mining event. Photo points to be done before and after the longwall mining event.	• Water level – read gauge plate. • Stream flow (gauge plate is indicator of flow to be correlated with downstream and upstream flow depths. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM9	Hunter River (upstream of Bowmans Creek)	Background		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high check with SES for flood warnings along Hunter River and water releases from upstream dams). • Areas of increased flooding relative to maps of flood lines. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – visual examination of and channel conditions and comment on visual estimate of depth of flow relative to channel sides. • Stream flow – visual examination of channel flow and comment. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM10	Hunter River (downstream of Bowmans Creek)	Impact of Bowmans Creek and upstream of longwall panels		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high check with SES for flood warnings along Hunter River and water releases from upstream dams). The extent of flooding could increased if the Bowmans river and Hunter river are both in flood at the same time and water is released from upstream dams. • Areas of increased flooding relative to maps of flood lines and subsidence zones. • Visual check along southern end of longwall panel areas for (unlikely) flow losses from drainage lines and ponded / flooded areas as indicated by visible areas of ingress of water to subsidence cracks that need urgent repair. • Photo points. • Field analysis of EC and pH.	• Water level – visual examination of and channel conditions and comment on visual estimate of depth of flow relative to channel sides. • Stream flow, visual observation of flow conditions relative other sites above and below the confluence with the Bowmans Creek. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Comprehensive analysis. • Photo points .

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM11	Glennies Creek (just above confluence with Hunter River)	Cumulative impact of project and other mines		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high and flow is rapid, check BOM web site for flood forecasts and flood conditions and check with SES for floods information and releases of flood water from upstream dams as the extent of flooding could increase if the Hunter river is also in flood and particularly if water is released from upstream dams on the Glennies Creek and on the Hunter River.). • Areas of increased flooding (if any) relative to maps of flood lines and subsidence zones. • Photo points. • Field analysis of EC and pH.	• Water level – visual examination of and channel conditions and comment on visual estimate of depth of flow relative to channel sides. • Stream flow, visual observation of flow conditions relative other sites above and below the confluence with the Hunter River. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM12	Hunter River (downstream of Glennies Creek)	Cumulative impact of project and other mines.		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high check with SES for flood warnings along Hunter River and water releases from upstream dams as alter to flood event and because the extent of flooding could increase if the Glennies Creek and Hunter rivers are in flood and if water is released from upstream dams). • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – visual examination of and channel conditions and comment on visual estimate of depth of flow relative to channel sides. • Stream flow, visual observation of flow conditions relative other sites above and below the confluence with Glennies Creek. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM13	Hunter River (upstream of Glennies Creek)	Impact of longwall panels		Flood event[3] or water levels exceed channel bank. • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is large check with BOM for flood warnings and SES for flood conditions along Hunter River and Bowmans Creek and water is released from upstream dams (as alert to flooding and checks for flood event and because the extent of flooding will increase if water released from upstream dams). • Visual check along subsidence zones of longwall Panel 1 for (unlikely) flow losses from drainage lines and ponded / flooded areas as indicated by visible areas of ingress of water to subsidence cracks that need urgent repairs. • Photo points. • Field analysis of EC and pH.	• Water level – visual examination of and channel conditions and comment on visual estimate of depth of flow relative to channel sides. • Stream flow, visual observation of flow conditions relative other sites between the confluence with Glennies Creek and downstream of the Bowmans Creek. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
SM14	Hunter River (Upstream of confluence with Glennies Creek)	Impact of longwall panels. Cumulative impact of project and other mines		Flood event[3] or water levels exceed channel bank • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe) • Flow (if water level is large check with BOM for flood warnings and SES for flood conditions along Hunter River and Bowmans Creek and water is released from upstream dams (as alert to flooding and checks for flood event and because the extent of flooding will increase if water released from upstream dams) • Visual check along subsidence zones of longwall Panel 1 for (unlikely) flow losses from drainage lines and ponded / flooded areas as indicated by visible areas of ingress of water to subsidence cracks that need urgent repairs • Photo points • Field analysis of EC and pH	• Water level – visual examination of and channel conditions and comment on visual estimate of depth of flow relative to channel sides • Streamflow, visual observation of flow conditions relative other sites between the confluence with Glennies Creek and downstream of the Bowmans creek • Visual observation of changes to stream banks and surrounding areas • Water quality screening analysis	• Water Quality – comprehensive analysis • Photo points

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
GC1	Glennies Creek, adjacent to bores WML120A-B, as shown on **Figure 13**.	To produce three-dimensional representations of the alluvium water table and the coal measures potentiometric surface. These will form the basis for monitoring to confirm any (unforeseen) flow losses and the recovery of the pre-mining hydraulic gradient towards Glennies Creek after mining is completed. Water levels in the Creek at sites GC1, GC2 and GC3 will be correlated to one another and to new upstream level monitoring site at GC4 to detect the relative change in surface water flow conditions. This correlation will target low flow conditions when differences (if any, will be more noticeable.)		Water levels[4] – using installed monitoring staffs. Event monitoring will be triggered two weeks prior to, and fortnightly during, the advancement of LW1 past the Glennies Creek.	• Water levels – using installed monitoring staffs for visual recording	
GC2	Glennies Creek, adjacent to bores WML119 as shown on **Figure 13**.			Water levels[4] – using installed monitoring staffs. Event monitoring will be triggered two weeks prior to, and fortnightly during, the advancement of LW1 past the Glennies Creek.	• Water levels – using installed monitoring staffs for visual recording	
GC3	Glennies Creek, adjacent to bores WML129 as shown on **Figure 13**.			Water levels[4] – using installed monitoring staffs. Event monitoring will be triggered two weeks prior to, and fortnightly during, the advancement of LW1 past the Glennies Creek.	• Water levels – using installed monitoring staffs for visual recording	
GC4	Glennies Creek, below the pump station and upstream of the Longwall 1 mining areas near to the Creek as shown on **Figure 13**.	This site provides an upstream point for use as a reference site for water levels that can be compared to level changes and trends at sites GC1, GC2 and GC3		Water levels[4] – using installed monitoring staffs. Event monitoring will be triggered two weeks prior to, and fortnightly during, the advancement of LW1 past the Glennies Creek.	• Water levels – using installed monitoring staffs for visual recording	

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
BC1	Bowmans Creek Pool 1 above LW6B	Level results to be utilised to guide the construction of block banks to their final level and to check levels of water in the pool to ascertain needs to drain water from the block banks to the pools for ecological purposes.		Water level[5] – using installed monitoring staffs for visual recording. Weekly monitoring to be triggered by and continued during mining of Longwall 6B.	• Water level – using installed monitoring staffs for visual recording	
BC2	Bowmans Creek Pool 2 above LW6B	Level results to be utilised to guide the construction of block banks to their final level and to check levels of water in the pool to ascertain needs to drain water from the block banks to the pools for ecological purposes		Water level[5] – using installed monitoring staffs for visual recording. Weekly monitoring to be triggered by and continued during mining of Longwall 6B.	• Water level – using installed monitoring staffs for visual recording	
FG1	Bowmans Creek Upstream of Diversions (monitoring site to be installed)	Continuous water level recorder to be used as indicator of flow above the diversion. These levels should be compared and calibrated against the NOW gauge 210130.	Flow	Continuous recording data loggers to be checked and data downloaded.	• Continuous recording data loggers to be checked and data downloaded.	
FG2	Bowmans Creek Downstream of Diversions (monitoring site to be installed)	Continuous water level recorder to be used as indicators of flow below the diversion. These levels should be compared and calibrated against the NOW gauge 210130.	Flow	Continuous recording data loggers to be checked and data downloaded .	• Continuous recording data loggers to be checked and data downloaded	

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
210130	NOW Flow Gauging Station (Foy Brook)	Flow gauging for government purposes. Provides flow data that is also beneficial to ACOL	FLOW	Flood event[3] or water levels exceed channel bank • Download real time data for flood flow at gauge 210130 using NSW Water Information website (www.waterinfo.nsw.gov.au), • Compare to flood frequency projections	• Download data using NSW Water Information website (www.waterinfo.nsw.gov.au), • Visual observation of changes to stream banks and surrounding areas • Observable water quality issues • Water quality screening analysis	Water Quality – comprehensive analysis
Onsite Water System						
PW	Process Water Dam – located near the CHPP	To ensure appropriate quality and sufficient operating capacity for water supply purposes and sufficient buffer storage to accommodate additional inflow during storm events.			• Water level • Sediment level observation • Observable water quality issues • Water quality screening analysis	• Water Quality – comprehensive analysis
SD	Settling Dam – located near the CHPP Process Water Dam	To ensure appropriate quality and sufficient operating capacity for water supply purposes and sufficient buffer storage to accommodate additional inflow during storm events.			• Water level • Inflow channel condition (signs of erosion or sedimentation) • Sediment level observation • Observable water quality issues • Water quality screening analysis	• Water Quality – comprehensive analysis

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
D56	Dam 56 located at the eastern end of the Eastern Emplacement Area	To ensure appropriate quality and sufficient operating capacity for water supply purposes and sufficient buffer storage to accommodate additional inflow during storm events.			• Water level • Erosion and/or sedimentation in inflow channels • Sediment level observation • Observable water quality issues • Water quality screening analysis	• Water Quality – comprehensive analysis
BP	Barrett Pit (open cut void)	To ensure appropriate quality and sufficient operating capacity for water supply purposes and sufficient buffer storage to accommodate additional inflow during storm events.			• Water level • Visual observation of erosion of side walls and inflow channels • Observable water quality issues • Water quality screening analysis	• Water Quality – comprehensive analysis
AP	Arties Pit	To ensure appropriate quality and sufficient operating capacity for water supply purposes and sufficient buffer storage to accommodate additional inflow during storm events.			• Water level • Visual observations of erosion of sidewalls and inflow channels • Sediment level observation • Observable water quality issues • Water quality screening analysis	• Water Quality – comprehensive analysis
TD	Tailings Dam Decant	To ensure appropriate quality and sufficient operating capacity for water supply purposes and sufficient buffer storage to accommodate additional inflow during storm events.			• Water level • Erosion of side walls and outflow channels • Water quality screening analysis	• Water Quality – comprehensive analysis

Site #	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
WC	Western Rehabilitation Culvert	To ensure runoff from final rehabilitation is equivalent to the clean water catchment.			• Sediment level observation • Observable water quality issue • Observable signs of erosion, sediment transport and deposition	• Water Quality – comprehensive analysis
Site Flow Meters	The volumes of water inflow, storage, transfer onto and within the Site and used within the WMS are monitored using a series of in-line flow meters and water level gauges at strategic locations within the System.	To ensure the effective management and usage of water sources and transfers with into and within the water management system. To ensure accurate accounting against water licences.			• Flow volume. Check to ensure quantities are within license constraints	

Notes:

1 Major ions and metals along with total petroleum and polycyclic aromatic hydrocarbons (PAH) are analysed on a monthly basis at surface water monitoring site SM4.

2 An additional round of comprehensive quality monitoring will be taken at SM8 when ULD Seam LW1 passes midway along the Glennies Creek 'barrier' area of to assess potential mining/subsidence impacts to the Creek.

3 Flood Event – daily checking of BOM forecasts to ascertain risk of flooding. Triggers include events projected to exceed a:

- 1:20 ARI storm event of 24-hour duration for Storm Retention Dams; and/or
- 1:100 ARI storm event of 72-hour duration.

4 While mining in the 'barrier' area of LW1, water levels to be monitored weekly.

5 While mining in LW6B level to be monitored weekly as per DA Schedule C Commitment, Item 5.1.

9.3 Groundwater Monitoring

An extensive and comprehensive monitoring program is in place to provide regular measurements of groundwater pressures/levels within all monitoring bores (vibrating wire and standpipe piezometers) and involves:

- water quality sampling from groundwater across the project area, on a weekly, monthly and annual basis;
- monitoring and assessment of groundwater inflows and quality to the open cut and underground mining operations;
- monitoring of the volume of water abstracted from the mine workings;
- monitoring the volume and quality of individual sources of groundwater inflows, where separation of sources is possible;
- monitoring groundwater levels in:
  - Alluvial aquifers associated with Glennies Creek, Bowmans Creek and the Hunter River;
  - Aquifers within the coal seams proposed to be mined in the underground mine;
  - Coal measure aquifers above the goaf of the underground mine;
  - Coal measure aquifers between the underground mine and Glennies Creek; and
  - The regional coal measures aquifer system.

The locations of the groundwater monitoring points are shown in Figure 12 and a description of the location and monitoring frequency is summarised in Table 9.3 and further detailed in Appendix D.

The groundwater monitoring program specifically deals with:

- impacts on groundwater levels on neighbouring properties and on any users of groundwater;
- impacts on GDEs associated with the alluvial aquifer(s) of Bowmans Creek and Glennies Creek; and
- impacts of the development on groundwater quality such as around rejects storages;
- periodical monitoring for changes and local and regional impacts of the underground mine on groundwater levels and quality during the Project and on a reduced basis for at least 5 years post mining; and
- monitoring the effects of subsidence on hydraulic conductivity (permeability) of overlying strata to ensure impacts are within development consent impact assessment predictions (EIS, 2001 and EA 2009).

A number of piezometers are equipped with data loggers set to record groundwater levels six-hourly, which enables impacts related to subsidence to be accurately related to the position of the longwall face. Monitoring for the underground is also carried out using nested multi-level vibrating wire piezometers, with one in each of the target coal seams. Some of these bores may need to be replaced following mine subsidence to enable continued monitoring of impacts from extracting coal from the deeper coal seams. Monitoring frequency of bore water levels/pressures is periodically increased to fortnightly intervals in selected bores depending on the relative location of underground mining.

Information gained from the monitoring program will enable three-dimensional representation of groundwater levels (alluvium water table and coal measures potentiometric surfaces) to be updated during and post underground mining. This will be used to evaluate the impact of the mine on groundwater sources and to monitor recovery of the pre-mining hydraulic gradients after completion of mining.

Table 9.3: Groundwater Monitoring

Site Numbers	Location description	Purpose	Monitoring Undertaken and Frequency					
			Continuous	Event triggered	Fortnightly	Monthly	Quarterly	Annually
Monitoring of groundwater impacts to Glennies Creek near NEOC								
G1	To the north of the open cut near the perimeter of the ACP DA area.	To measure the regional impact of the NEOC on groundwater levels and quality in the Permian coal measures.				Water Level	Field parameters EC, TDS and pH	Groundwater Comprehensive Analysis
WML172, WML173, WML174	Between the NEOC and Glennies Creek	To assess the impact of the NEOC on the Glennies Creek alluvial aquifer.				Water Level	Field parameters EC, TDS and pH	Groundwater Comprehensive Analysis
G3A	Shallow well in the alluvium. Beneath Camberwell village.	To assess the impact of the mine on local groundwater levels, and potential ground water users				Water Level	Water Level Monitoring	
Monitoring of groundwater impacts due to subsidence around Bowmans Creek								
WMLP311, WMLP323, WMLP324, WMLP325	To the east of LW6B	To evaluate the potential operational risk that is posed by flows entering the old Creek channel and entering the workings via connective cracking above LW6B. Monitoring is also particularly important during the early stages of the diversion, during mining of the PG Seam, and when some flows may still be directed down		Water Level 2 weeks prior to and fortnightly during the extraction of LW6B in order to monitor groundwater drainage from the alluvium		Water Level	Field parameters EC, TDS and pH	Groundwater Comprehensive Analysis

Site Numbers	Location description	Purpose	Monitoring Undertaken and Frequency					
			Continuous	Event triggered	Fortnightly	Monthly	Quarterly	Annually
		the old Creek channel.						
Monitoring hydraulic connection with Bowmans Creek and connected alluvium								
PB1, T2A/P, T3A/P, T4A/P, T5, T6, T7, T8, T9, T10, RA8, RA02, RA08, RA10, RA14, RA15, RA17, RA18, RA20, RA30, RM6, RM7, RM10 WML112A* to C, WML113A* to C, WMLP308, WMLP311, WMLP316, WMLP320, WMLP323, WMLP324, WMLP325 WMLP326, WMLP237, WMLP328 *VWP		To provide pre-mining baseline water quality data and to compare with post mining. To identify any water quality or stream flow impact due to mining. To identify any groundwater level impact due to mining (i.e. drainage from Bowmans Creek alluvium). To identify the extent of vertical cracking from the goaf to the ground surface Monitor unforseen impacts on River Red Gum (GDE's)	Key bores above/around the area of active LW mining will be equipped with loggers during mining. These bores will be assessed on a case by case basis	Water Level 2 weeks prior to, and fortnightly during the early and final stages of LW6A, LW6B, LW7A and LW7B mining. Note: Only selected bores above and in close proximity to the active LW need to be monitored fortnightly during LW extraction		Water Level	Field parameters EC, TDS and pH	Groundwater Comprehensive Analysis
Monitoring hydraulic connection with Glennies Creek and connected alluvium								
WML120B, WML129,	Between Glennies	To provide pre-mining baseline water quality	Key bores above/aroun	Water level 2 weeks prior to,		Water level	Field parameters EC, TDS and pH	Ground Water Comprehensive

Site Numbers	Location description	Purpose	Monitoring Undertaken and Frequency					
			Continuous	Event triggered	Fortnightly	Monthly	Quarterly	Annually
WML181-186 WML261 WML262 WML301 WML302 WML106-7* WMLC248* WMLC333* WMLC334* WMLC335* WMLP336 – WMLP339 *VWP	Creek and the eastern side of LW1	data to compare with post mining. To identify any water quality or stream flow impact due to mining. To assess the baseflow/water level impacts of the project on Glennies Creek and alluvium. To assess changes in permeability of the barrier pillar prior to and post longwall mining; To monitor for post-mining recovery of groundwater	d the area of active LW mining will be equipped with loggers during mining. These bores will be assessed on a case by case basis	and fortnightly during the advancement of LW1 past the Glennies Creek				Analysis
WML172, WML173, WML174, WML239, WML240, WML241, WML243, WML249, WML250, WML252, WML253, WML256	Between the NEOC and Glennies Creek East of Glennies Creek	To provide pre-mining baseline water quality data to compare with post mining. To identify any water quality or stream flow impact due to mining. To assess the impacts of the project on the groundwater environment. To monitor groundwater levels in vicinity of River Red Gum (GDE's) on eastern side of Glennies Creek			Water level		Field parameters EC, TDS and pH	Ground Water Comprehensive Analysis
Monitoring hydraulic connection with Hunter River and connected alluvium								

Site Numbers	Location description	Purpose	Monitoring Undertaken and Frequency					
			Continuous	Event triggered	Fortnightly	Monthly	Quarterly	Annually
RA27 WML180, WMLP275, WMLP276, WMLP277, WMLP278, WMLP279, WMLP280, WML269* WMLC333* WMLC334* WMLP337 *VWP	Bores located at the end of panel, following completion of extraction adjacent to the Hunter River or alluvium.	To provide pre-mining baseline water quality data to compare with post mining. To assess the baseflow / water level impacts of the project on the Hunter River and alluvium. To identify any water quality or stream flow impact due to mining.	Key bores above/around the area of active LW mining will be equipped with loggers during mining. These bores will be assessed on a case by case basis	Water level 2 weeks prior to, and fortnightly during the early stages of LW5, LW6A, LW7A,		Water level	Field parameters EC, TDS and pH	Ground Water Comprehensive Analysis
Glennies Creek barrier bore monitoring								
WML119 WML120A WML181 to 186, WML302, WML262, WML261, WML301, WML106 to 7* WMLC248* WMLC333* WMLC334* WMLC335* WMLP336 to 339 *VWP	Along the ridgeline in the barrier between Glennies Creek and LW1.	To assess: Baseline groundwater conditions; Permeability of the barrier pillar prior to and post LW1 extraction; The stratigraphic location and extent of any lateral shear that may occur post mining as a result of movement of the barrier pillar; Groundwater responses to longwall mining and any change post mining; and The impacts of drift development to deeper	Key bores above/around the area of active LW mining will be equipped with loggers during mining. These bores will be assessed on a case by case basis	Water Level and water quality (field parameters) 2 weeks prior to, and fortnightly during the advancement of LW1 past the Glennies Creek Permeability and Comprehensive groundwater Analysis Prior to LW1 extraction and end of ULD LW1 extraction (after full subsidence),		Water level	Field parameters EC, TDS and pH	Groundwater Comprehensive Analysis

Site Numbers	Location description	Purpose	Monitoring Undertaken and Frequency					
			Continuous	Event triggered	Fortnightly	Monthly	Quarterly	Annually
		seams.						
Monitoring Coal Measures								
WML21 WML106 (VW* 84m) WML213 (VW 205.5m) WML189 (VW 93m)	Above the longwall mining area Vibrating Wire in to the PG Seam	Monitoring drawdown and post-mining recovery of groundwater	Key bores above/around the area of active LW mining will be equipped with loggers during mining. These bores will be assessed on a case by case basis		Water levels Vibrating Wire			
WML106 to 189, WML191, WML213, WMLC248 WML106 to 7 WMLC333 WMLC334 WMLC335	Vibrating Wire in other seams	To identify the extent of connective cracking from the goaf to the ground surface			Water levels Vibrating Wire			

9.3.1 Underground Flow and Quality Monitoring

Groundwater inflows into the underground mine are determined using a water balance approach, which requires balancing total water extracted from the mine against the volume of water pumped into the mine (used for dust suppression and operational purposes). Total flow into the mine is recorded on a flow meter on the water line at the surface of the underground mine. Worked 'return' water being pumped from the mine is measured at the entrance to each gateroad, and a total flow is measured using flow meters at the mine portal exit as well as at strategically located dewatering borehole pump sites.

Underground flow monitoring is undertaken as per **Table 9.4** to:

- measure the flows into PG TG1A in order to record seepage inflows from Glennies Creek alluvium and to monitor any changes that may occur in the permeability of the PG Seam between LW1 and the Glennies Creek alluvium;
- observe trends in bulk water salinity as a means of identifying new sources of mine seepage inflows as mining progresses;
- monitor the volume of water extracted from the underground workings for the life of the mine;
- quantify the water extracted from the mine (this will be extended to the ULD and lower seams as these are mined);
- assess the impact to the Bowmans Creek alluvium and ensure it is within EA 2009 predictions. Early indication of inflow potential will also be gained from measuring groundwater levels and pressures in surrounding monitoring bores; and
- identify any hydraulic connection impact due to mining with the Hunter River, Glennies Creek and Bowmans Creek, and their connected alluvium.

The volume and quality of individual sources of groundwater inflows will be monitored where identification of separate of sources is possible.

Table 9.4: Underground mine flow monitoring parameters

<table>
<tr><th>Monitoring sites</th><th>Location description</th><th>Purpose</th><th>Continuous (daily)</th><th>Event triggered</th><th>Fortnightly</th><th>Monthly</th><th>Quarterly</th><th>Annually</th></tr>
<tr><td>LW1 back road pipe (TG1-A)</td><td>LW1 Tailgate</td><td>Monitor seepages from Glennies Creek alluvium
Assess change in permeability characteristics of barrier from LW mining
Identify trends in bulk water salinity as a means of identifying new sources of mine seepage inflows as mining progresses</td><td rowspan="2">Visual inspections of the underground workings
(Noting any changes in roof or floor conditions, and the location and flow rates of individual water inflows)</td><td>Flows / Water Quality (EC/TDS/pH)
Weekly during extraction of LW1
and
Comprehensive Immediately following a sudden increase of flows or discolouration of water</td><td>Flow
V-notch
Water Quality
Field parameters EC, TDS and pH</td><td></td><td></td><td>Water Quality
Comprehensive analysis</td></tr>
<tr><td>All underground pump stations including main gate seals (MG1 to 9)</td><td>Drainage points at southern ends of each LW</td><td rowspan="4">Monitor mine inflows
Identify trends in bulk water salinity as a means of identifying new sources of mine seepage inflows as mining progresses
Monitor Impact to Bowmans Creek alluvium</td><td>Water Quality
Comprehensive Immediately following a sudden increase of flows or discolouration of water</td><td>Field parameters EC, TDS and pH</td><td></td><td></td><td>Water Quality
Comprehensive analysis</td></tr>
<tr><td>BH2 sump</td><td>UG discharge point SW of LW6A</td><td rowspan="3">Flow
Metered</td><td rowspan="3">Water Quality
Comprehensive Immediately following a sudden increase of flows or discolouration of water</td><td rowspan="3"></td><td rowspan="3">Field parameters EC, TDS and pH</td><td rowspan="3"></td><td rowspan="3">Water Quality
Comprehensive analysis</td></tr>
<tr><td>NW mains
(Fish tank),</td><td>NW mains</td></tr>
<tr><td>UGMO1 Portal</td><td>Portal</td></tr>
</table>

9.4 Subsidence Impact Monitoring

9.4.1 Ground Surface Level Monitoring – Glennies Creek

East-west survey cross-lines have been installed at regular intervals along the LW1 tailgate roadways extending across the chain pillars and down towards Glennies Creek. These were installed at the following locations (relative to PG TG cut-throughs):

- 100m inbye of 18CT
- CT18
- CT16
- CT14
- CT12
- CT10
- CT8

Survey cross-lines comprise marker posts installed at 10m intervals along the length of the line. Relative movement of the marker posts will be monitored by repeat survey to determine the stability of the underlying rib wall and barrier pillar, and to detect any horizontal ground movement. Lateral ground movement will be used as a trigger to reassess the hydraulic conductivity of the barrier between LW1 and Glennies Creek. Periodic re-surveying will be undertaken during subsequent extraction of ULD LWs 2 to 4, which will allow for more accurate subsidence predictions before undertaking ULD Stage 2 mining.

9.4.2 Bowmans Creek

Subsidence monitoring is undertaken across each longwall panel within the Bowmans Creek alluvium, and across in-bye and out-bye ends of each LW panel to ensure that monitored results are consistent with the predictions.

ACOL has undertaken a detailed pre-project inspection of Bowmans Creek, and a water quality study to assess exchange/discharge rates of local groundwaters to Bowmans Creek. This assessment will be repeated bi-annually until at least five years after completion of longwall mining.

10 TRIGGER ACTION RESPONSE PLANS

The Trigger Action Response Plans (TARPs) for surface water and groundwater have been developed to focus upon appropriate trigger and response actions for the management or mitigation of impacts to the natural environment as a result of coal extraction and are presented in **Table 10.1** and **Table 10.2**.

Monitoring serves to notify changes to the groundwater or surface water flow, quality, biology or geomorphology, or unforeseen discharges. Monitoring is necessary to indicate that an abnormal condition relating to coal extraction has developed.

Each monitoring program as described in **Section 8** has established triggers (**Section** 7), which are used to indicate levels of impact and trigger an appropriate response. The fundamental means of determining the magnitude of any impact and the need for further monitoring and/or remedial actions is based upon the impact assessment criteria detailed in **Section** 7. The responses (actions) documented in the TARPs are proposed to ensure the timely and adequate management of impacts outside of the established trigger levels.

The TARPs have been designed to allow reference to identified risks of impact from mining to environmental aspects identified within the mining area and surrounds. These may be either predicted or unpredicted.

10.1 ACOL Responsible Impacts Procedure

Where investigations detailed in the TARP determine that either surface water or groundwater impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, the following procedure is actioned:

i. Inform landholders adjacent to streams and/or private bore owners, and the DRE and the NSW Office of Water of preliminary investigation outcomes, as appropriate.
ii. Undertake a detailed investigation and assess possible mitigation measures in consultation with the landowner and the DRE and the NSW Office of Water, as appropriate.
iii. If deemed necessary prepare and implement a site mitigation/action plan to the satisfaction of DP&I, in consultation with the landowner, DRE and the NSW Office of Water, as appropriate.
iv. Conduct a review of results from the follow up investigation.

Further, the timing of the above includes, but is not limited to:

i. Results of preliminary investigation reported within 1 week of completion.
ii. Commence preparation of detailed investigation including assessment of possible mitigation measures immediately.
iii. Commence preparation of mitigation/action within 1 week of the need being identified.

10.2 Notification of Significant Impact

Where a significant, confirmed impact to the environment or private landowner has occurred according to the TARPs, relevant agencies will be contacted immediately.

10.3 Surface Water TARP

Table 10.1: Surface Water Trigger Action Response Plan

Trigger	Action	Timing	Responsibility	Reporting
10.3.1 Surface Water Flows				
Observed altered surface drainage topography due to subsidence causing surface ponding. **(Section 6.1.2.1)**	The affected areas are rehabilitated and landscaped to minimise the risk of ingress of surface runoff into subsidence fractures, restore surface drainage and minimise the risk of uneven surfaces to livestock.	Immediately where risk to people, surface infrastructure or livestock is identified. Where impacts are not causing risk to people, surface infrastructure or livestock schedule in consideration of predicted subsidence from subsequent panels and seams.	UG Technical Services Manager / Environmental Coordinator	Monthly updates of investigation progress. Report at End of Panel (EoP) to inform relevant agencies of results of monitoring. Reporting of observed parameter variations within AEMR
Observation of sudden variation in flow connectivity between surface and groundwater within a flowing stream (unexpected change in relative flow quantities of water as it moves downstream, based on periods of low flow and relative depths of water between successive monitoring sites and monitoring periods.) (Baseline conditions for this type of comparison of low flow conditions have not been developed previously at ACOL and monthly comparisons of such data and its associated trends are being initiated. Trigger values will initially be set at a 10% change in the comparisons of relative depths of low flow amounts along river reaches between each	Engage a hydrogeologist / hydrologist to undertake a preliminary investigation and report on any identified changes. Inspect channel beds, check for visible subsidence cracks or flow paths of water indicating likelihood of such cracks. To confirm trends, repeat water quantity measurements. To identify likely water sources and flow directions conduct water quality sampling and initiate laboratory water quality sampling of adjacent bores on a monthly basis. Where appropriate, identify contingency measures such as: Remediation inclusive of infilling with layers of impervious material such as clay and layers of	Immediately repair any visual subsidence cracks across drainage lines. **BOWMANS CREEK – Redundant Creek sections** Immediately repair any visual subsidence cracks across water ways and drainage lines. Where not already constructed immediate construction of full height	UG Technical Services Manager / Environmental Coordinator	Monthly updates of investigation progress. Report at End of Panel (EoP) to inform relevant agencies of results of monitoring. Reporting of observed parameter variations within AEMR

Trigger	Action	Timing	Responsibility	Reporting
successive monitoring point. Trigger values will be refined as spatial relations between various depths and flows develop over time. Reliance on calibrated groundwater model projections of baseflow impacts will be continued in parallel with calibrations being updated at least once each five years unless significant connectivity changes are observed.	protective material (rocks). Ensure as a precaution, sufficient stockpiles of raw materials (clay, rock etc.) and earth moving equipment are kept readily available for use in closing large unforeseen subsidence cracks that extend below channel beds of rivers and creeks. Check flow measurement results and repeat measurements if differences in low flows are likely to be due to other factors such as recent rainfall. Where investigations determine that impacts are the result of ACOL operations, offset the loss of any baseflow to the surrounding watercourses and/or associated creeks caused by ACOL as per DA condition 4.2. May also secure additional licences where required to account for increased baseflow reductions. Where loses are associated with Bowmans Creek, return flows from year 6 of the HUAWS WSP during cease to pump conditions. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1** **BOWMANS CREEK – Redundant Creek sections prior to full diversion** If there is any indication that significant drainage of the alluvium is occurring, or there is a loss of stream flow, due to cracking, the full height block banks will be constructed immediately.	block banks. Submit EoP report within 3 months of longwall completion. As per **Section 10.1**		

Trigger	Action	Timing	Responsibility	Reporting
10.3.2 Baseflow				
Baseflow impact greater than predicted **(Section 6.2.1)** Glennies Creek: Observed seepages measured at TG1A which exceed the predicted Glennies Creek seepage rate for 3 consecutive months at any stage during the mine life. Bowmans Creek and Hunter River: A water table drawdown in the Bowmans Creek or Hunter River alluvium in excess of 115% of the predicted drawdown.	Engage a hydrogeologist / hydrologist to undertake a preliminary investigation and report on any identified changes. Inspect channel beds, check for visible subsidence cracks or flow paths of water indicating likelihood of such cracks. Ensure as a precaution, sufficient stockpiles of raw materials (clay, rock etc.) and earth moving equipment are kept readily available for use in closing large unforeseen subsidence cracks that extend below channel beds of rivers and creeks. Check flow measurement results and repeat measurements on a monthly basis. Where investigations determine that impacts are the result of ACOL operations, offset the loss of any baseflow to the surrounding watercourses and/or associated creeks caused by ACOL as per DA condition 4.2. May also secure additional licences where required to account for increased baseflow reductions. Where loses are associated with Bowmans Creek, return flows from year 6 of the HUAWS WSP during cease to pump conditions. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1** Recalibrate groundwater model and revise predictions.	Immediate implementation of remediation of large visible cracks in channel. If reduction is not due to obvious cracking then initiate preliminary investigation within 1 week of impact being confirmed. If reduction is significant immediately notify agencies and discuss strategy. EoP report within 3 months of longwall completion.	Environmental Coordinator	Monthly updates of investigation progress. Report at EoP to inform relevant agencies of results of monitoring. Reporting of observed parameter variations within AEMR.

Trigger	Action	Timing	Responsibility	Reporting
	BOWMANS CREEK – Redundant Creek sections prior to full diversion If there is any indication that significant drainage of the alluvium is occurring, or there is a loss of stream flow, due to cracking, construction of the full-height block banks will commence as soon as practicable.			
10.3.3 Surface Water Quality				
Monitoring results outside of the impact assessment criteria stated in **Section 7.2.2**, with reference to upstream background water quality levels.	Investigate potential causes: • Conduct visual inspection to ascertain if any obvious causes are visible (e.g. broken pipe, discharge from dam etc) • If cause identified implement immediate repairs. If no obvious visible cause then: • Engage a Hydrologist to undertake a preliminary investigation and report on any identified changes if required. • Confirm trends or anomalies by repeating water quality and sampling of impacted streams as required. • Compare exceedence with climatic conditions. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1**	Immediate visual inspection. If likely cause is due to failure of infrastructure or equipment implement immediate repairs. If not due to visible infrastructure failure then arrange preliminary investigation and initiate within 1 week of trends being confirmed. EoP report within 3 months of longwall completion. As per **Section 10.1**	Environmental Coordinator	Monthly updates of investigation progress. If related to underground operations report at EoP to inform relevant agencies of results of monitoring. Reporting of observed parameter variations within AEMR. If hazardous substances are involved or licence criteria are breached then report immediately. As Per **Section 13.1.5**

Trigger	Action	Timing	Responsibility	Reporting
10.3.4 Flooding and Surface Drainage Reporting to Underground Mine				
Mine inflow rates greater than those predicted in **Section 7.3.5**.	Undertake an initial investigation to asses if unforeseen ponding of floodwaters on the Bowmans Creek, Hunter River or Glennies Creek alluvial plain may be possibly reporting to the underground mine workings as a result of subsidence. Where investigations determine that this may be the case, identify and implement contingency measures such as: Some areas such as the land above the southern tip of LW1, can be easily landscaped and infilled to prevent ponding in the subsided area. For subsidence in low lying areas that are prone to flooding and any ponded areas or channels used for drainage of water then priority is given to rapid identification of subsidence cracks, ripping, backfilling and compaction of subsidence troughs and addressing the drainage of ponded water through actions such opening drainage lines across ridges between subsidence troughs, creating drains and/or local diversion bund to route flowing water to drainage lines to achieve a free draining landform, and reduce ponding, and therefore mine infiltration. Evacuate underground workings if significant inrush of water occurs underground or appears likely to occur. Where there is no identified surface ponding, Engage a hydrogeologist / hydrologist to undertake a preliminary investigation and report on any identified changes.	Opportunistic, however immediate attention is needed if flooding is forecast by the Bureau of Meteorology. Immediate attention must also be given to repairing the impacts of subsidence on significant drainage lines.	UG Technical Services Manager / Environmental Coordinator	Reporting of predicted parameter variations within AEMR.

Trigger	Action	Timing	Responsibility	Reporting
	Where investigations determine that the result of the increased inflow may potentially impact on adjacent bores or surface water users, implement **Section 10.1**			
10.3.5 Discharge Event				
Unauthorised Discharge Breach of dam wall or holding ponds, unforeseen spillage from sediment ponds and unforeseen ruptures of pipelines containing tailings, saline water, or any pollutants.	Investigate discharge, considering any mitigating factors where applicable; • report discharge to the OEH; and • review adequacy of existing water management infrastructure and controls. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1**	Immediate investigation	Environmental Coordinator	Any of these events would require immediate reporting under the POEO Act. If hazardous substances are involved or licence criteria are breached then report immediately. As Per **Section 10.1** Monthly updates of investigation progress. Reporting of predicted parameter variations within AEMR.

10.4 Groundwater TARP

Table 10.2: Groundwater Trigger Action Response Plan

Trigger Levels	Action	Timing	Responsibility	Reporting
10.4.1 Groundwater Level				
Water table decline greater than predicted drawdown **(Section 7.3.1)**	Investigate potential contributing factors: • Confirm trends or anomalies by repeating water level sampling as required. • Compare exceedance with climatic conditions • Engage a Hydrologist to undertake a preliminary investigation and report on any identified changes if required. • Engage a hydrogeologist to undertake a preliminary investigation and report on any identified changes. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1** Proposed actions following findings of investigations specific to areas; **Hydraulic Connection with Glennies Creek and Connected Alluvium greater than predicted.** If the monitoring and investigation shows impacts associated with Hydraulic Connection with Glennies Creek and Connected Alluvium greater than predicted levels: • Continue water level monitoring; • Initiate laboratory water quality sampling on	Preliminary investigation initiated within 1 week of trends being confirmed. As per **Section 10.1**	Environmental Coordinator	Monthly updates of investigation progress. Report at EoP to inform relevant agencies of results of monitoring. Reporting of predicted parameter variations within AEMR.

Trigger Levels	Action	Timing	Responsibility	Reporting
	a monthly basis until resolved (including the monitoring of underground seepages); • Undertake hydraulic testing of piezometers in the barrier. • Increase licence allocation to account for addition loss • If the impact continues to be significantly higher than predicted, mitigation measures such as those outlined under **Section Error! Reference source not found.** will be considered. **Hydraulic Connection with Bowmans Creek and Connected Alluvium greater than predicted.** If the monitoring and investigation shows impacts associated with Hydraulic Connection with Bowmans Creek and Connected Alluvium greater than predicted levels: • Increase licence allocation to account for addition loss • Modify mine plan to mitigate future impact **Hydraulic Connection with Hunter River and Connected Alluvium greater than predicted.** If the monitoring and investigation shows impacts associated with Hydraulic Connection with Hunter River and Connected Alluvium greater than predicted levels: • Increase licence allocation to account for addition loss • Modify mine plan to mitigate future impact			

Trigger Levels	Action	Timing	Responsibility	Reporting
10.4.2 Groundwater Quality				
Changing trend in measured parameters outside limits of baseline levels (**Section 7.3.3**).	Confirm trends by repeating water level sampling of impacted and adjacent bores as required. Engage a hydrogeologist to undertake a preliminary investigation and report on any identified changes. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1**	Preliminary investigation initiated within 1 week of trends being confirmed. EoP Report within 3 months of longwall completion. As per **Section 10.1**	Environmental Coordinator	Monthly updates of investigation progress. Report at EoP to inform relevant agencies of results of monitoring. Reporting of predicted parameter variations within AEMR.
10.4.3 Groundwater Users				
Reported adverse impact on the yield of an existing water supply well or bore. Observed variation in measured groundwater levels outside of the predicted levels.	To confirm trends, repeat water level sampling of affected and adjacent bore(s) as required. Engage a hydrogeologist to undertake a preliminary investigation and report on any identified changes. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1**. The cause will be investigated and if it is related to the ACP, either the affected bore or well will be deepened or an alternative water source will be provided, or alternative agreed compensation paid. The matter will be dealt with in consultation with the NSW Office of Water and to the satisfaction of the DP&I Director-General. ACOL will provide compensatory water supply to any landowner of privately-owned land whose water entitlements are impacted.	Preliminary investigation confirming loss of water supply due to mining impacts initiated within 1 week of trends being confirmed. Inform DP&I/NSW Office of Water and other relevant agencies within 1 week. EoP Report within 6 months of longwall completion. As per **Section 10.1**	Environmental Coordinator	Report to landholder of investigation findings. Where impacts are determined to be the result of ACOL operations. Inform landholder and the DP&I/NSW Office of Water of preliminary investigation outcomes. Monthly updates of investigation progress. Report at EoP to inform relevant agencies of results. Reporting within AEMR.

Trigger Levels	Action	Timing	Responsibility	Reporting
10.4.4 Mine Inflow				
Observable increases in flow rate above prediction Sudden inrush of groundwater into underground workings. (**Section 7.3.5**)	Immediate reporting to UG Technical Services Manager, Environmental Coordinator and Mine Manager. Repeat water quality sampling and initiate laboratory water quality sampling on a fortnightly basis. Engage a hydrogeologist to undertake a preliminary investigation and report on any identified changes. Where investigations determine that impacts are the result of ACOL operations or may potentially impact on adjacent bores or surface water users, implement **Section 10.1**	As per **Section 10.1**	UG Technical Services Manager / Environmental Coordinator	Monthly updates of investigation progress. Report at EoP to inform relevant agencies of results of monitoring. Reporting of predicted parameter variations within AEMR
10.4.5 Groundwater Dependent Ecosystems				
Groundwater level fall in alluvium of 0.5m (not attributable to natural conditions) in the alluvium adjacent to RRG stands. (**Section 7.3.4**) Observation of RRG poor health during bi-annual survey.	Repeat bi-annual survey and groundwater level monitoring to confirm any adverse impact. Engage a hydrogeologist and Ecologist to undertake a preliminary investigation and report on any identified changes.	Investigation initiated within 1 week.	Environmental Coordinator	Reporting of predicted parameter variations within AEMR Results of investigation reported to the NSW Office of Water, DP&I, OEH and DRE.

10.5 Contingency Responses to Glennies Creek Inflows

Should impacts to Glennies Creek change beyond those predicted within the Extraction Plan and Development Consent (e.g. exceed the triggers identified in this WMP) then one of the following remediation options, or a combination thereof, will be investigated in consultation with relevant experts and government authorities as a possible mitigation measure.

Table 10.3: Surface Water Trigger Action Response Plan

Option	Method	Comments
Licensing and monitoring	Utilise high security licences on Glennies Creek	Licensing represents a legal mechanism that may satisfy the relevant legislation and is cost effective and manageable. This may require temporary or permanent trade of appropriate water entitlements on the water market.
Block seepage exit	Filling tailgate with impermeable fill such as cement stabilised tailings or fly ash	Technically feasible and demonstrated industry experience, however the potential for success in reducing seepage is not well quantified.
Reduce permeability - achieved by grouting cleats in coal seam	Grout applied to coal seam via vertical holes adjacent to Glennies Creek	Surface grouting potentially creates environmental issues, including significant interference with the slopes immediately adjacent to the Creek.
Physical barrier	Slurry cut-off wall	For a physical barrier to be most effective it would need to be installed close to creek. This would potentially create environmental issues, including significant interference with the slopes immediately adjacent to the creek.
	Steel sheet piling or interlocking concrete piles	
	Lining of creek	

Consideration may also be given to returning water to a system from which it is lost. ACOL may apply this approach initially and delay any further physical remediation to allow adequate time for detailed monitoring, assessment, planning and design to be completed.

Deferring the final physical remediation response until near the end of the project or at the mine closure stage should enable the most effective measures to be identified once the loss mechanisms and optimal solution(s) are better understood – allowing a greater likelihood of success.

11 EROSION AND SEDIMENT CONTROL

Erosion is defined as the loss of soil particles from a ground surface; whereas sedimentation is classed as the accumulation of soil particles (DECC, 2008a).

11.1 Site Constraints and Characteristics

The site-specific constraints and characteristics, which are relevant to the management of erosion and sediment are summarised in **Table 11.1**.

Table 11.1: Site specific erosion and sediment control constraints and characteristics

Constraint/characteristic	Value/Details
Rainfall *(Rainfall Erosivity Factor)*	R-factor = 1500 Singleton (from Landcom, 2004, vol. 1, Appendix B) 643.7mm mean annual rainfall (Jerrys Plains Meteorological Station)
Rainfall zone	Zone 6 (from Landcom, 2004, vol. 1, Figure 4)
Slope gradients	NEOC disturbed areas – moderate slope gradient – generally 14^{o} and slope lengths up to 100m. Natural landscape includes: • Steeper slopes (20%, relief 40m) north and west of Glennies Creek. • Undulating slopes (25-30m local relief) directing flow towards Glennies Creek and Bowmans Creek. • Near level floodplains (2% slope) east and west of Glennies Creek and Bowmans Creek. • Current elevation ranges from 58 – 136mAHD (includes disturbed areas).
Potential erosion hazard	Low for slopes less than 15%, high for slopes greater than 15% (from Landcom, 2004, vol. 1, Figure 4.6)
Soil erodibility *(Soil Erodibility Factor – K)*	K-factor = 0.037 The ACP contains the following soil landscapes: Bayswater – NEOC area. Moderate sheet and gully erosion is common on slopes, with gullies (to 3m) associated with the highly erodible yellow solodic soils. These yellow soils also have a high hazard and salinity rating and a very high to extreme erosion hazard. Hunter – Floodplain areas. These soils may seasonally crack and/or crust under cultivation, with a high risk of structural degradation and erosion. Roxburgh – EL5860 and land east of Glennies Creek. Minor to moderate sheet erosion is common on these soils with gullies up to 3m occurring on the dispersible solodic soils. They possess a high risk of structural degradation and are often hard setting on the surface.
Calculated soil loss	The average potential soil loss across the ACP (determined using the Revised Universal Soil Loss Equation, Landcom, 2004, vol 2) is approximately 6.011t/ha/yr. The ACP covers approximately 880ha which gives rise to a potential total soil loss of about 5290t/yr.
Soil loss class	Very low
Soil texture group	Types C and D
Disturbed site area	Total of 880ha – includes open cut and underground operations, plus associated infrastructure.
Rural land capacity (pre-disturbance)	Classes (of relevance to erosion and sediment control): III – Regular cultivation with structural soil conservation measures; and IV and V – Suitable for grazing, occasional cultivation.

Constraint/characteristic	Value/Details
Agricultural land suitability (pre-disturbance)	Class 1 – Arable land along Bowmans Creek and Glennies Creek suitable for intensive agriculture and cropping. Class 3 – Open areas suited for pasture or cultivated for the occasional crop, in the form of pasture improvement. Class 4 – Poor grazing land in areas adjacent to Class 1 and 3. Class 5 – Steep sloped areas not suitable for agriculture.
Waterfront land (in accordance with Strahler stream classification system)	Bowmans Creek and Glennies Creek are classified as third order streams, whereas the Hunter River is a fourth order stream. Betty's Creek, which is predominately outside the mining lease area, is a second order stream. Prior to disturbance, the NEOC area would have drained to Betty's Creek to the north/north-west. Water is currently diverted via channels and pipelines to onsite dams. Land impacted by underground operations drains west into Bowmans Creek, east to Glennies Creek and south to the Hunter River.

Sources/references:

Managing urban stormwater: soils and construction, volume 1, 4th edition (Landcom, 2004) – for figure/data references.

Managing urban stormwater: soils and construction, volume 2E Mines and quarries (DECC, 2008) – for table format/requirements.

HLA Envirosciences, 2001, 'Soils and Land Capability Report' – for establishing soil characteristics.

11.2 Sources and Impact of Erosion and Sediment

Soil erosion and the generation of sediment can be caused by a variety of activities at the ACP, which include:

- the alteration of existing surface water flow patterns;
- land disturbance (vegetation clearing, topsoil stripping, road and infrastructure construction, and vehicular movement), which can cause increase runoff volumes and velocities;
- topsoil stockpiling;
- overburden emplacement;
- rejects emplacement; and
- underground mining, which results in varying degrees of subsidence as the multi-seam longwall descends through the underlying coal seams.

Potential impacts arising from erosion and sediment loss at the ACP include:

- increased surface runoff volume due to the introduction of impervious surfaces and hardstand areas;
- liberation of salt from overburden resulting in increased salinity levels;
- increased sediment movement resulting in a decline in water quality, such as Total Suspended Solids (TSS) entering watercourses and bodies; and
- alteration of overland flow paths within existing drainage lines due to changes in surface topography as a result of subsidence.

11.3 *Erosion and Sediment Management*

ACOL's guiding principle is to firstly minimise erosion to prevent pollution, and secondly, capture sediment from disturbed areas to control it. Erosion and sediment control is integrated with site water management (**Section** 5), which distinguishes between raw and worked water drainage areas, ensuring that water from disturbed areas is diverted into onsite dams, which also serve as sediment entrapment and settling facilities.

An environmental induction for all personnel prior to the commencement of operations and ongoing environmental training is in place to heighten awareness of Site erosion and sedimentation concerns.

Erosion and sediment management and related control structures are consistent with the specifications contained in *Managing urban stormwater – soils and construction,* Volume 1, 4th edition (Landcom, 2004), and particularly Volume 2E *Mines and Quarries* (DECC, 2008a).

Various activities associated with the construction of the Bowmans Creek Diversion (BCD) have the potential to cause soil mobilisation and sedimentation. Erosion and sediment control for BCD construction and maintenance is addressed in the BCD Management Plan in **Appendix F**.

11.3.1 Minimising Soil Erosion

Soil mobilisation is minimised by restricting the extent of disturbance and clearing to the minimum that is practical and in accordance with the Mining Operations Plan (MOP). Managing subsidence appropriately and rehabilitating disturbed land assist in reducing soil loss at the ACP.

11.3.1.1 Subsidence Management

Surface cracking will be closely monitored for erosion and remediated as required to ensure existing drainage lines continue to function. Where required, cracks will be reshaped, scarified and stabilised, topsoil applied if necessary and spray or hand seeded. Interim erosion control devices such as hay bales and geotextile barriers will be provided as necessary to divert runoff away from the remediated area until sufficient ground cover has been established. Nick points in grassland or woodland areas will be reshaped and remediated in a similar manner.

Minor ephemeral drainage lines may develop nick points that will require reshaping to ensure velocities and scour characteristics are not altered. Once reshaped, any steepened areas that may remain unstable will be lined with loosely placed rock to dissipate runoff energy.

While it is not expected to occur, surface cracking of rock exposures in drainage lines may be sealed by cement or chemical grout as appropriate.

Longwall mining subsidence impacts are addressed and managed in accordance with ACP Subsidence Management Plans (SMP) and/or Extraction Plans (EP).

11.3.1.2 Rehabilitation of Disturbed Land

The progressive rehabilitation of disturbed land is in accordance with the MOP and is carried out as soon as practicable in relation to favourable weather conditions (subsequent to the peak high-intensity storm season, yet when soil is and will continue to be moist). Traffic to cleared and rehabilitated areas is limited by barriers or signage.

As part of the rehabilitation process, soil analysis to date conducted across the mine site has not identified any areas impacted by dryland salinity. Any soil materials which are utilised for rehabilitation are tested to determine the type and degree of conditioning required (i.e. gypsum, lime and fertiliser application). This encourages infiltration and enables runoff water to be within acceptable limits.

An organic growth medium (OGM) is spread on top of either topsoil or overburden to increase the nutrient level and water holding capacity of the soil. OGM has been shown to assist the quality and cover of rehabilitation at the ACP.

11.3.2 Topsoil and Stockpile Management

Topsoil stockpiles are established away from slopes and drainage lines, in designated areas, and protected by appropriate erosion control structures and temporary sediment fences if necessary.

Where possible, topsoil will only be stockpiled and sown when no areas of reshaped overburden are available for direct placement and spreading. The topsoil is stripped moist and then reused as soon as possible to ensure the viability of its existing seed bank, and fungal and microbial activity.

In the case where topsoil is not placed directly, stockpiles will be formed, which will be either be revegetated with the final revegetation or cover crop seed mixture and kept weed-free; or will covered with jute mesh (details in ACOL's Land Management Plan).

Erosion and sediment control measures will be implemented in advance of, or in conjunction with, topsoil stripping, stockpiling and placement.

11.4 Erosion and Sediment Control Structures

Major erosion and sediment control structures at the ACP include dams, sediment fences, bunds, drains and channels, which are shown on **Figure 3**. Control structures are installed prior to the disturbance of any land. Temporary controls include hay bales and geotextile barriers to filter runoff and capture sediment.

The longevity of structures is taken into consideration during construction so as to ensure they remain until post closure, and form part of the final rehabilitated landform.

11.4.1 Sediment Settling Dams and Water Storages

All sedimentation dams were originally designed to control and treat runoff from a 1 in 20 year storm event of 24-hour duration. Some catchment areas have altered since completion of open cut mining in Barrett Pit and have increased the size of the rehabilitated EEA. The required dam sizes were therefore checked against the existing dam sizes using the calculation methods provided by Landcom (2004). Calculations were performed in accordance with the Landcom (2004) specified methodology for sizing dams. The dams are kept in a drawn down state to accommodate large storm events. For sediment settling, Landcom (2004) suggest dams should accommodate a five-day 75th percentile rainfall event. This guideline aims at settlement settling conditions prior to release of water to the natural system.

In addition to the major runoff storage dams within the NEOC, there are a number of minor runoff capture dams such as those located on top of the EEA. They intercept stormwater water for attenuation purposes before it leaves the top of the dump to the side rehabilitation slopes. This reduces flow rates and dissipates energy to contribute to a reduction in erosion and sediment control. These dams and drainage lines may also contain sedimentation management devices in the form of hay bales, silt fences, and other controls where and when required.

The SD has been sized to contain a 1:100 year 72-hour ARI storm event. Management strategies are in place to enable ACOL to avoid discharge during a 1:100 ARI storm event of 72 hour duration. This includes pumping to redistribute water between storage facilities to ensure maximum buffer capacity in those dams needed for stormwater and sediment control.

Several strategies are in place to minimise peak flow rates and associated scour, and also to reduce sediment generation. For example, the top of the EEA contains two ponds which attenuate flow rates before it enters into rock lined drop structures (drains). The length of travel of each contour drain along the side slope terraces of the EEA is different; so as to further attenuate the total peak flow rate draining from the EEA. Extensive organic soil treatment is applied to the EEA area to ensure dense grass and vegetation covers play a major role in minimising erosion.

The minimum required dam sizes for sediment settling using the Landcom (2004) guidelines are compared in **Table 11.2**, to the sizes of the dams established on the site. In practice, two sediment settling dams are located in tandem above (adjacent) the PWD so that sediment removal can occasionally be applied to one of the sediment dams and maintenance to remove sediment from the PWD is largely avoided.

Table 11.2 Comparison of actual dam sizes to minimum sizes required for sediment settling

Dam	Current size (ML)	Minimum size needed (ML)	Adequate?
Dam 56	56	5.67	Yes
Arties Pit Sump	30	1.62	Yes
Sediment Settling Dam (upper)	22.5	19.98	Yes
Sediment Settling Dam (central)	30	19.98	Yes
Process Water Dam	36	19.98	Yes

Note **1** Minimum size needed relative to Landcom (2004) criteria for 75th percentile 5-day rainfall occurrence.

Some of the current sedimentation dams are planned to be retained for stock watering purposes subsequent to rehabilitation being completed.

11.4.2 Diversion Drains and Channels

Stable drainage lines (rock check dams, drop structures and contour drains) are constructed and maintained to improve the stability of rehabilitated land. Three main rock-lined drop structures are situated on the EEA. Diversion drains and channels are designed for peak runoff from a 1 in 5 year ARI storm. Sectional areas, energy dissipaters, scour protection and hydraulic grades were required to produce flow velocities of less than 1.5m/s.

Scour protection devices including rock riprap, or reinforced turf or geotextile fabric, are installed where runoff enters natural watercourses, to reduce flow rate and break up directional forces.

These controls are in accordance with the NOW (formerly DLWC) 1999 draft *Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites* and are designed for the life of mine so as to not cause erosion.

11.5 Maintenance of Erosion and Sediment Control Structures

Surface water management structures are regularly inspected to ensure the integrity of the system is maintained. All sediment dams are inspected on a monthly basis to ensure they have at least 75% of their capacity available for runoff / sediment retention. Dams are de-silted as soon as practicable, with silt being disposed of to an area approved by the Environmental Coordinator.

A visual inspection of sediment and erosion control safeguards (dams, sediment traps, contour banks, roads, channels, diversions, silts fences and hay bales) is undertaken monthly and after periods of heavy rainfall. Excess sediment is removed from banks and drains and from behind sediment trapping devices to ensure their structural integrity and repair is undertaken as necessary.

A priority system is in place for repairs and maintenance following intense storms. Specific works to be completed will be assessed by the Environmental Coordinator at the time, taking into consideration the severity of the damage and availability of equipment to carry out repairs. It will generally follow an order of importance, such as:

i. Rejects emplacement area
ii. Inflow points to sedimentation dams and spill ways
iii. Rehabilitated areas
iv. Active mining area
v. Subsided areas

The surface water quality monitoring program includes the testing of Total Suspended Solids (TSS). Results are reviewed regularly to check the effectiveness of sediment and erosion control structures.

All structures in rehabilitated areas remain in place until exposed areas are approved stable by the Environmental Coordinator.

12 BOWMANS CREEK DIVERSION MANAGEMENT PLAN

The Bowmans Creek Diversion Management Plan (**Appendix F**) provides details of the construction, rehabilitation and ongoing management activities related to the diversion of two sections of Bowmans Creek on land owned by ACOL between the New England Highway and the Hunter River. The objective of the Plan is to develop and maintain an ecologically healthy connective creek corridor, which provides:

- Channels that mimic the hydraulic and geomorphic characteristics of the existing creek and provide similar resilience;
- Improved fish passage and diversity of aquatic habitat;
- An ecologically diverse, naturally vegetated, riparian corridor; and
- Where possible a free draining floodplain that is vegetated to a standard consistent with the final intended land use.

The plan includes:

- An assessment of baseline conditions related to:
  - surface water hydrology, flooding and water quality,
  - fluvial geomorphology and channel stability, and
  - aquatic, riparian and floodplain ecology;
- Detailed design specifications for:
  - channel alignment and cross section geometry,
  - leakage control and bed stabilisation,
  - construction of block banks to divert flow into the diversion channels, and
  - works to maintain a free draining landform following subsidence;
- A construction program, which is integrated with the mine schedule, covering the staging and management of:
  - channel construction works and staged construction of block banks, and
  - progressive filling and drainage construction works on the floodplain following subsidence;
- A revegetation program, which is integrated with the mine schedule, and provides for:
  - Post construction site stabilisation,
  - Progressive rehabilitation of the diversion channels,
  - Development of appropriate vegetation communities within the diversion channels and the adjoining floodplain using a range of local native species,
  - Rehabilitation management procedures including seed collection, soil improvement, weed management planting methods and weed control, and
  - Contingency management for weed invasion, poor plant establishment and bushfire;
- Performance and completion criteria for:
  - Earthworks construction,
  - Geomorphic stability,
  - Riparian zone rehabilitation and floodplain vegetation establishment, and
  - Water quality and aquatic ecology;

- A program to monitor and maintain:
    - surface water hydrology and water quality,
    - geomorphic stability, and
    - riparian and aquatic ecology

13 REPORTING AND REVIEW

13.1 Reporting

13.1.1.1 Mid-Panel Data Review

ACOL will prepare a succinct summary review of observed data for LWs 1, 2, and 3 in the ULD Seam, within two weeks of passing XL5 (nominally located above 10ct). A copy of this review will be provided to DRE and NOW for reference.

This review will focus on the subsidence survey monitoring and groundwater monitoring data collected to that point. The review will comment on the adequacy of the mine plan, provide a brief comparison of the observed data to the predicted subsidence and ground water effects, and whether it is considered that there have been any impacts to Glennies Creek or the Hunter River.

13.1.2 End of Panel Reports

Post-mining longwall panel subsidence monitoring reports are produced to detail subsidence and induced fracturing, groundwater levels, water quality and mine inflows, and assess these against the EIS/EA and the SMP/EP predictions for the mined panel and seam. End of Panel reports, are to be to the satisfaction of the Director-General of the DP&I and DRE.

These reports are subjected to independent review by a NSW Office of Water approved hydrogeological expert. Approval will be sought from the NSW Office of Water for the proposed expert reviewer prior to appointment.

13.1.3 Annual Environmental Management Report

The following water issues will be reported in the AEMR to the satisfaction of the Director-General (Planning and Infrastructure) and DRE:

i. an interpretation and statistical analysis of water quality results and changes in time for water quality and water levels at surface and ground water monitoring points (supported with graphs and contour plots showing changes in aquifer pressure levels);

vi. the outcome of the mine water balance for the year;

vii. the effectiveness of established water management structures, sediment control devices and the particulars of any remedial measures undertaken in instances where uncontrolled erosion or heavy sediment deposition has occurred;

viii. a discussion of any exceedances in relation to compliance criteria and predictions made in the EIS or the EA; and responses taken to ameliorate those exceedances;

ix. reporting on the differentiation between shallow and deep aquifers, with interpretation of results; and

x. an interpretation of the water balance identifying the volume and make-up of mine pit inflows as compared to Part 5 licence entitlements (required under Part 5 of the *Water Act* 1912), and predictions made in the EIS, EA or previous AEMR;

An electronic copy of the data will be provided to NOW.

In addition, the AEMR will incorporate a Groundwater Management Report prepared by an independent expert to the satisfaction of NOW. It will identify trends in groundwater monitoring data and provide a comparison to predictions.

Copies of the AEMR will be submitted at the same time to the DP&I, DRE, OEH, NOW, SSC and the CCC, and made available for public information at SSC within fourteen days of submission to these authorities.

13.1.4 Annual Return for EPL 11879

An annual return is completed each year and submitted to the EPA within 60 days of the reporting period for the ACP, which includes:

- Statement of Compliance;
- Water monitoring and complaints summary; and
- An explanation for any missing water monitoring results.

13.1.5 Complaints

Complaints in relation to water resources are maintained in an up-to-date database from the start of mining to date, which includes:

- The date and time of the complaint;
- The method by which the complaint was made;
- Any personal details of the complainant which were provided by the complainant or, if no such details were provided , a note to that effect;
- The nature of the complaint;
- The action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant, and
- If no action was taken by the licensee, the reasons why no action was taken.

Complaint records are available upon request by an EPA officer.

13.1.6 Notification of Environmental Harm

When material harm to the environment is caused or threatened ACOL will immediately notify each relevant authority (identified below)

Material harm includes actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial or that results in actual or potential loss or property damage of an amount over $10,000.

1. Firstly, call 000 if the incident presents an immediate threat to human health or property. (Fire and Rescue NSW, the NSW Police and the NSW Ambulance Service are the first responders, as they are responsible for controlling and containing incidents).

If the incident does not require an initial combat agency, or once the 000 call has been made, notify the relevant authorities in the following order. The 24-hour hotline for each authority is given when available:

1. EPA on 131 555
2. the Ministry of Health via the local Public Health Unit – see www.health.nsw.gov.au/publichealth/infectious/phus.asp
3. WorkCover Authority – phone 13 10 50
4. Singleton Council - 6572 1400
5. Fire and Rescue NSW – phone 000.
6. DP&I Singleton office – phone 6575 3405

As outlined in the TARP, any breaches of the Development Consent Conditions or other relevant license will be reported to the relevant authority. The DP&I will be notified of any breaches to any of the consent conditions, whilst the NOW and OEH will be notified of any breaches to the sites water licenses and Environmental Protection License.

13.2 Community Consultation

The details of the community consultation will be provided in the ACOL Community Consultation Program. This will include water management issues as follows:

- Site water management issues and water monitoring summaries will be communicated at quarterly Community Consultative Committee meetings and the ACOL Environmental Coordinator will address specific issues directly with landowners and residents on an as required basis.
- Results of monitoring will be reported annually in the AEMR, which will also be available to the public for review and comment.
- The WMP (including the monitoring program), will be made available to the public on the Internet within two weeks of approval by the relevant government authority.

13.3 Review

13.3.1 Reviews of Subsidence Impacts on Groundwater System

End of Panel reports include a review of the groundwater environment, as mentioned above in **Section 13.1**.

In accordance with industry best-practice (Middlemis/MDBC, 2001), a modelling post-audit will be carried out once Bowmans Creek has been diverted and the redundant section of Creek is undermined in the PG. Following this review, if necessary, the model will be re-calibrated and confirmatory forward impact predictions made.

Inflow rates and modelling will be reviewed at the end of mining for the ULD, ULLD and LB seams as appropriate.

Should any review, report or post-audit indicate a significant variance from the model predictions with respect to water quality or groundwater levels, then the implications of such variance will be assessed and appropriate response actions implemented in accordance with the protocols described in this WMP to plan appropriately for future extractions.

13.3.2 Groundwater Quality

To regularly confirm the rates and directions of groundwater movements, the groundwater model will be recalibrated at regular intervals to include updated water monitoring data. Recalibration will be done at completion of each significant stage of the mine's development or at intervals of three years, whichever is soonest.

13.3.3 Review and Modification of WMP

The surface water and groundwater monitoring program has been reviewed and updated for this WMP to ensure the optimal use of water resources and to meet the conditions of the latest DA modifications and commitments.

The WMP is a living document and will be reviewed and updated periodically to reflect changes to the mine plan, DA conditions, technology/operational practices and following significant water related incidents. It will also be updated as a result of changes in environmental circumstances, water monitoring results and reviews by the community and authorities. All significant revisions and updates will be undertaken in consultation with relevant authorities and approval from the Director-General of the DP&I.

Reviews will include an assessment of the effectiveness of the water management and erosion control system and its performance against the WMP's objectives and DA.

The water monitoring program will be reviewed annually, and reported in the AEMR. A comprehensive review will be carried out at important milestones in the mine life, which will include reviewing the groundwater modelling predictions and if necessary a re-calibration of the groundwater model and trigger levels.

If the predicted impacts using the re-calibrated model differ significantly from the 2009 EA predictions (or relevant later document), the assessment of potential groundwater impacts will be revised and if necessary additional or revised mitigation measures implemented in consultation with NOW.

The trigger level for requiring a revision of the impact assessment will be an assessed leakage rate from the Bowmans Creek, Glennies Creek or Hunter River alluvium into the coal measures as detailed under **Section 7.2**.

Whilst this WMP is under a review or submission with the DP&I, existing plans will be utilised onsite.

14 ROLES AND RESPONSIBILITIES

In addition to specific tasks that are assigned to ACOL personnel in the TARP, responsibilities for particular staff and contractors are provided below:

General Manager

- Has the overall responsibility for works undertaken at the ACP.

Mine Managers – Open cut and Underground *(reports to the General Manger)*

- Ensuring all procedures that are documented in the WMP are complied with by Site personnel;
- Ensuring that all relevant regulations, licences, approvals are complied with by Site personnel;
- Directing the construction of earthworks and the installation and maintenance of erosion and sediment control structures; and
- Ensuring contractors engaged to carry out site works are appropriately experienced.

Underground Technical Services Manager (reports to the *UG Mine Manager*)

- Ensure mine planning is in accordance with the WMP, relevant regulations, licences and approvals; and
- Consults with relevant Ravensworth Underground Mine personnel on a seam by seam basis regarding the cumulative effect of both of the mines' planning, groundwater and subsidence.

Underground Mining Engineer (reports to the *Technical Services Manager*)

- Undertake regular inspections of subsided areas, and erosion and sediment control structures;
- Oversee any remediation works and/or the installation of devices and ensure they remain until the area is stabilised; and
- Ensure that contractors on site are appropriately trained and inducted.

Environment and Community Relations Manager (reports to the *General Manager*)

- Ensuring all procedures that are documented in the WMP are complied with by Site personnel;
- Ensuring that all relevant regulations, licences, approvals are complied with by Site personnel;
- Engages appropriately qualified personnel to undertake required actions;
- Acts as the interface for environmental and heritage matters between government authorities, private industry, contractors, community groups and the wider community;
- Ensures that all personnel onsite conform to the requirements of relevant environmental laws, regulations, consents, approvals, systems and plans;
- Develops the AEMR;
- Develops solutions to any unplanned events that may potentially result in (or have caused) adverse environmental impacts;
- Implements the WMP; and
- Consults with relevant Ravensworth Underground Mine personnel on a seam by seam basis regarding the cumulative effect of both of the mines' planning, groundwater and subsidence.

Environmental Coordinators (reports to the *Environment and Community Relations Manager*)

- Maintain the environmental monitoring program to gauge the effects of mining operations on surface water and groundwater resources;
- Undertake regular inspections of subsided areas, and erosion and sediment control structures;
- Ensure that all personnel onsite conform to the requirements of relevant environmental laws, regulations, consents, approvals, systems and plans;
- Oversee any remediation works and/or the installation of devices and ensure they remain until a area is stabilised; and
- Ensure that contractors on site are appropriately trained and inducted.

All Employees and Contractors

- Are to abide by the requirements of this Plan;
- Are required to undertake environmental training, including site specific rules and procedures, prior to commencing work onsite. The training will include erosion and sediment control objectives and incident response procedures;
- Are to report defective water management systems and infrastructure to management; and
- Contractors are required to follow the directions of ACOL personnel whilst working onsite and demonstrate that they are trained in the management of erosion and sediment control. In addition, they are to provide an Environmental Control Plan and/or risk assessment if applicable.

14.1 Emergency Contacts

Emergency contacts relevant to this management plan are detailed in **Table 14.1** below.

Table 14.1: Emergency contacts relevant to the WMP

Role	Contact	Telephone Contact
ACOL		
General Enquiries	n/a	Hotline: 1800 657 639
General Manager	Brian Wesley	Tel: (02) 6576 1111 Mob: 0407 025 379
Open Cut Mine Manager	Brian Chilcott	Tel: 02 6570 9128 Mob: 0429 176 203
Underground Mine Manager	David Gibson	Tel: 02 6570 9104 Mob: 0408 643 721
Underground Technical Services Manager	Aaron McGuigan	Tel: 02 6570 9124 Mob: 0408 603 609
Environment and Community Relations Manager	Lisa Richards	Tel: 02 6570 9219 Mob: 0427 462 650 Email: lrichards@ashtoncoal.com.au
Environmental Coordinator	Cassandra Ferguson	Tel: 02 6570 9106 Mob: 0427 722 070 Email: cferguson@ashtoncoal.com.au
Environmental Coordinator	Scotney Moore	Tel: 02 6570 9125 Mob: 0427 904 268 Email: smoore@ashtoncoal.com.au

Role	Contact	Telephone Contact
Emergency Services and Government Agencies		
Police (Singleton)	-	000 (02 6578 7499)
Ambulance	-	000
Office of Environment & Heritage	Environment Line (EPA)	131 555
Department of Primary Industries	NSW Office of Water	02 8281 7777
Department of Planning & Infrastructure	Mining and Extractive Industries Department	02 9228 6111
Singleton Shire Council	General Enquiries	02 6578 7290
Neighbouring Mines		
Glennies Creek Underground Mine – Integra (Vale)	General Enquiries	02 6577 4200
Ravensworth Underground Mine – Xstrata	General Enquiries	02 6576 1500

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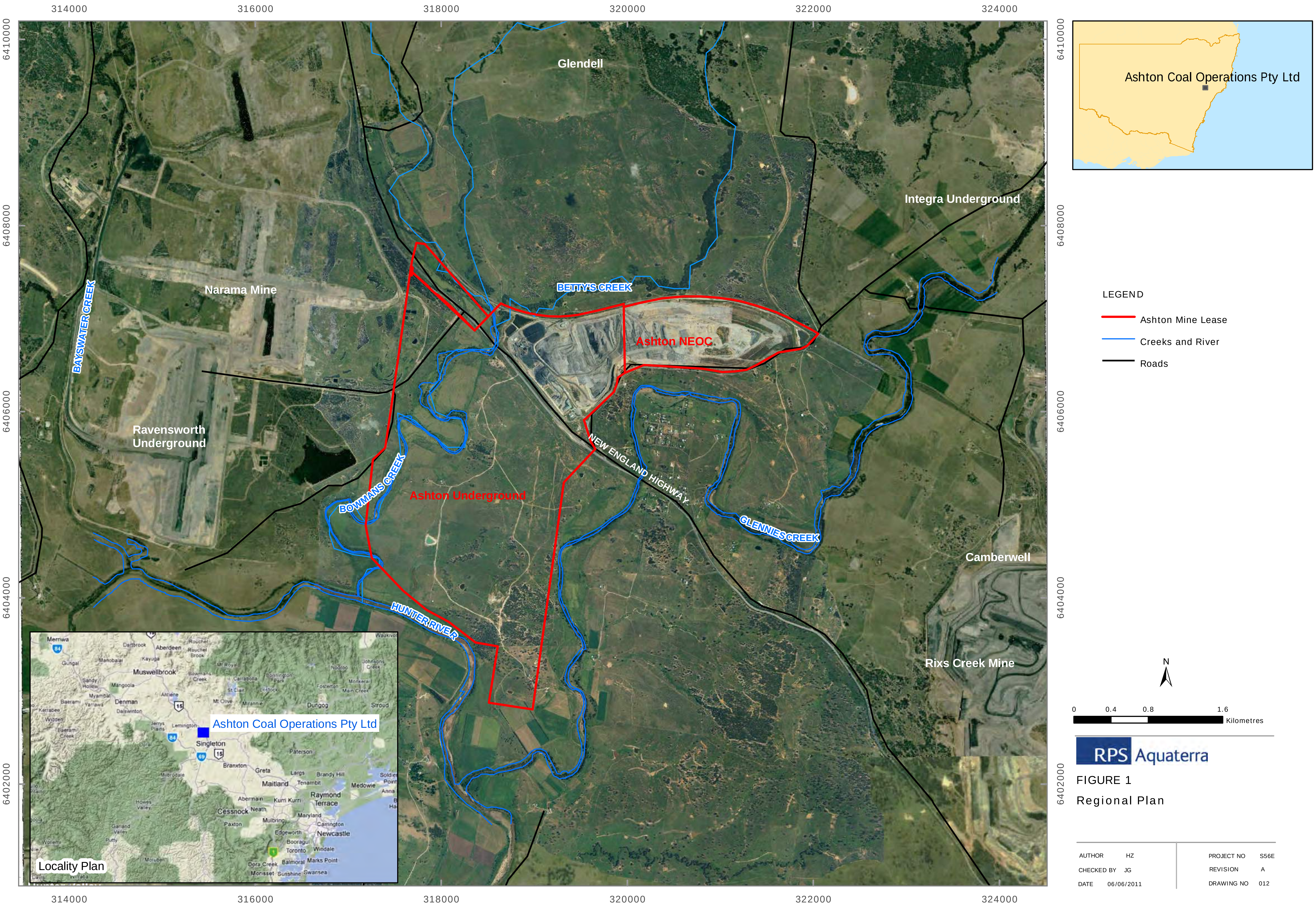
FIGURES

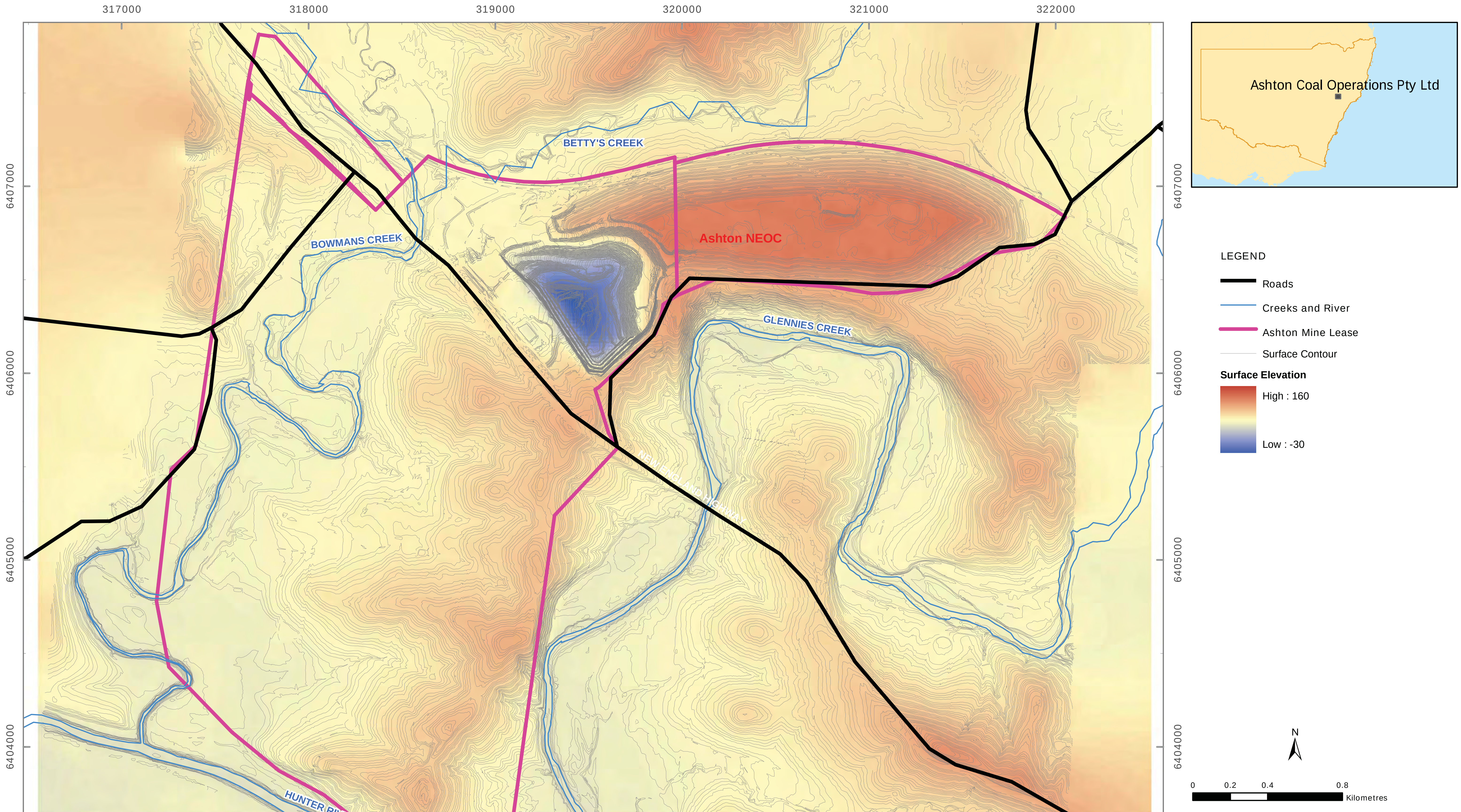


RPS Aquaterra

FIGURE 1

Regional Plan

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	JG	REVISION	A
DATE	06/06/2011	DRAWING NO	012



RPS Aquaterra

FIGURE 2

Site Topography

Floodlines Compiled from Hyer 2009 and Worley Parsons 2009

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	CS	REVISION	A
DATE	24/02/2012	DRAWING NO	035

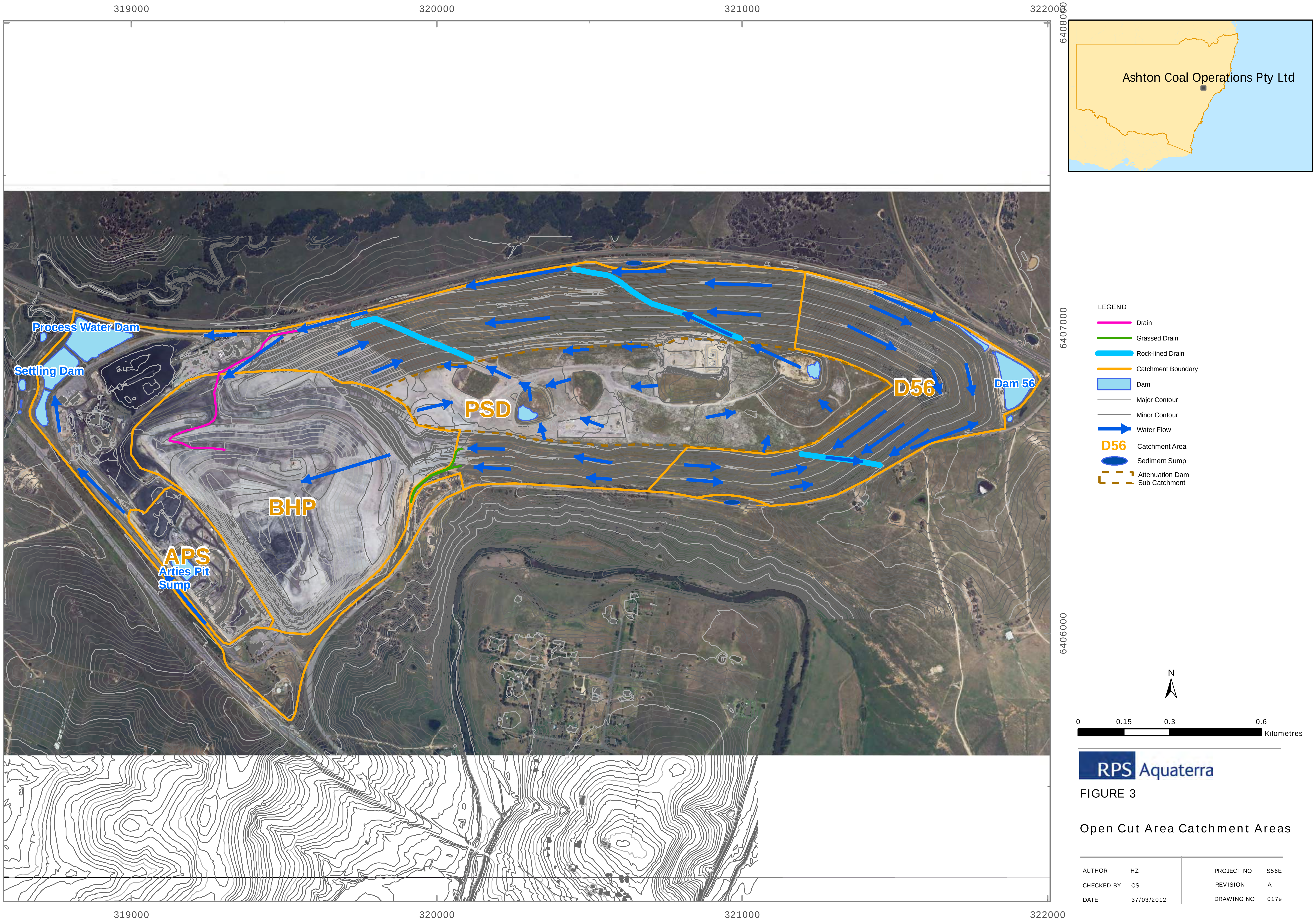


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FIGURE 3

Open Cut Area Catchment Areas

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	CS	REVISION	A
DATE	37/03/2012	DRAWING NO	017e

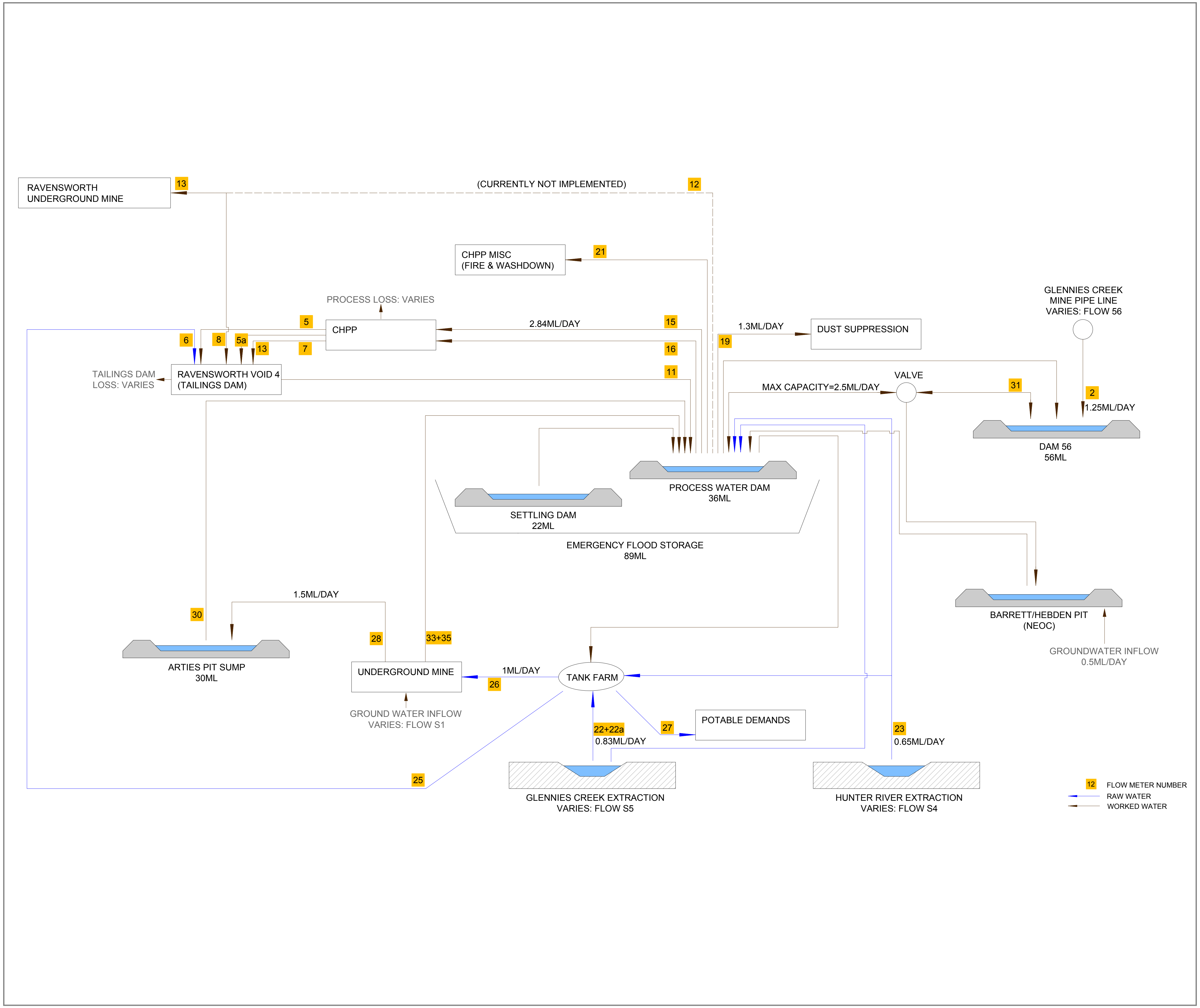

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FIGURE 4

Ashton Water Management Schematic

AUTHOR	HZ	PROJECT NO	S56
CHECKED BY	JG	REVISION	A
DATE	16/02/2012	DRAWING NO	101

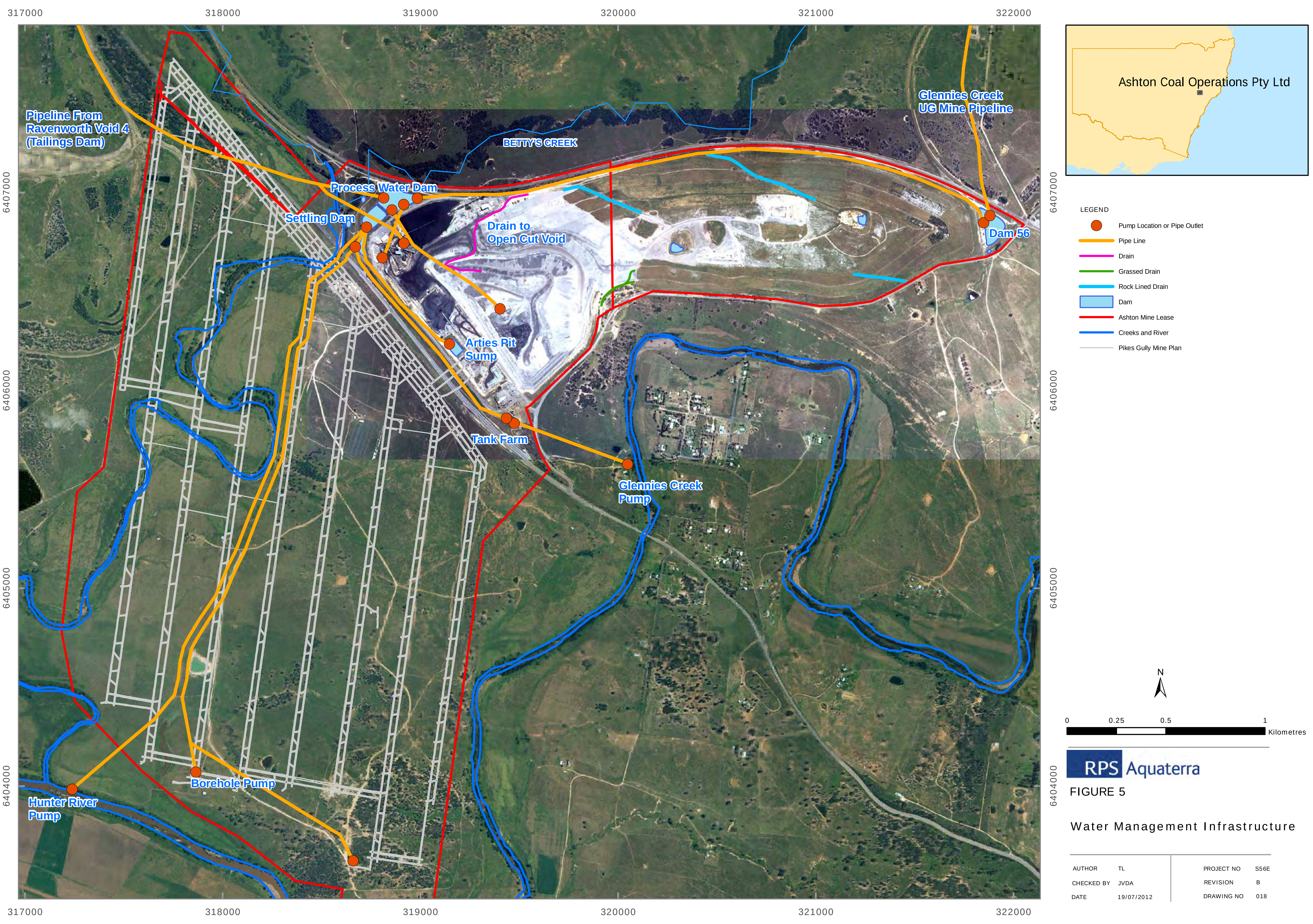

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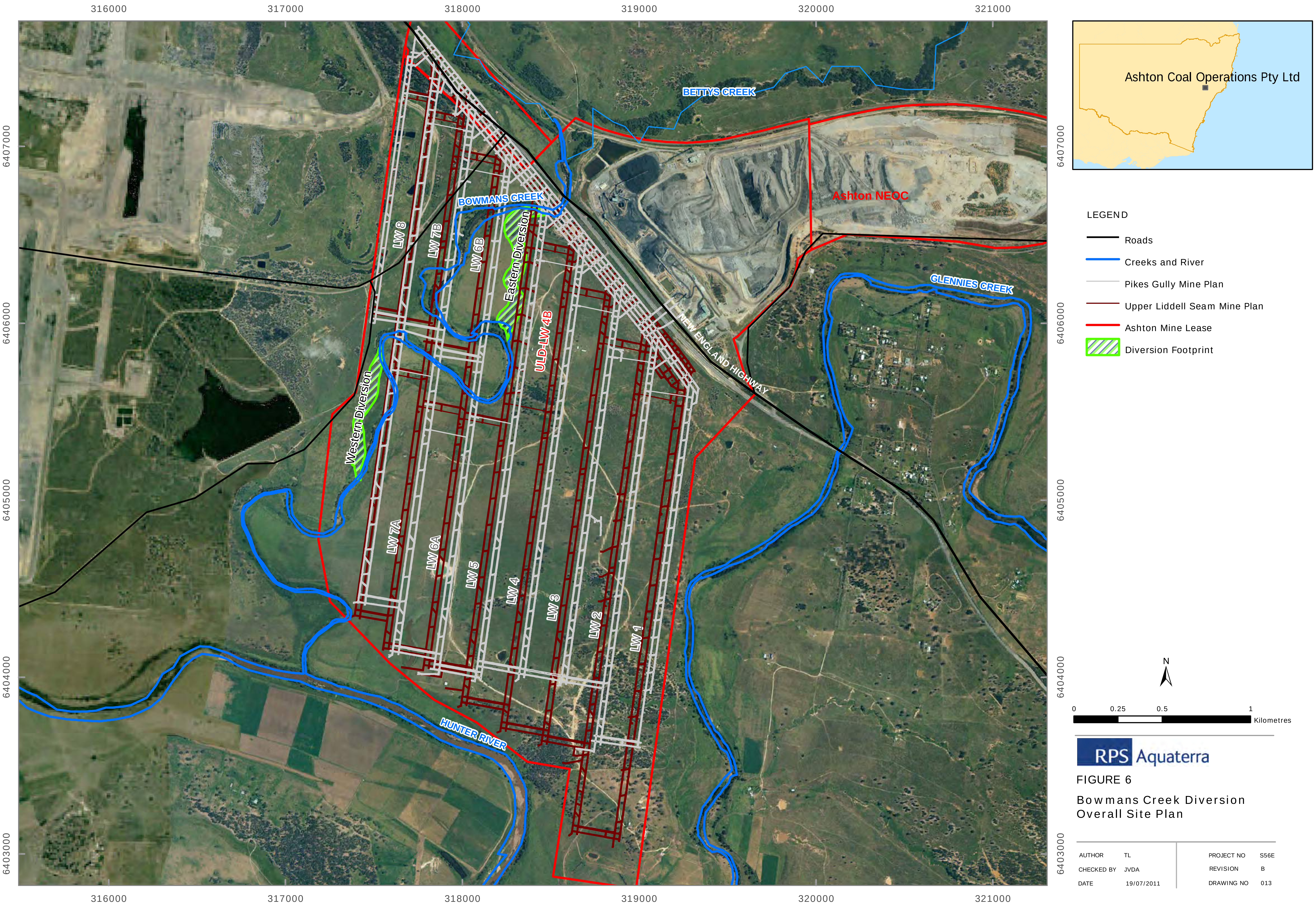
FIGURE 5

Water Management Infrastructure

AUTHOR	TL	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	B
DATE	19/07/2012	DRAWING NO	018

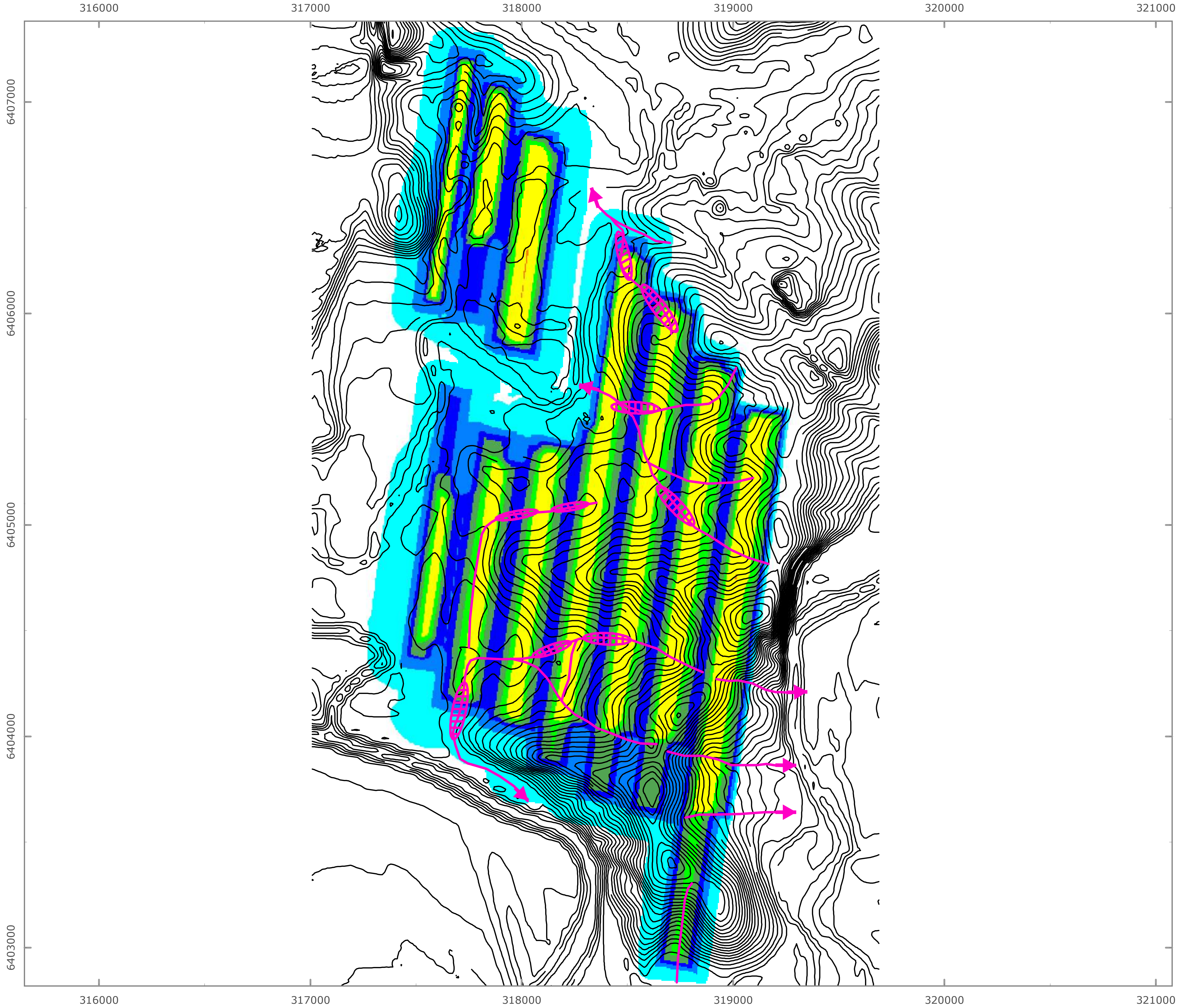


RPS Aquaterra

FIGURE 6

Bowmans Creek Diversion
Overall Site Plan

AUTHOR	TL	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	B
DATE	19/07/2011	DRAWING NO	013



LEGEND

- Drainage Line
- Post - Subsidence Surface to Topography
- Excavation for Drainage (Pending Subsidence Amount)

N

0 0.2 0.4 0.8 Kilometres

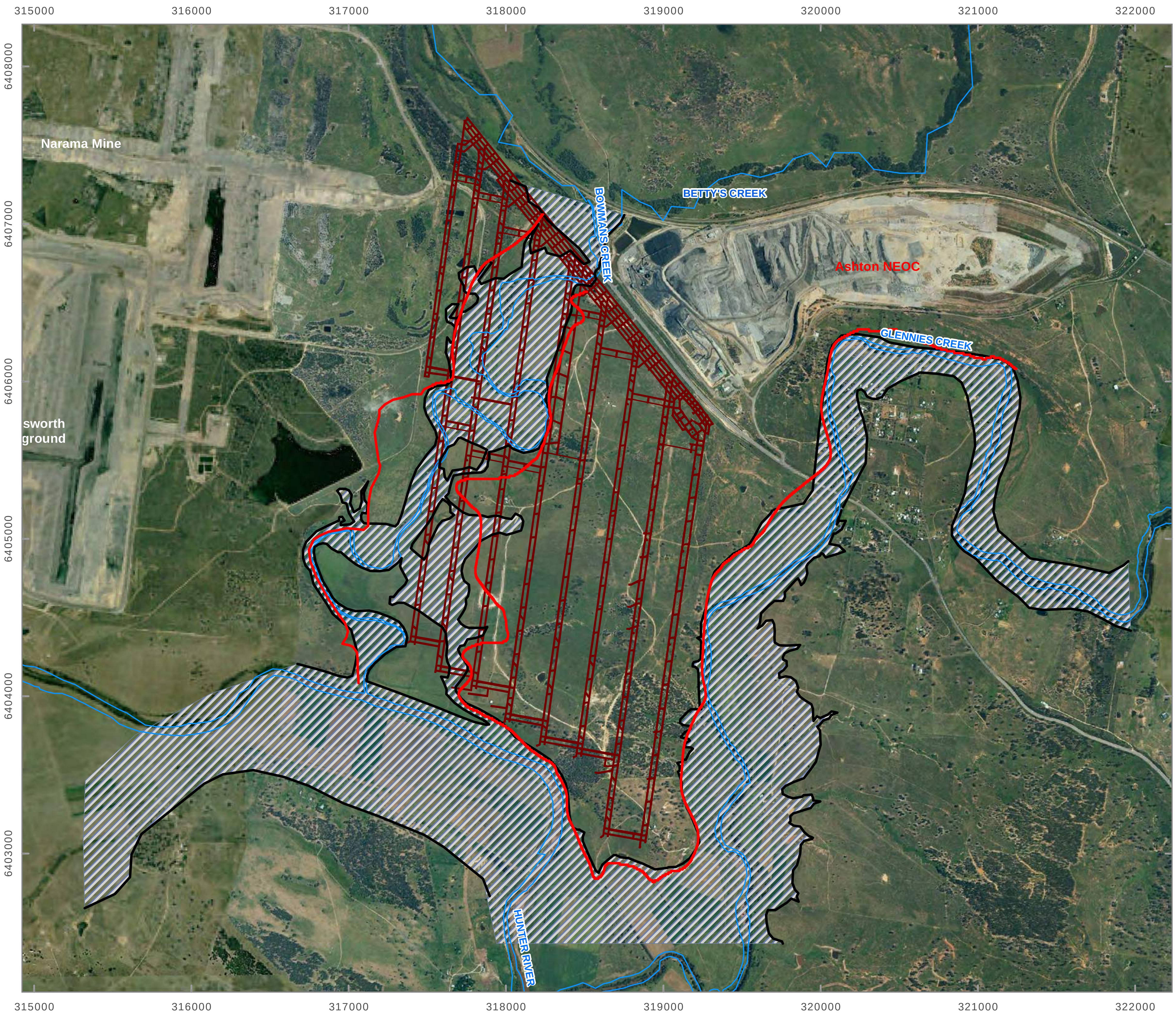
RPS Aquaterra

FIGURE 7

ULD Post - Subsidence Topography

Subsidence Information Provided by SCT, 2011

AUTHOR	HZ	PROJECT NO	S55J
CHECKED BY	CS	REVISION	A
DATE	30/11/2011	DRAWING NO	028



LEGEND

- Alluvium Boundary
- 1:100 Years Flood Line
- Creeks and River
- Upper Liddell Mine Plan
- 100 Years Flood Area

N

0 0.25 0.5 1 Kilometres

RPS Aquaterra

FIGURE 8

Alluvium Boundary and 1:100 Years Flood Line

Floodlines Compiled from Hyer 2009 and Worley Parsons 2009

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	A
DATE	19/07/2011	DRAWING NO	026a

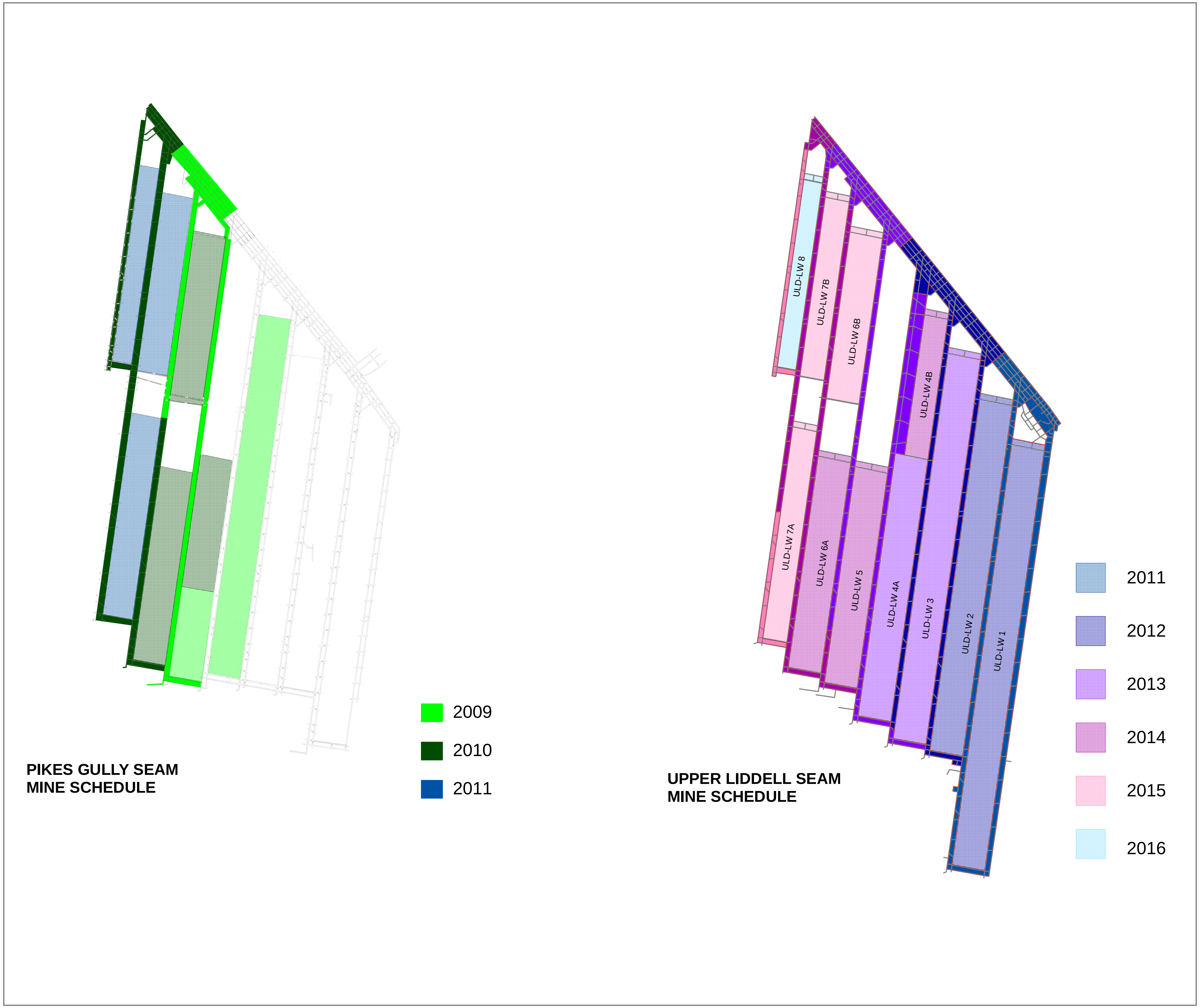


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FIGURE 9

Mining Schedule

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	CS	REVISION	A
DATE	11/08/2011	DRAWING NO	100

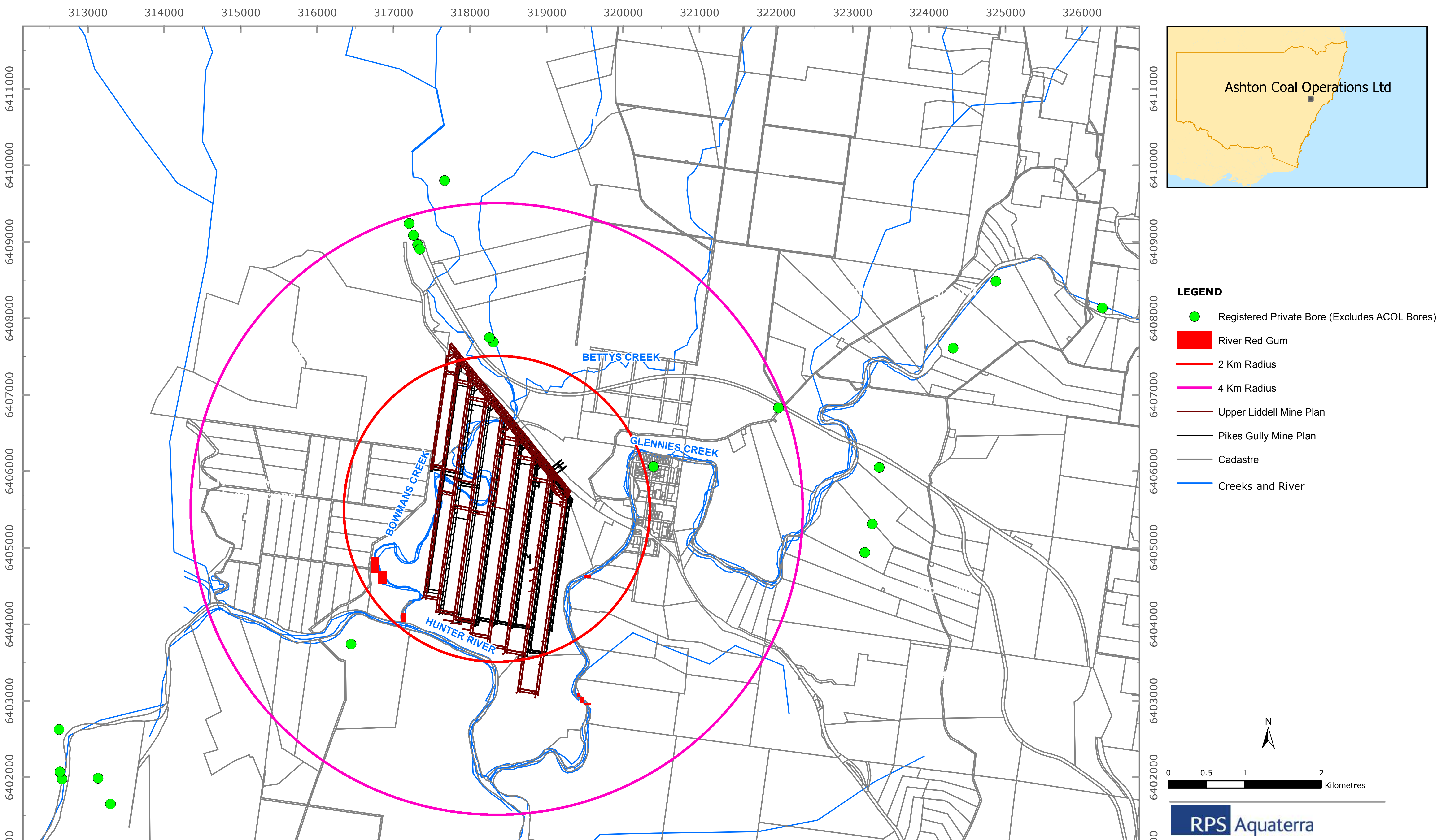
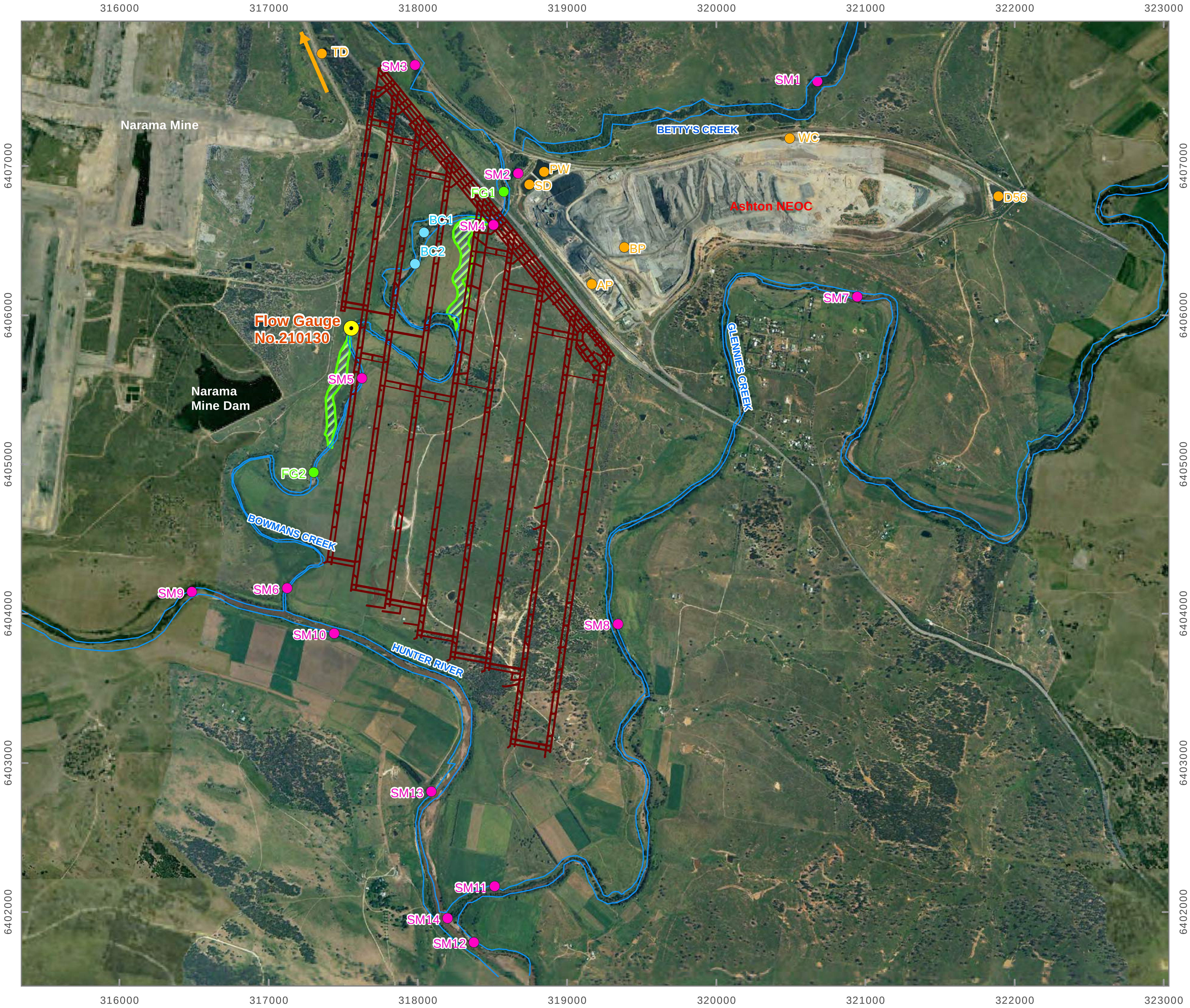


FIGURE 10

Location of Non-ACOL Registered Bores and GDEs

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	B
DATE	19/07/2012	DRAWING NO	024a



LEGEND

- Surface Water Monitoring Location
- Onsite Water Management Monitoring Location
- Bowmans Creek Monitoring Location
- ACOL Flow Gauge
- NSW Office of Water Gauge
- Upper Liddell Mine Plan
- Creeks or River
- Diversion Footprint

N

0 0.2 0.4 0.8 Kilometres

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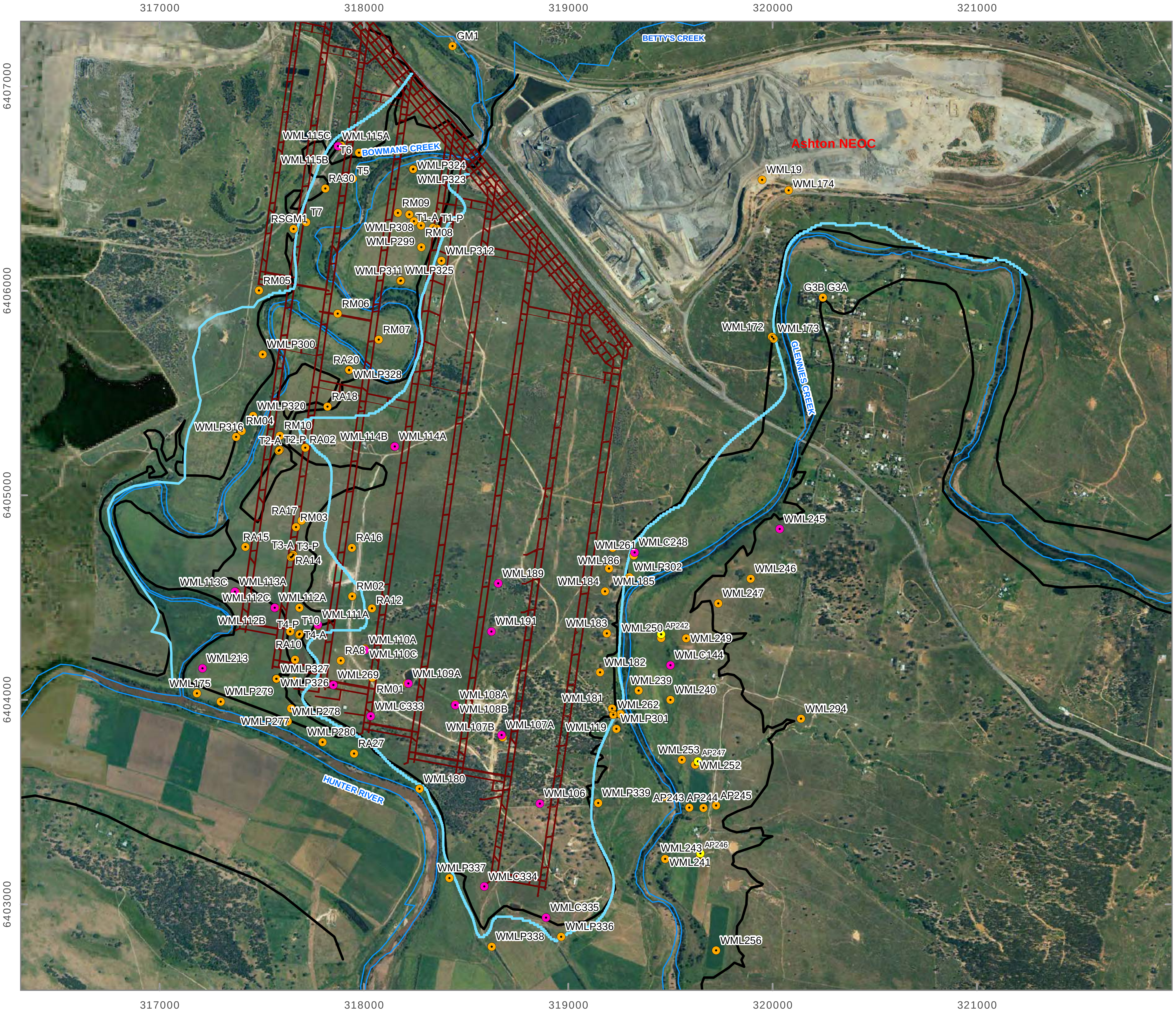
FIGURE 11

Surface Water Monitoring Network

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	A
DATE	19/07/2011	DRAWING NO	029e



LEGEND

- Standpipe Piezometers
- Test Bores
- Vibrating Wire Piezometers
- Alluvium Boundary
- Upper Liddell Mine Plan
- 1:100 Years Flood Line
- Creeks and River

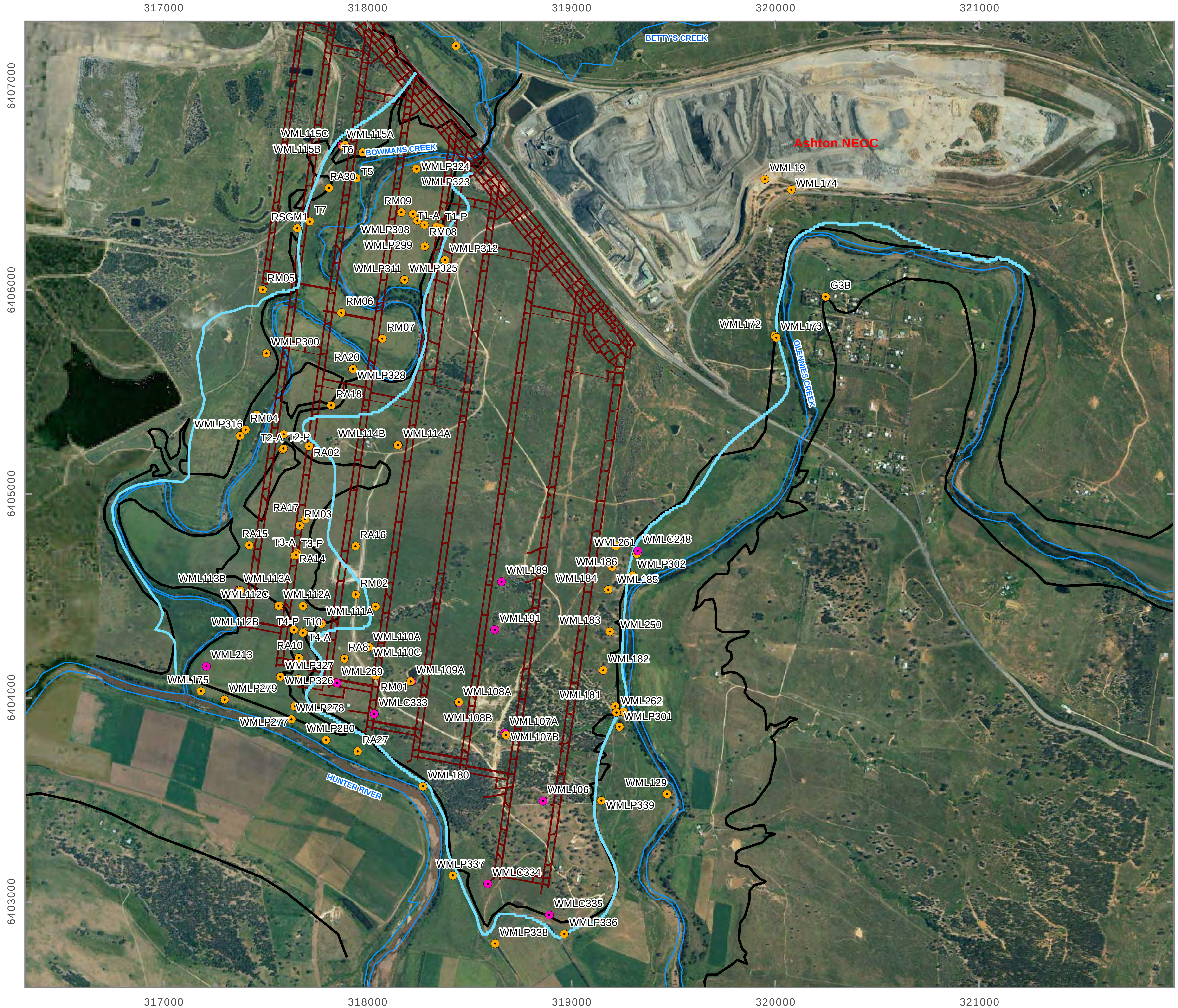
RPS Aquaterra

FIGURE 12

Groundwater Monitoring Network

Floodlines Compiled from Hyer 2009 and Worley Parsons 2009

AUTHOR	TL	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	B
DATE	19/07/2012	DRAWING NO	030b



LEGEND

All_bore_location_v2_withoutSEOC

FUNCTION

- Standpipe Piezometers
- Test Bores
- Vibrating Wire Piezometers
- Alluvium Boundary
- Upper Liddell Mine Plan
- 1:100 Years Flood Line
- Creeks and River

N

0 0.25 0.5 1 Kilometres

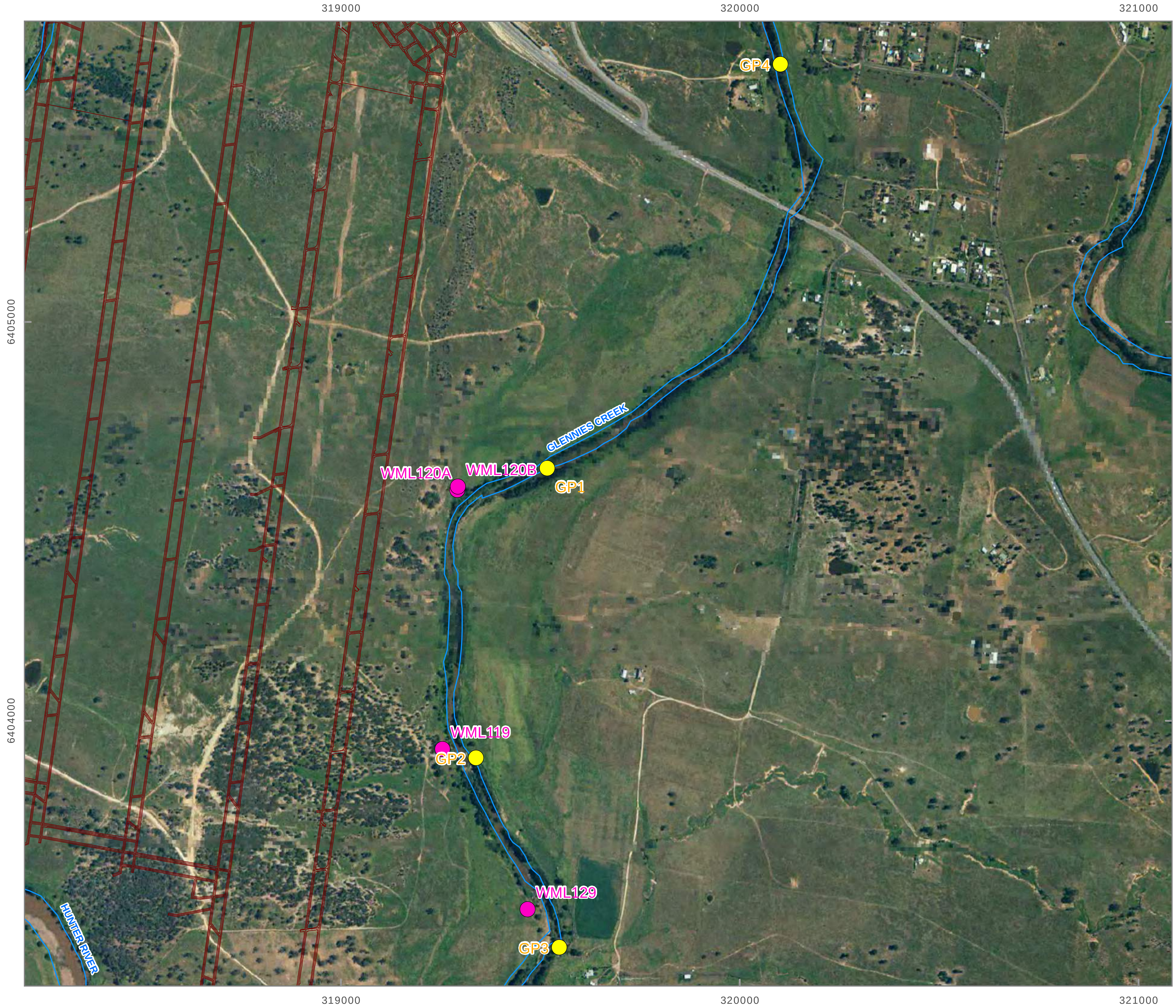
RPS Aquaterra

FIGURE 12A

Groundwater Monitoring Network

Floodlines Compiled from Hyer 2009 and Worley Parsons 2009

AUTHOR	TL	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	C
DATE	19/07/2012	DRAWING NO	030c



LEGEND

- Groundwater Level Monitoring Location
- Surface Water Level Monitoring Location
- Upper Liddell Mine Plan
- Creeks or River

N

0 0.125 0.25 0.5 Kilometres

RPS Aquaterra

FIGURE 13

Water Level Monitoring Locations - Glennies Creek

AUTHOR	HZ	PROJECT NO	S56E
CHECKED BY	JVDA	REVISION	A
DATE	19/07/2011	DRAWING NO	053

APPENDIX A

RELEVANT DEVELOPMENT CONSENT CONDITIONS AND COMMITMENTS, AND ENVIRONMENT PROTECTION LICENCE CONDITIONS

Development Consent Conditions 309-11-2001-i (following MOD-7 approval - 15 June 2011)

Condition number	Condition requirement	WMP section number
General		
1.21	**Management Plans/Monitoring Programs** The Applicant shall prepare revisions of any strategies, plans or programs required under this consent if directed to do so by the Director-General. Such revisions shall be prepared to the satisfaction of, and within a timeframe approved by, the Director-General.	Whole WMP
1.22	**Staged Submission of any Strategy, Plan or Program** With the approval of the Director-General, the Applicant may submit any strategy, plan or program required by this consent on a progressive basis. *Note: While any strategy, plan or program may be submitted on a progressive basis, the Applicant will need to ensure that the existing operations on the development site are covered by suitable strategies, plans or programs at all times.*	13.3
1.23	Until they are replaced by an equivalent strategy, plan or program approved under this consent, the Applicant shall continue to implement the existing strategies, plans or programs for development on the development site that have been approved under previous consents or approvals.	13.3
Land and Site Environmental Management		
3.9	**Performance Measures – Natural and Heritage Features, etc.** The Applicant shall ensure that underground mining does not cause any exceedences of the performance measures in Table 1, to the satisfaction of the Director-General. *Table 1: Subsidence Impact Performance Measures*	Appendix F Bowmans Creek Diversion Management Plan (BCDMP) and Relevant Extraction Plan / Subsidence Management Plan 6.2, 6.3, 7.1 & 7.3

Watercourses	
Bowmans Creek	No greater subsidence impact or environmental consequences than predicted in the documents referred to in condition 1.2 ac)
Bowmans Creek – Eastern and Western Diversions	Hydraulically and geomorphologically stable
Bowmans Creek alluvium	No greater subsidence impact or environmental consequences than predicted in the documents referred to in condition 1.2 ac)

Notes:

1) The Applicant will be required to define more detailed performance indicators for each of these performance measures in the various management plans that are required under this consent (see condition 3.12 below).

2) The requirements of this condition only apply to the impacts and consequences of mining operations undertaken following the date of approval of

Condition number	Condition requirement	WMP section number
	modification 6.	
3.12 (in part)	**Extraction Plans** The Applicant shall prepare and implement an Extraction Plan for the second workings within each seam to be mined to the satisfaction of the Director-General. Each Extraction Plan must: (h) include a: • Water Management Plan, which has been prepared in consultation with OEH and NoW, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on surface water resources, groundwater resources and flooding, and which includes: - Surface and groundwater impact assessment criteria, including trigger levels for investigating any potential adverse impacts on water resources or water quality; - a program to monitor and report groundwater inflows to underground workings; and - a program to manage and monitor impacts on groundwater bores on privately-owned land; (i) include a program to collect sufficient baseline data for future Extraction Plans.	Whole WMP and ULD Extraction WMP are combined in this document
3.13	The Applicant shall ensure that the management plans required under the condition 3.12(h) above include: (a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this consent; (b) a detailed description of the measures that would be implemented to remediate predicted impacts; and (c) a contingency plan that expressly provides for adaptive management.	5, 6, 7, 9, 10, 10.5, 12
Water Management and Monitoring		
4.1	**Water Supply** The Applicant shall ensure that it has sufficient water for all stages of the development, and if necessary, adjust the scale of mining operations to match its water supply. *Note: The Applicant is required to obtain all necessary water licenses for the development under the water act 1972 and/or Water Management Act 2000.*	4
4.2	**Baseflow Offsets** The Applicant shall offset the loss of any baseflow to the surrounding watercourses and/or associated creeks caused by the development to the satisfaction of the Director General. *Notes:*	5.3.1 and 12

Condition number	Condition requirement	WMP section number
	1) This condition does not apply in the case of losses of baseflow which are negligible. *2) Offsets for long-term baseflow losses should be provided via the retirement of adequate water entitlements to account for the loss attributable to the development.*	
4.3	**Compensatory Water Supply** The Applicant shall provide compensatory water supply to any landowner of privately-owned land whose water entitlements are impacted (other than an impact that is negligible) as a result of the development, in consultation with NoW, and to the satisfaction of the Director-General. The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent to the loss attributed to the development. Equivalent water supply must be provided (at least on an interim basis) within 24 hours of the loss being identified. If the Applicant and the landowner cannot agree on the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Director-General for resolution. If the Applicant is unable to provide an alternative long-term supply of water, then the Applicant shall provide alternative compensation to the satisfaction of the Director-General.	4
4.4	**Surface Water Discharges** The Applicant shall ensure that all surface water discharges from the DA area comply with the: (a) discharge limits (both volume and quality) set for the development in any EPL; or (b) relevant provisions of the POEO Act or *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*.	5.2.3
4.5	**Bowmans Creek – Eastern and Western Diversions** The Applicant shall construct, manage and maintain the eastern and western diversions of Bowmans Creek in the underground mining area to the satisfaction of the Director-General.	BCDMP, 12 Appendix F
4.6	Within 6 months of completing the construction of the diversions, the Applicant shall submit an as-executed report, certified by a practising engineer, to the Director-General and to NoW. *Note: The objective of the report is to confirm that the diversions are and will remain sufficiently hydraulically and geomorphologically stable.*	BCDMP, 12 and Appendix F
4.7	The Applicant shall prepare and implement a Water Management Plan for the development to the satisfaction of DG. This plan must: (a) be prepared in consultation with OEH, NoW, DRE and Council by suitably qualified and experienced persons whose appointment has been approved by the Director-General; (b) be submitted to the Director-General for approval by the end of June 2011, and include: (c) a Site Water Balance, which must: • include details of: - sources and security of water supply; - water use on site;	Whole WMP 4

Condition number	Condition requirement	WMP section number
	- water management on site; and - any off-site water transfers, and • describe what measures would be implemented to minimise clean water use on site;	
	(d) a Bowmans Creek Diversion Management Plan for the proposed creek diversions in the underground mining area, which must: • be consistent with any related requirements in future Extraction Plan(s); and • include: - a vision statement for the creek relocations; - an assessment of the surface water and groundwater quality, ecological, hydrological and geomorphic baseline conditions within the creek; - the detailed design specifications for the creek relocations; - a construction program for the creek relocations, describing how the work would be staged, and integrated with mining operations; - a revegetation program for the relocated creeks using a range of suitable native species; - water quality, ecological, hydrological and geomorphic performance and completion criteria for the creek relocations based on the assessment of baseline conditions; and - a program to monitor and maintain surface water and groundwater quality, ecological, hydrological and geomorphic stability of the creek diversions;	BCDMP, 12 and Appendix F
	(e) an Erosion and Sediment Control Plan which must: • be consistent with the requirements of the *Managing Urban Stormwater: Soils and Construction Manual* (Landcom 2004, or its latest version); • identify activities that could cause soil erosion and generate sediment; • describe measures to minimise soil erosion and the potential for the transport of sediment to downstream waters; • describe the location, function, and capacity of erosion and sediment control structures; and • describe what measures would be implemented to maintain the structures over time.	10.5
	(f) a Surface Water Management Plan, which must include: • detailed baseline data on surface water flows and quality in creeks and other waterbodies that could potentially be affected by the development; • surface water impact assessment criteria including trigger levels for investigating any potentially adverse surface water impacts from the development; • a program to monitor and assess surface water flows and quality, impacts on water users and stream health.	5.2 7.2, 8.1, 8.2 9.1, 9.2, 10.3
	g) a Groundwater Management Plan, which must include: • detailed baseline data of groundwater levels, yield and quality in the area, and privately-owned groundwater bores, which could be affected by the development;	5.3, 7.3, 8.3

Condition number	Condition requirement	WMP section number
	• groundwater impact assessment criteria including trigger levels for investigating any potentially adverse groundwater impacts from the development; and • a program to monitor and assess: - groundwater inflows to the open cut and underground mining operations; and - impacts of the development on the region's aquifers, any groundwater bores and surrounding watercourses, in particular Bowmans Creek, Glennies Creek and the Hunter River and adjacent alluvium; and	9.3, 9.4, 10.4
	(h) a Surface and Groundwater Response Plan, which must include: • a response protocol for any exceedences of the surface water and groundwater assessment criteria; • measures to offset the loss of any baseflow to watercourses caused by the development; • measures to compensate landowners of privately-owned land whose water supply is adversely affected by the development; and • measures to mitigate and/or offset any adverse impacts on groundwater dependent ecosystems or riparian vegetation.	6, 10, 13
Monitoring / Auditing		
8.1	In addition to the requirements contained elsewhere in this consent, the Director-General may, at any time in consultation with the relevant government authorities and Applicant, require the monitoring programs under this consent to be revised or updated to reflect changing environmental circumstances or changes in technology/operational practices. Changes shall be made and approved in the same manner as the initial monitoring programs. All monitoring programs shall also be made publicly available at SSC and on the internet within two weeks of approval by the relevant government authority.	13.2 and 13.3
8.2	All sampling strategies and protocols undertaken as part of any monitoring program shall include a quality assurance/quality control plan and shall be included in the relevant environmental management plan. Only accredited laboratories shall be used for laboratory analysis.	1.1
Reporting		
9.2 (in part)	**Annual Environmental Management Report (AEMR)** The Applicant shall, throughout the life of the mine and for five years after completion of mining in the DA area, prepare and submit an Annual Environmental Management Report (AEMR) to the satisfaction of the Director-General and DRE. The AEMR shall review the performance of the mine against the Environmental Management Strategy and the relevant Mining Operations Plans, the conditions of this consent, and other licences and approvals relating to the mine. To enable ready comparison with the predictions made in the EIS, diagrams and tables, the report shall include, but not be limited to, the following matters: a) an annual compliance audit of the performance of the project against conditions of this consent and statutory approvals; b) assess the development against the predictions made in the EIS and the terms and commitments made in the documents listed in condition 1.2; d) Groundwater Management Report prepared by an independent expert to the satisfaction of NoW, addressing: (i) work done under and the level of compliance with, the groundwater management measures defined in the Groundwater Management Plan;	13.1.3

Condition number	Condition requirement	WMP section number
	and (ii) identification of trends in groundwater monitoring data and comparison with predictions, in documents referred to in condition 1.2 and any previous SMPs, over the life of mining operations. e) a review of the effectiveness of the environmental management of the mine in terms of OEH, NoW, DRE, and SSC requirements; f) results of all environmental monitoring required under this consent or other approvals, including interpretations and discussion by a suitably qualified person; h) identify trends in monitoring results over the life of the mine; i) an assessment of any changes to agricultural land suitability resulting from the mining operations, including cumulative changes; k) the outcome of the mine water balance for the year; m) environmental management targets and strategies for the next year, taking into account identified trends in monitoring results.	
9.6	**Recording and Reporting Requirements** ***Monitoring Records*** All records required to be kept by the licence must be: • in a legible form, or in a form that can readily be produced to a legible form; • kept for at least 4 years after the monitoring or event to which they relate took place; and • produced in a legible form to any authorised officer of the OEH who asks to see them.	9, 13
9.7	The following records must be kept in respect of any samples required to be collected: • the date(s) on which the sample was taken; • the time(s) at which the sample was collected; • the point at which the sample was taken; and • the name of the person who collected the sample.	9
9.8	The Applicant must provide an annual return to the OEH in relation to the development as required by any licence under the Protection of the Environment Operations Act 1997 in relation to the development. In the return the Applicant must report on the annual monitoring undertaken (where the activity results in pollutant discharges), provide a summary of complaints relating to the development, report on compliance with licence conditions and provide a calculation of licence fees (administrative fees and, where relevant, load based fees) that are payable. If load based fees apply to the activity the applicant will be required to submit load-based fee calculation worksheets with the return. This may form part of the AEMR.	13.1
Applicant's Obligations		
11.14	**Responsibility for the Costs of Remediation** The Applicant shall be responsible for the costs of all impact management measures (including measures to minimise, mitigate, offset or remediate impacts of the development which are not recoverable by a third party through the Mine Subsidence Compensation Act 1961 or the Mining Act 1992)	Supplementary water flows - 6.2

Condition number	Condition requirement	WMP section number
	including but not limited to remediation of natural features, rehabilitation of ecological systems, monitoring of the effectiveness of the works and provision of supplementary water flows, as determined by the Director-General. *Note: The Applicant is not responsible under this condition for costs of impact management measures associated with impacts of the development on built features which are constructed or upgraded following approval of a Subsidence Management Plan which manages subsidence impacts at the affected location.*	

Development Consent Schedule C – Bowmans Creek Diversion

Statement of Commitments

Item	Commitment	Timing	Where Addressed
General			
2.1	Subsidence troughs will be reshaped and fill will be used where practicable to create a freedraining landform. This approach is expected to reduce the potential for surface pooling and inflow into the mine.	In accordance with this WMP and the BCDMP	6.2, 6.3 and BCDMP Appendix F
2.2	The diversion channels will be constructed in accordance with detailed civil and landscape design plans generally consistent with EA Plan Sets 2 and 3**.**	In accordance with the BCDMP	BCDMP Appendix F
2.3	A geosynthetic clay liner will be placed under the low flow section of the diversion channels to minimise loss of baseflow from the constructed channels and to preserve surface flows in the diverted creek.	In accordance with the BCDMP	BCDMP Appendix F
2.4	All workers involved in the construction of the diversion channels and block banks will receive site specific induction that includes requirements for good environmental management, including management of noise and dust; erosion and sediment; Aboriginal heritage; hazardous materials; and waste.	In accordance with the BCDMP	BCDMP Appendix F
Subsidence Monitoring and Mitigation			
3.4	Subsidence and groundwater experts will be used to assess the western longwall (LW8) to ensure concurrent operation of the RUM and ACOL underground mines can be undertaken safely.	Prior to and during LW8 operations	6.3, 9.4
Groundwater			
4.1	The current ACP groundwater monitoring network will be maintained and expanded to enable monitoring of water extracted from the mine workings as the lower seams are developed and mined.	In accordance with this WMP	9.1, 9.3
4.2	Additional (nested) groundwater monitoring bores will be installed in the alluvium and Pikes Gully overburden at the following locations: • Southwest of LW6A. • On the eastern side of LW6B near the downstream end of the Eastern Diversion. • On the eastern side of LW6B near the upstream end of the Eastern Diversion. These monitoring points will be monitored monthly as part of the routine monitoring and weekly at the time that mining occurs in the Pikes Gully seam immediately below in order to monitor groundwater drainage from the alluvium.	For the life of the project	9.3

Item	Commitment	Timing	Where Addressed
4.3	The volume of water extracted from the mine workings will be monitored for the life of mine.	For the life of the project	9.3
4.4	The volume and quality of individual sources of groundwater inflows will be monitored where separation of sources is possible.	In accordance with this WMP	9.3
4.5	The existing ACP Groundwater Trigger Action Response Plan will be reviewed and extended to include monitoring of the lower seam inflows as they are mined.	Included in this WMP review	9, 10, 13.3
Surface Water			
5.1	Water level monitoring will be undertaken in two pools immediately above LW6B as part of the routine monthly monitoring program and used to guide construction of block banks to their final level. While mining is occurring in LW6B, water levels will be monitored weekly.	In accordance with this WMP	9
5.2	The existing ACP surface water quality monitoring program will be reviewed and updated where required.	Included in this WMP review	9.1, 13.3
5.3	Setting back all secondary workings by at least 40 m (in a horizontal direction) to the high bank of Bowmans Creek in its diverted function form.	In accordance with MOP	6.2.1
Water Licensing			
6.1	Hold appropriate and adequate water entitlements to account for water from all sources impacted by underground operations on an annual basis.	Ongoing	2.2
6.2	Returning flows to Bowmans Creek whenever the rules of the Water Sharing Plan for Jerrys Management Zone prohibit the taking of water, including provisions for returning flows post-mine closure. Returned flows will be of an equal or better quality than the receiving waters.	As required	BCDMP Appendix F
6.3	Retaining or retiring an equivalent licensed entitlement to account for the long-term annual water based impacts, post-mine closure.	Post-mine closure	5.3.1
6.4	The provision of an ongoing financial contribution to cover the cost associated with returning flows to Bowmans Creek, post-mine closure, when baseflow impacts to Bowmans Creek are not permitted under the rules of the relevant water sharing plan (from 2015 onwards).	Post-mine closure	BCDMP Appendix F
Construction of Diversion Channels			

Item	Commitment	Timing	Where Addressed
8.2	Erosion and sediment controls for the construction works will generally be consistent with: • The existing ACP Erosion and Sediment Control Management Plan. • Detailed diversion engineering design drawings (C045 – C047). • Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries (DECC 2008, or its latest version).	During planning and construction of BCD	9.4.2 and BCDMP Appendix F
8.4	During and immediately after mining of the Pikes Gully seam, groundwater monitoring together with visual monitoring of stream flows and pools within Bowmans Creek (as diverted) will be undertaken. If there is any indication that significant drainage of the alluvium is occurring, or there is loss of stream flow, due to cracking, the full height block banks will be constructed immediately.	During and after mining Pikes Gully Seam	8 and BCDMP Appendix F
Environmental Monitoring and Reporting			
13.1	Environmental monitoring will be carried out generally as described in the EA for the creek diversion.	As per BCDMP	BCDMP Appendix F
13.2	An Annual Environmental Management Report (AEMR) will be prepared and forwarded to relevant government departments, including DoP. The AEMR will include a summary of all monitoring undertaken during the year, including a discussion of any exceedances and responses taken to ameliorate these exceedances.	Annually	13

Development Consent Schedule E – Underground Mine Interim Gas Drainage and Open Cut Hebden Seam Recovery

Statement of Commitments

Item	Commitment	Timing	Where Addressed
Mining			
1c	The management measures described in existing approved ACOL environmental management plans will continue to be implemented.	Ongoing	1.2
Water			
7a	Gas drainage well pads will be located to avoid impacts to surface drainage lines, wherever practicable.	In accordance with this WMP	5.2.2.1
7b	Self bunded fuel tanks and chemical spill kits will be implemented at active gas drainage well pads.	Ongoing	5.2.3.3
7c	The frequency of monitoring groundwater levels in monitoring bores surrounding the open cut pit was increased to monthly for the duration of the extraction of coal from the Hebden Seam. This can be revised after the effects of infilling the Pit with tailings has stabilised.	As per WMP – during extraction of coal from Hebden Seam. Extraction has been completed.	
Soils and Erosion Control			
8a	Industry standard sediment control measures will be implemented prior to ground disturbance, including use of clean water diversions, where required.	In accordance with this WMP	11.3 Appendix F
8b	Long-term stockpiles will be stabilised with jute mesh or grass cover.	In accordance with this WMP	11.3.2 Appendix F
8c	Clean water diversions will be implemented around gas drainage well pads.	In accordance with this WMP	5.2.2.1

Environmental Protection Licence (EPL 11879, 2 December 2011 version) conditions (relevant to water management only)

Condition Number	Condition Requirement	WMP Section Number
P1 Location of monitoring/discharge points and areas		
P1.2	The following points referred to in the table [listed grouped points below] are identified in this licence for the purposes of the monitoring and/or the setting of limits for discharges of pollutants to water from the point.	Note only
P1.3	The following utilisation areas referred to in the table below [listed grouped points below] are identified in this licence for the purposes of the monitoring and/or the setting of limits for any application of solids or liquids to the utilisation area.	Note only
Monitoring Point Table [grouped]	Ambient surface water monitoring at SM3, SM4, SM5, SM6, SM9, SM10 shown in Figure 4 “EPA Surface Water Monitoring Sites” dated 8/8/03	Note only
	Groundwater monitoring at locations shown on Figure 1A “Groundwater Monitoring Piezometer Locations for EPL” dated 26/10/06	Note only
P3 Pollution of waters		
L1.1	Except as may be expressly provided in any other condition of this licence, the licensee must comply with section 120 of the Protection of the Environment Operations Act 1997.	9, 10, 13
O4 Processes and management		
O4.1	Stormwater Management Scheme A Stormwater Management Scheme must be prepared for the development and must be implemented. Implementation of the Scheme must mitigate the impacts of stormwater runoff from and within the premises following the completion of construction activities. The Scheme should be consistent with the Stormwater Management Plan for the catchment. If a Stormwater Management Plan has not yet been prepared, the Scheme should be consistent with the guidance contained in *Managing Urban Stormwater: Council Handbook* (available from the EPA).	5, 9, 10,10.5 Appendix F
O4.2	Banks, channels and similar works must be constructed and maintained to divert stormwater away from disturbed or contaminated land surfaces such as mine workings, haul roads, overburden disposal areas, coal handling areas and wastewater treatment facilities. All diversion banks, channels and points of discharge must be constructed or stabilised so as to minimise erosion and scouring.	5, 9, 10,10.5 Appendix F
O5 Waste management		
O5.1	A water management system must be constructed and utilised to manage the collection, storage, treatment, use and disposal of mine water, sewage effluent and other wastewater.	5.1, 5.2
O5.2	Bund(s) must be installed around areas in which fuels, oils and chemicals are stored. Bunds must: a) Have walls and floors constructed of impervious materials; b) Be of sufficient capacity to contain 110% of the volume of the tank (or 110% volume of the largest tank where a group of tanks are installed);	5.2.3

Condition Number	Condition Requirement	WMP Section Number
	c) Have walls not be less than 250 millimetres high; d) Have floors graded to a collection sump; and e) Not have a drain valve incorporated in the bund structure.	
O5.3	A wastewater treatment facility with oil separator and sediment trap must be installed to treat drainage form the hardstand, vehicle servicing and general workshop areas.	5.2.3.3
O5.4	An area must be provided for the use of effluent from the sewage treatment plant. The design of the system must be in accordance with the EPA's draft guideline "Utilisation of Treated Effluent by Irrigation".	5.2.1
O5.5	Wastewater utilisation areas must effectively utilise the wastewater applied to those areas. This includes the use for pasture or crop production, as well as ensuring the soil is able to absorb the nutrients, salts, hydraulic load and organic materials in the solids or liquids. Monitoring of land and receiving waters to determine the impact of wastewater application may be required by the EPA.	5.2.1
M1 Monitoring records		
M1.1	The results of any monitoring required to be conducted by this licence or a load calculation protocol must be recorded and retained as set out in this condition.	9
M1.2	All records required to be kept by this licence must be: a) In a legible form, or in a form that can readily be reduced to a legible form; b) Kept for at least 4 years after the monitoring or event to which they relate took place; and c) Produced in a legible form to any authorised officer of the EPA who asks to see them.	9
M1.2	The following records must be kept in respect of any samples required to be collected for the purposes of this licence; a) The date(s) on which the sample was taken; b) The time(s) at which the sample was collected; c) The point at which the sample was taken; and d) The name of the person who collected the sample.	9
M2 Requirement to monitor concentration of pollutants discharged		
M2.1	For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns:	5.2.1, 8, 9
Points 2, 3, 4, 5, 6, 7 [SM3, SM4,	Monitoring once a month (min. of 4 weeks) of: • EC (µS/cm using probe);	5.2.1, 8, 9

Condition Number	Condition Requirement	WMP Section Number
SM5, SM6, SM9, SM10]	• pH (pH from grab sample); and • TSS (mg/L from grab sample)	
Point 8 [GW monitoring points]	Monitoring of EC (µS/cm from grab sample) and standing water level (m using in line instrumentation) every 6 months.	5.2.1, 8, 9
M5 Recording of pollution complaints		
M5.1	The licensee must keep a legible record of all complaints made to the licensee or any employee or agent of the licensee in relation to pollution arising from any activity to which this licence applies.	13.1.5
M5.2	The record must include details of the following: a) the date and time of the complaint; b) the method by which the complaint was made; c) any personal details of the complainant which were provided by the complainant or, if no such details were provided, a note to that effect; d) the nature of the complaint; e) the action taken by the licensee in relation to the complaint, including any follow-up contact with the complainant, and f) if no action was taken by the licensee, the reasons why no action was taken.	
M5.3	The record of a complaint must be kept for at least 4 years after the complaint was made.	
M5.4	The record must be produced to any authorised office of the EPA who asks to see them.	
R1 Annual Return documents		
R1.1	The licensee must complete and supply to the EPA an Annual Return in the approved form comprising: a) a Statement of Compliance; and b) a monitoring and Complaints Summary. At the end of each reporting period, the EPA will provide to the licensee a copy of the form that must be completed and returned to the EPA.	13.1.4
R1.5	The Annual Return for the reporting period must be supplied to the EPA by registered post not later than 60 days after the end of each reporting period or in the case of a transferring licence not later than 60 days after the date the transfer was granted (the 'due date').	
R2 Notification of environmental harm		
R2.1	Notifications must be made by telephoning the Environment Line service on 131 555.	13.1.6

Condition Number	Condition Requirement	WMP Section Number
R2.2	The licensee must provide written details of the notification to the EPA within 7 days of the date on which the incident occurred.	
Note	The licensee or its employees must notify the EPA of incidents causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident in accordance with the requirements of Part 5.7 of the Act.	

APPENDIX B

WATER MANAGEMENT PLAN CORRESPONDENCE

NSW GOVERNMENT | Planning & Infrastructure

Major Projects Assessment
Mining & Industry
Contact: Howard Reed
Phone: (02) 9228 6308
Fax: (02) 9228 6466
Email: howard.reed@planning.nsw.gov.au

Mr Michael Moore
Approvals Manager
Ashton Coal Operations Pty Ltd
PO Box 699
SINGLETON NSW 2330

1 AUG 2012

Dear Michael

Ashton Coal Project (DA 309-11-2001-i) – Upper Liddell Seam Longwalls 1-8 Extraction Plan and Related EMPs

I refer to the Department's letter of 27 July 2012 approving the Extraction Plan for the Ashton Coal Project titled *Ashton Coal Extraction Plan – Upper Liddell Seam Longwall Panels 1-8*, including the separate management plans provided in the appendices.

In relation to these management plans, the Department confirms that it is satisfied that the Heritage Management Plan, Biodiversity Management Plan and Water Management Plan meet the requirements of conditions 3.36, 3.46 and 4.7 of the development consent, respectively. This is in addition to the plans meeting the requirements of condition 3.12 of the consent, as referred to in the Department's previous letter.

As outlined in the Department's previous letter, the Department's approval of the Extraction Plan (including the sub-plans) applies to ULD Seam Longwalls 1-4 only.

Should you have any enquiries in relation to the above, please contact Phil Jones on 9228 6331.

Yours sincerely

Howard Reed

Howard Reed 10.8.12
Manager Mining Projects
as nominee of the Director-General

Major Projects Assessment
Mining & Industry
Contact: Howard Reed
Phone: (02) 9228 6308
Fax: (02) 9228 6466
Email: howard.reed@planning.nsw.gov.au

Mr Michael Moore
Approvals Manager
Ashton Coal Operations Pty Ltd
PO Box 699
SINGLETON NSW 2330

Dear Michael

Ashton Coal Project (DA 309-11-2001-I) – Upper Liddell Seam Longwalls 1-8 Extraction Plan

I refer to the draft Extraction Plan for the Ashton Coal Project titled *Ashton Coal Extraction Plan – Upper Liddell Seam Longwall Panels 1-8*, including revisions up to and including that dated 17 July 2012.

The Department has reviewed the draft Extraction Plan as required under condition 3.12 of the development consent for the mine, including the separate management plans provided in the appendices which include the:

- Coal Resource Recovery Plan (condition 3.12(g));
- Subsidence Monitoring Program (condition 3.12 (g));
- Built Features Management Plan (condition 3.12 (g));
- Public Safety Management Plan (condition 3.12(g));
- Rehabilitation Management Plan (condition 3.12(g));
- Water Management Plan (condition 3.12(h));
- Biodiversity Management Plan (condition 3.12(h));
- Land Management Plan (condition 3.12(h)); and
- Heritage Management Plan (condition 3.12(h)).

The Department notes that Ashton Coal is only seeking approval for Longwalls 1-4 in the Extraction Plan at this time, and will seek further approval for Longwalls 5-8 at a subsequent date.

The Department is satisfied that the Extraction Plan meets the requirements of conditions 3.12 and 3.13 of the development consent, insofar as it relates to Longwalls 1-4. **Consequently I hereby approve the plan, for the purposes of Longwalls 1-4 only, on behalf of the Director-General.**

However, the Department takes this opportunity to remind Ashton Coal of its requirement to comply with the subsidence performance criteria in the development consent which, amongst other things, require no greater subsidence impacts or environmental consequences on Bowmans Creek and its alluvium than that predicted in the Bowmans Creek Diversion Environmental Assessment (EA). Whilst the revised subsidence modelling undertaken for the Extraction Plan indicates an increase in subsidence effects above that in the EA, the Department accepts that Longwalls 1-4 are able to be managed to avoid increased subsidence impacts or environmental consequences on the creek. The Department will be monitoring this issue closely as mining progresses through Longwalls 1-4 and when approval is sought to extend the Extraction Plan's coverage to include Longwalls 5-8.

The Department also notes that Ashton Coal is yet to receive final written feedback on the Extraction Plan from the NSW Office of Water (NOW). However, the Department is satisfied that Ashton Coal has adequately consulted with NOW for the purposes of condition 3.12 of the development consent, and acknowledges Ashton Coal's commitment to reviewing and if necessary revising the Extraction Plan once any feedback from NOW is received.

Should you have any enquiries in relation to the above, please contact Phil Jones on 9228 6331.

Yours sincerely

Howard Reed

Howard Reed 27.7.12
Manager Mining Projects
as nominee of the Director-General

From:	Phil Jones
To:	Michael Moore
Subject:	Fwd: Ashton Coal ULD Seam Extraction Plan
Date:	Friday, 6 July 2012 9:23:30 AM

Michael,

Further to the general comments below, the Department has the following comments on the draft Water Management Plan:

- Sections 4 and 5.2.2.2 - measures to minimise water use on site should be better outlined;
- Section 13.1.5 - Section should include hotline number for DP&I Singleton office (6575 3405), and should also include reference to notification of other incidents such as breaches of consent conditions, EPL conditions or licencing requirements under the Water Management Act.

Regards,
Phil

Phil Jones
Environmental Planning Officer
Major Projects Assessment
Department of Planning and Infrastructure
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SYDNEY NSW 2001
p. 02 9228 6583
f. 02 9228 6466
e. Phil.Jones@planning.nsw.gov.au

>>> Phil Jones 29/03/2012 1:57 pm >>>
Hi Michael,

The Department has reviewed the Draft ULD Seam Extraction Plan. In general it is well organised and adequately detailed.

My comments include:

- Extraction Plan - the subsidence performance criteria in the consent requires no greater subsidence impact or environmental consequences on Bowmans Creek and its alluvium than that predicted in the EA. The revised subsidence modelling for the EP indicates an increase in subsidence than that in the EA. The groundwater assessment based on this revision states that impacts on Bowmans Creek would be less, however my reading of the impacts presented in Table 8 of the EP indicate that they would be greater, when the modelled impacts from LW1-4 and LW5-8 are added together (eg. 0.59L/s + 0.86L/s = 1.45L/s, as opposed to 1.2L/s for LW1-8 in the BCD EA). I understand in this example that the 0.86L/s may be cumulative (iw. LW1-8), in which case the assertion that the impacts are less would be correct. Can you please clarify this;
- Subsidence Monitoring Program - Section 2.6 - A summary of the archaeological/heritage monitoring should be included, unless sufficiently demonstrated otherwise;
- Subsidence Monitoring Program - Section 3.2 - The commitment to far field subsidence monitoring should be firmer, in line with the recommendations in the SCT report;
- Specific Management Plans - The relevant predicted subsidence tables in each plan should include the cumulative subsidence predictions (ie. ULD + PG Seams), as per Table 7 of the main EP;
- Flora and Fauna Mgt Plan - Some of the performance indicators are not very specific or measurable. In particular, the Weed Control PI should be more like the equivalent PI in the Land Mgt Plan;
- Flora and Fauna Mgt Plan - Please ensure that the recommendations of the Terrestrial and Aquatic Ecology Assessments (ie. Technical Reports No.5 & 6) are addressed in the FFMP (I couldn't see were some of the recommendations were addressed).
- General - Please forward consultation outcomes on the Draft EP from the relevant authorities,

as required under the consent.

I note that we are still awaiting receipt of the Water Management Plan, which has not been reviewed.

Regards
Phil

Phil Jones
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Major Development Assessment
Department of Planning
Lv 4, 23 Bridge Street
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SYDNEY NSW 2001
p. 02 9228 6331
f. 02 9228 6466
e. Phil.Jones@planning.nsw.gov.au

From: Phil Jones
To: Michael Moore
Cc: Howard Reed; Scott Brooks
Subject: Ashton Coal Project - Bowmans Creek Diversion Management Plan
Date: Thursday, 19 January 2012 3:48:23 PM

Hi Michael,

The Department has reviewed the draft Bowmans Creek Diversion Management Plan, submitted on 6 December 2011. In general the plan is well presented and acceptable, although the Department has the following comments:

1. Consent Condition 4.7 requires the Plan to be prepared in consultation with OEH, NOW, DRE and Council. Whilst Section 1.3 of the plan indicates that it has been prepared in consultation with the relevant agencies, there is no evidence that the agencies have reviewed and accept the draft plan. Could you please provide this evidence, particularly for key agencies (ie. NOW, DRE), and address any issues raised in the plan.
2. The key purpose of the project is to divert the creek into a clay lined diversion so there will not be water loss from the creek caused by mine subsidence in the future. In this regard, the draft plan lacks performance criteria, groundwater monitoring detail, and contingency measures if it is found the diversion works leak. The plan will need to be strengthened in this regard.

Could you please address these matters and return a revised (electronic) version of the management plan, at your earliest convenience.

Regards
Phil

Phil Jones
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NSW EPA

ENVIRONMENT PROTECTION AUTHORITY

Your reference:
Our reference: DOC12/14856, LIC06/533-08
Contact: Karen Marler 02 4908 6803

Mr Phil Fletcher
Technical Services Manager
Ashton Coal Operations Pty Limited
PO Box 699
SINGLETON NSW 2330

7 JUN 2012

Dear Mr Fletcher

Water Management Plan for Ashton Coal Operations Pty Limited

Thankyou for forwarding the Ashton Coal Operations Water Management Plan for our records.

The Environment Protection Authority (EPA) encourages the development of such plans to ensure that proponents have determined how they will meet their statutory obligations and designated environmental objectives. However, EPA does not review these documents as our role is to set environmental objectives for environmental management, not to be directly involved in the development of strategies to achieve those objectives.

Should you have any questions please phone me on 02 4908 6803.

Yours sincerely

KAREN MARLER
Head Regional Operations Unit – Hunter
Environment Protection Authority

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Enquiries to: **Frank Sullivan**
02 6578 7334

Our Ref: DA223/2011

Your Ref:

Lisa Richards
AshtonCoal
PO Box 699
SINGLETON NSW 2330

Dear Lisa,

Thank you for your letter of April 10 2012, in which you sought comments from Singleton Council on the three updated management plans for Flora & Fauna (Biodiversity), Water and Built Features. We acknowledge that these plans form part of the ACOL extraction plan for Longwalls 1-4 in the Upper Liddell Seam, DA309-11-2001-i.

Flora & Fauna (Biodiversity) and Water Management plans
Singleton Council do not propose to provide comment in relation to these plans as we have no direct requirements under the plans.

Built Features Management Plan
Singleton Council recognises that this plan outlines measures to monitor and manage subsidence of the future Singleton Council infrastructure (Lemington Rd). We note that there are no expected impacts by ACOL's Longwalls 1-4 in the Upper Liddell seam and as such no comment is required at this time. We are however currently working with ACOL and Xstrata Coal in relation to this matter for the later panels.

F.J. Sullivan

Frank Sullivan
Development Engineer

FS.

ATTACHMENT A: SUMMARY OF CONSULTATION FOR WATER MANAGEMENT PLAN –JULY 2012

Stakeholder	Date	Description	Information provided	Comments / Feedback / Outcomes
DP&I	13-Sep-11	Letter to DP&I - Endorsement of Experts	CVs of Extraction Plan team	Endorsement of experts received 3/6/2011
	19-Jan-12	Email from DP&I – questions/comments on BCD Management Plan	BCD Management Plan is included as part of the site wide Water management plan	Response to be prepared in revised site WMP (revised BCD Management Plan provided as part of site WMP)
	11-Apr-12	Letter to DP&I - site Water Management Plan supplied in support of EP	Water Management Plan	
	6-Jul-12	Email from DP&I – questions/comments on WMP		Response to be prepared in revised WMP (to be provided)
	17-Jul-12	Letter to DP&I - Response to Question & - Submission of Revised EP addressing responses to consultation.	Response to Questions Consultation Summary Revised EP documents (excluding WMP)	Seeking final approval of the EP. **Actions:** revised WMP to be submitted.
DRE	18-Apr-12	Letter to DRE - Submission of Water Management Plan in support of EP	Water Management Plan	See consultation with DRE subsidence and sustainability below **Actions:** Letter from DRE to DP&I to confirm to DP&I that DRE "satisfied" with EP (per condition 3.12 of the Development Consent). Followed by SMP Approval once EP approved.
	17-Jul-12	Letter to DRE - Submission of Revised EP addressing responses to consultation.	Consultation Summary Revised EP documents (excluding WMP)	
DRE – Subsidence	1-Jun-12	Consultation meeting with DRE and NOW	Report by W Gale (SCT)"*Subsidence & Hydraulic Conductivity Effects East of LW1 in the PG Seam (ULD LW1-4 EP)*"	**Key Consultation outcomes**: Design for LW 1-4 generally OK. Questions focused on EP and addressed in EP. Additional comments and information provided regarding hydraulic conductivity of LW1 and stability of LW4 (SCT assessments).
	28-Jun-12	Email – submission of SCT Report		
DRE – Sustainability	9-May-12	Consultation – DRE Maitland Verbal – No comments/ OK		**Consultation outcomes**: Verbally informed that plans are satisfactory. See required actions above.

Stakeholder	Date	Description	Information provided	Comments / Feedback / Outcomes
NOW	28-Mar-12	Letter - copy of Extraction Plan Upper Liddell Seam LW 1-4 for consultation (excluding Water Management Plan)	Extraction Plan (excluding WMP)	**Consultation outcomes** (in meeting):- The following are notes on key items raised during the meeting; • Requested additional base / source data (provided 19-Jun-12), • Management of potential impacts to Glennies Ck (GC), use of TARP, potential for water monitoring around LW1 near GC, additional detail on potential remediation options • Agreed actions to amend reporting mechanisms EOP report, mid-panel review, fortnightly status report email, ACOL is waiting for formal written response from NOW. They have indicated that correspondence is under preparation. The revised WMP includes additional information regarding a number of issues raised by NOW. **Action:** The WMP will be updated in response to consultation completed to date. Further NOW response may be addressed in a "staged" manner as per condition 1.12 of the Development Consent.
	5-Apr-12	Letter - Submission of site Water Management Plan wide and in support of EP	Water Management Plan	
	1-Jun-12	Consultation meeting – NOW office with DRE		
	19-Jun-12	Email – Additional Data	Additional base data behind WMP	
	28-Jun-12	Email – submission of SCT Report	Report by W Gale (SCT) "*Subsidence & Hydraulic Conductivity Effects East of LW1 in the PG Seam (ULD LW1-4 EP)*"	
	June / July-12	Various Email/Phone – correspondence regarding NOW response / additional meetings	Correspondence re response	
OEH	11-Apr-12 14-Jun-12	Letter to OEH - copy of Extraction Plan Upper Liddell Seam LW 1-4 for consultation. Letter from OEH – response and comments	Flora and Fauna Management Plan, Heritage Management Plan, Water Management Plan, Extraction Plan (in full on CD)	**Consultation outcomes**: in letter to ACOL 14 June 12 – WMP to be addressed by NOW,
EPA	11-Apr-12	Letter from EPA - Extraction Plan Upper Liddell Seam LW 1-4	Water Management Plan	**Consultation outcomes:** Letter to ACOL 7 June 12 - no comment, conceptually supportive.

APPENDIX C

BASELINE SURFACE WATER MONITORING DATA

Client sample ID (Primary)	Analysis: All measurements in mg/L unless specified	pH Value (Lab/field)	Electrical Conductivity @ 25°C (Lab/field)	Total Dissolved Solids (TDS) at 180 C	Total Suspended Solids (TSS)	Total Hardness as CaCO3	Calcium	Magnesium	Sodium	Potassium	Chloride	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Sulfate as SO4	Fluoride	Arsenic - Filtered	Barium - Filtered	Boron - Filtered	Cadmium - Filtered
SM1	Min	6.65	145	10	38	20	6	5	97	6	144	1	70	75	0.2	0.002	0.051		0.0001
	Mean	7.26	519	414.4	179.6	57.2	38	39.6	104	6	144	1	70	75	0.2	0.002	0.051		0.0001
	Median	7.29	573	375	97.5	42	23	17	104	6	144	1	70	75	0.2	0.002	0.051		0.0001
	Max	7.88	777	1260	716	119	100	96.7	111	6	144	1	70	75	0.2	0.002	0.051		0.0001
SM2	Min	6.63	141	366	14	20	13	16	104	5	140	1	54	68	0.2	0.003	0.057		0.0001
	Mean	7.01	636	598.9	180	92.7	20.3	34.3	409	5.5	140	1	54	68	0.2	0.003	0.057		0.0001
	Median	6.87	381	586	46	73	21	27	409	5.5	140	1	54	68	0.2	0.003	0.057		0.0001
	Max	7.63	1220	1230	724	187	27	60	714	6	140	1	54	68	0.2	0.003	0.057		0.0001
SM3	Min	6.85	386	264	1	85	4	2	8	1	116	1	119	77.1	0.17	0.001	0.03	0.06	0.0001
	Mean	7.62	1106	682.5	19.7	228.6	41.1	22.5	98	2.2	140.8	1	166.3	93.5	0.29	0.001	0.0368	0.06	0.0001
	Median	7.61	1075	670	12	231	44.5	25	123	2	142	1	162.5	86.5	0.3	0.001	0.0375	0.06	0.0001
	Max	8.40	1750	976	232	336	58	32	134	3	163	1	221	124	0.4	0.001	0.042	0.06	0.0001
	20th Percentile	7.40	897	532.4	5.2	186													
	80th Percentile	7.81	1430	862.8	24	278.2													
SM4	Min	7.33	175	212	4	39	9	4	16	2	24	1	32	16	0.19	0.001	0.032	0.05	0.0001
	Mean	7.91	2257	1513.2	33.8	319.2	46.1	41.4	361.9	4.5	554.5	1	183.1	116.0	0.28	0.0018	0.0722	0.064	0.0001
	Median	7.90	1370	964	20	268	46	27	130.5	3	162	1	162	91	0.3	0.001	0.043	0.06	0.0001
	Max	8.77	14100	8080	592	1210	78	252	2190	19	3930	1	358	309	0.4	0.006	0.288	0.1	0.0002
	20th Percentile	7.74	989	538.4	11	187													
	80th Percentile	8.09	2928	2116	40	435.2													
SM5	Min	6.90	195	292	1	39	37	20	107	2	130	1	120	79.5	0.19	0.001	0.036	0.06	0.0001
	Mean	7.79	1204	736.0	13.0	226.3	43.2	24.6	123.8	2.3	149.5	1	158.3	94.6	0.30	0.001	0.0375	0.06	0.0001
	Median	7.80	1150	786	9.5	232	41	24	125.5	2	153	1	161	89	0.3	0.001	0.036	0.06	0.0001
	Max	8.28	1960	1120	98	314	51	29	137	3	162	1	191	121	0.4	0.001	0.042	0.06	0.0001
	20th Percentile	7.66	921	557.2	5.8	193													
	80th Percentile	7.96	1572	899.2	18.2	278													
SM6	Min	6.84	284	270	2	43	38	22	113	2	133	1	138	91	0.19	0.001	0.036	0.06	0.0001
	Mean	8.02	1121	519.6	20.4	226.0	42.2	26	134	2.25	158.8	1	166.3	100.9	0.30	0.00125	0.041	0.06	0.0001
	Median	8.10	1100	500	14	226	42	26	136.5	2	160	1	163.5	96.3	0.3	0.001	0.0415	0.06	0.0001
	Max	8.46	2000	1080	163	343	46	30	150	3	182	1	200	120	0.4	0.002	0.045	0.06	0.0001
	20th Percentile	7.88	831	388	8	197													
	80th Percentile	8.23	1446	605.2	24.2	259.4													
SM7	Min	7.15	148	131	2	27	19	10	32	2	45.3	1	103	10.1	0.12	0.001	0.017	0.05	0.0001
	Mean	7.83	543	236.5	18.4	99.0	28.4	16.2	61	2.8	93.9	1	110	28.5	0.23	0.001	0.0273	0.05	0.000125
	Median	7.82	500	203.5	12	86.5	29	15	54.5	3	86.65	1	109.5	29.5	0.25	0.001	0.0285	0.05	0.0001
	Max	8.40	1040	460	226	253	36	22	103	3	157	1	118	45	0.3	0.001	0.035	0.05	0.0002
	20th Percentile	7.65	265	158	7.2	74													
	80th Percentile	8.03	830	332	20.8	122													
SM8	Min	7.18	219	131	1	56	22	11	31	2	44.5	1	83	9.92	0.13	0.001	0.02	0.05	0.0001
	Mean	7.75	373	232.0	18.1	97.4	29.3	16	56.4	2.6	83.98	1	108.8	27.8	0.23	0.001	0.028	0.05	0.0001
	Median	7.75	316	200.5	14	85.5	28.5	14.5	52	3	77.7	1	115	30	0.2	0.001	0.028	0.05	0.0001
	Max	8.30	829	440	84	190	40	22	96	3	139	1	117	44	0.3	0.001	0.035	0.05	0.0001
	20th Percentile	7.58	264	156	8.6	75													
	80th Percentile	7.95	490	324	22.4	130													

Client sample ID (Primary)	Analysis: All measurements in mg/L unless specified	Chromium - Filtered	Copper - Filtered	Lead - Filtered	Manganese - Filtered	Nickel - Filtered	Selenium - Filtered	Zinc - Filtered	Iron - Total	Iron - dissolved	Mercury - Filtered	Ammonia as N	Nitrate as N	Total Anions meq/L	Total Cations meq/L	Ionic Balance %	Oil and Grease	Total petroleum hydrocarboms	Polycyclic Aromatic Hydrocarbons
SM1	Min	0.003	0.005	0.002	0.046	0.004	0.01	0.016	4.76	0.44	0.0001	0.042	0.243				0.01	0	0
	Mean	0.003	0.005	0.002	0.046	0.004	0.01	0.016	4.76	0.44	0.0001	0.042	0.243				4.50	0	0
	Median	0.003	0.005	0.002	0.046	0.004	0.01	0.016	4.76	0.44	0.0001	0.042	0.243				5	0	0
	Max	0.003	0.005	0.002	0.046	0.004	0.01	0.016	4.76	0.44	0.0001	0.042	0.243				6	0	0
SM2	Min	0.004	0.005	0.002	0.11	0.006	0.01	0.012	6.02	0.54	0.0001	0.135	0.326				0.01	220	1
	Mean	0.004	0.005	0.002	0.11	0.006	0.01	0.012	6.02	0.54	0.0001	0.135	0.326				4.34	220	1
	Median	0.004	0.005	0.002	0.11	0.006	0.01	0.012	6.02	0.54	0.0001	0.135	0.326				5	220	1
	Max	0.004	0.005	0.002	0.11	0.006	0.01	0.012	6.02	0.54	0.0001	0.135	0.326				6	220	1
SM3	Min	0.001	0.001	0.001	0.016	0.001	0.01	0.005	0.22	0.05	0.0001	0.01	0.03				0.01	70	0.5
	Mean	0.001	0.001	0.001	0.0223	0.001	0.01	0.005	0.2375	0.06	0.0001	0.011	0.124				4.88	145	0.875
	Median	0.001	0.001	0.001	0.021	0.001	0.01	0.005	0.22	0.05	0.0001	0.01	0.13				5	145	1
	Max	0.001	0.001	0.001	0.031	0.001	0.01	0.005	0.29	0.09	0.0001	0.013	0.207				7	220	1
	20th Percentile																		
	80th Percentile																		
SM4	Min	0.001	0.001	0.001	0.018	0.001	0.01	0.005	0.2	0.05	0.0001	0.01	0.01	124	120	0.941	0.01	70	0.5
	Mean	0.0013	0.0015	0.00145	0.1142	0.00136	0.01091	0.00709	1.19	0.128	0.0001	0.03109	0.126	124	120	0.941	5.44	105	0.95
	Median	0.001	0.001	0.001	0.023	0.001	0.01	0.005	0.32	0.055	0.0001	0.02	0.03	124	120	0.941	5	70	1
	Max	0.004	0.004	0.004	0.834	0.002	0.02	0.016	5.26	0.3	0.0001	0.07	0.49	124	120	0.941	39	220	1
	20th Percentile																		
	80th Percentile																		
SM5	Min	0.001	0.001	0.001	0.018	0.001	0.01	0.005	0.21	0.05	0.0001	0.01	0.01				0.01	70	0.5
	Mean	0.001	0.001	0.001	0.0278	0.001	0.01	0.0065	0.28	0.053	0.0001	0.015	0.077				4.57	145	0.88
	Median	0.001	0.001	0.001	0.0245	0.001	0.01	0.005	0.245	0.05	0.0001	0.015	0.03				5	145	1
	Max	0.001	0.001	0.001	0.044	0.001	0.01	0.011	0.42	0.06	0.0001	0.02	0.239				5	220	1
	20th Percentile																		
	80th Percentile																		
SM6	Min	0.001	0.001	0.001	0.024	0.001	0.01	0.005	0.28	0.05	0.0001	0.01	0.01				0.01	70	0.5
	Mean	0.001	0.0013	0.001	0.0425	0.001	0.01	0.00525	0.55	0.05	0.0001	0.014	0.086				4.63	145	0.88
	Median	0.001	0.001	0.001	0.037	0.001	0.01	0.005	0.52	0.05	0.0001	0.01	0.05				5	145	1
	Max	0.001	0.002	0.001	0.072	0.001	0.01	0.006	0.88	0.05	0.0001	0.025	0.234				7	220	1
	20th Percentile																		
	80th Percentile																		
SM7	Min	0.001	0.001	0.001	0.025	0.001	0.01	0.005	0.36	0.05	0.0001	0.01	0.01	5.21	5.27	0.0059	0.01	70	0.5
	Mean	0.0013	0.001	0.001	0.0408	0.001	0.01	0.00675	0.7625	0.057	0.0001	0.017	0.068	5.21	5.27	0.00795	4.66	120	0.83
	Median	0.001	0.001	0.001	0.035	0.001	0.01	0.006	0.855	0.05	0.0001	0.01	0.025	5.21	5.27	0.00795	5	70	1
	Max	0.002	0.001	0.001	0.068	0.001	0.01	0.01	0.98	0.07	0.0001	0.036	0.211	5.21	5.27	0.01	5	220	1
	20th Percentile																		
	80th Percentile																		
SM8	Min	0.001	0.001	0.001	0.023	0.001	0.01	0.005	0.3	0.05	0.0001	0.01	0.01	5.12	4.94	0.0186	0.01	70	0.5
	Mean	0.001	0.001	0.001	0.0506	0.001	0.01	0.0064	0.844	0.098	0.0001	0.023	0.100	5.12	4.94	0.0186	4.57	145	0.88
	Median	0.001	0.001	0.001	0.045	0.001	0.01	0.005	0.9	0.065	0.0001	0.01	0.02	5.12	4.94	0.0186	5	145	1
	Max	0.001	0.001	0.001	0.075	0.001	0.01	0.012	1.14	0.21	0.0001	0.042	0.229	5.12	4.94	0.0186	6	220	1
	20th Percentile																		
	80th Percentile																		

Client sample ID (Primary)	Analysis: All measurements in mg/L unless specified	pH Value (Labfield)	Electrical Conductivity @ 25°C (Labfield)	Total Dissolved Solids (TDS) at 180 C	Total Suspended Solids (TSS)	Total Hardness as CaCO3	Calcium	Magnesium	Sodium	Potassium	Chloride	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Sulfate as SO4	Fluoride	Arsenic - Filtered	Barium - Filtered	Boron - Filtered	Cadmium - Filtered	Chromium - Filtered	Copper - Filtered	Lead - Filtered	Manganese - Filtered	Nickel - Filtered	Selenium - Filtered	Zinc - Filtered	Iron - Total	Iron - dissolved	Mercury - Filtered	Ammonia as N	Nitrate as N	Total Anions meq/L	Total Cations meq/L	Ionic Balance %	Oil and Grease	Total petroleum hydrocarbons	Polycyclic Aromatic Hydrocarbons
SM9	Min	7.50	236	266	3	127	34	24	40	2	56	1	158	26	0.1	0.001	0.018	0.05	0.0001	0.001	0.001	0.001	0.014	0.001	0.01	0.005	0.27	0.05	0.0001	0.01	0.01				0.01	70	0.5
	Mean	8.16	685	419.5	26.2	227.9	42.2	29.8	78	3	116.5	1	182.3	54.5	0.18	0.001	0.0295	0.05	0.0001	0.001	0.0015	0.001	0.0585	0.002	0.01	0.00575	0.6225	0.05	0.0001	0.013	0.102				4.55	145	0.88
	Median	8.21	688	389.5	23	219.5	37	27	68	3	122	1	167.5	37.0	0.15	0.001	0.029	0.05	0.0001	0.001	0.0015	0.001	0.0435	0.0015	0.01	0.0055	0.675	0.05	0.0001	0.01	0.035				5	145	1
	Max	8.52	1220	722	133	364	58	41	136	4	166	1	236	118	0.3	0.001	0.042	0.05	0.0001	0.001	0.002	0.001	0.133	0.004	0.01	0.007	0.87	0.05	0.0001	0.023	0.328				5	220	1
	20th Percentile	8.04	555	334	9.4	195.2																															
	80th Percentile	8.31	899	484.8	34	269																															
SM10	Min	7.64	287	272	2	43	29	21	44	2	61	1	135	31	0.1	0.001	0.02	0.05	0.0001	0.001	0.001	0.001	0.029	0.001	0.01	0.005	0.49	0.05	0.0001	0.01	0.06				0.01	70	0.5
	Mean	8.19	728	408.6	30.5	218.8	39.3	30	61.7	2.3	91.3	1	183	36.1	0.17	0.001	0.0267	0.05	0.0001	0.0017	0.002	0.001	0.0913	0.002	0.01	0.0063	1.0733	0.05	0.0001	0.01	0.107				4.38	120	0.83
	Median	8.22	706	397	26	211	36	27.5	48	2	68	1	157	37.3	0.2	0.001	0.027	0.05	0.0001	0.001	0.001	0.001	0.107	0.001	0.01	0.007	0.66	0.05	0.0001	0.01	0.07				5	70	1
	Max	8.52	1170	648	148	362	56	44	93	3	145	1	257	40	0.2	0.001	0.033	0.05	0.0001	0.003	0.004	0.001	0.138	0.004	0.01	0.007	2.07	0.05	0.0001	0.01	0.19				5	220	1
	20th Percentile	8.04	615	340	10.4	186																															
	80th Percentile	8.31	866	460	41.6	265																															
SM11	Min	7.10	208	126	2	58	19	10	30	2	47.6	1	85	10.7	0.13	0.001	0.017	0.05	0.0001	0.001	0.001	0.001	0.023	0.001	0.01	0.005	0.24	0.05	0.0001	0.01	0.01	4.95	5.01	0.0061	0.01	70	0.5
	Mean	7.88	374	233.6	17.6	101.2	28.8	15.8	55.6	2.6	86.9	1	100.2	28.1	0.21	0.001	0.0258	0.05	0.0001	0.001	0.001	0.001	0.0394	0.001	0.01	0.005	0.788	0.095	0.0001	0.016	0.094	4.95	5.01	0.0061	4.66	145	0.88
	Median	7.88	312	201.5	13	85.5	29	14.5	52	3	83.4	1	97	31	0.2	0.001	0.027	0.05	0.0001	0.001	0.001	0.001	0.039	0.001	0.01	0.005	0.8	0.09	0.0001	0.01	0.03	4.95	5.01	0.0061	5	145	1
	Max	8.45	825	434	86	275	40	22	94	3	140	1	117	43	0.3	0.001	0.032	0.05	0.0001	0.001	0.001	0.001	0.054	0.001	0.01	0.005	1.06	0.15	0.0001	0.025	0.21	4.95	5.01	0.0061	5	220	1
	20th Percentile	7.73	265	156	6.6	75																															
	80th Percentile	8.02	517	322	20.4	128																															
SM12	Min	7.60	239	178	2	84	28	21	32	2	45	1	138	25	0.1	0.001	0.026	0.05	0.0001	0.001	0.001	0.001	0.034	0.001	0.01	0.005	0.34	0.05	0.0001	0.01	0.01				0.01	70	0.5
	Mean	8.03	509	316.1	26.4	167.9	37	26.8	50.7	2.7	82.3	1	164.7	31.4	0.13	0.001	0.0267	0.05	0.0001	0.0027	0.0027	0.001	0.0907	0.0037	0.01	0.007	1.74	0.05	0.0001	0.02	0.097				4.81	120	0.83
	Median	8.08	505	303	22	159	35.5	27	52	3	75	1	157	31	0.1	0.001	0.026	0.05	0.0001	0.001	0.001	0.001	0.103	0.002	0.01	0.005	0.6	0.05	0.0001	0.01	0.06				5	70	1
	Max	8.32	947	640	136	288	49	32	68	3	127	1	199	38.2	0.2	0.001	0.028	0.05	0.0001	0.006	0.006	0.001	0.135	0.008	0.01	0.011	4.28	0.05	0.0001	0.04	0.22				6	220	1
	20th Percentile	7.80	339	239.6	10	120.4																															
	80th Percentile	8.21	656	383.2	36	212.8																															
SM13	Min	7.70	293	260	1	139	25	19	28	2	37	1	135	24	0.1	0.001	0.021	0.05	0.0001	0.001	0.001	0.001	0.031	0.001	0.01	0.005	0.38	0.05	0.0001	0.01	0.01				0.01	70	0.5
	Mean	8.18	714	405.4	33.2	220.9	37.8	28	51	2.75	83.4	1	177.5	31.6	0.13	0.001	0.02575	0.05	0.0001	0.00225	0.00225	0.001	0.0865	0.00325	0.01	0.00575	1.52	0.05	0.0001	0.015	0.179				5.05	145	0.88
	Median	8.20	666	377.5	27	209	35	24	45.5	2.5	69.8	1	156.5	32	0.1	0.001	0.0245	0.05	0.0001	0.001	0.0015	0.001	0.0905	0.002	0.01	0.005	0.745	0.05	0.0001	0.01	0.16				5	145	1
	Max	8.68	1160	750	214	361	58	43	85	4	157	1	262	38.3	0.2	0.001	0.033	0.05	0.0001	0.006	0.005	0.001	0.134	0.008	0.01	0.008	4.21	0.05	0.0001	0.029	0.384				17	220	1
	20th Percentile	8.02	593	337.2	11.2	183																															
	80th Percentile	8.31	852	488.4	39.6	266																															
SM14	Min	7.70	446	240	5	138	26	19	29	2	38	1	132	25	0.08	0.001	0.019	0.05	0.0001	0.001	0.001	0.001	0.016	0.001	0.01	0.005	0.21	0.05	0.0001	0.01	0.01				0.01	70	0.5
	Mean	8.15	741	422.5	38.9	230.8	38.8	28.8	53.8	2.8	82.0	1.25	171.5	33.6	0.12	0.001	0.0248	0.05	0.0001	0.0023	0.0023	0.001	0.0843	0.0035	0.01	0.0055	1.4975	0.05	0.0001	0.014	0.189				4.551	145	0.88
	Median	8.18	686	420	24	214	37	27	47	2.5	69.6	1	158	33.7	0.1	0.001	0.0235	0.05	0.0001	0.001	0.0015	0.001	0.0925	0.003	0.01	0.005	0.935	0.05	0.0001	0.01	0.155				5	145	1
	Max	8.48	1160	666	209	360	59	45	92	4	151	2	238	42	0.2	0.001	0.033	0.05	0.0001	0.006	0.005	0.001	0.136	0.007	0.01	0.007	3.91	0.05	0.0001	0.027	0.435				6	220	1
	20th Percentile	8.00	580	346	13.6	177																															
	80th Percentile	8.30	936	502	45.2	292																															

APPENDIX D

BOREHOLE MONITORING NETWORK

Abbreviations
Aquifer Monitored
HR = Hunter River
GC = Glennies Creek
GCA = Glennies Creek Alluvium
GCC = Glennies Creek Colluvium
BCA = Bowmans Creek Alluvium
BCC = Bowmans Creek Colluvium
HRA = Hunter River Alluvium
CMOB = coal measures overburden
PG = Pikes Gully
LEM = Lemington
ART = Arties
ULD = Upper Liddell
ULLD = Upper Lower Liddell
MLD = Middle Liddell
ULLL = Upper Lower Lower Liddell
UB = Upper Barrett
LB = Lower Barrett
HEB = Hebden
Monitoring Status
C = Current
H = Historic
Function
SP = stand pipe piezometer
VW = vibrating wire piezometer

Borehole Monitoring Network (as at July 2012)

Borehole	Aquifer Monitored	Monitoring status	Function	Bore status	Reason for not monitoring
G1	ULD	C	SP	Piezometer	
G2	LB	H	SP	Not in network	Not monitored - Dry
G3A	UB	C	SP	Piezometer	
G3B	GCA	C	SP	Piezometer	
PB1	BCA + CMO	C	SP	Piezometer	
PB2	BCA	H	SP	Not in network	Bore removed (BCD)
RA01	CMO	H	SP	Not in network	Bore removed
RA02	BCA + CMO	C	SP	Piezometer	
RA03	CMO	H	SP	Not in network	Bore removed
RA10	BCA	C	SP	Piezometer	
RA12	BCC	C	SP	Piezometer	
RA14	BCA	C	SP	Piezometer	
RA15	BCA	C	SP	Piezometer	
RA16	BCC	C	SP	Piezometer	
RA17	BCC	C	SP	Piezometer	
RA18	BCC	C	SP	Piezometer	
RA20	BCA	H	SP	Not in network	Not monitored - Dry
RA27	HRA	C	SP	Piezometer	
RA30	BCA	C	SP	Piezometer	
RA8	BCC	C	SP	Piezometer	
RA9	BCA	H	SP	Not in network	Not monitored - Dry
RM01	BCA	C	SP	Piezometer	
RM02	BCA + CMO	C	SP	Piezometer	
RM03	BCA + CMO	C	SP	Piezometer	
RM04	BCA	C	SP	Piezometer	
RM05	CMO	C	SP	Piezometer	
RM06	BCA + CMO	C	SP	Piezometer	
RM07	BCA + CMO	C	SP	Piezometer	
RM08	BCA + CMO	H	SP	Not in network	Bore removed
RM09	BCA	H	SP	Not in network	Bore removed
RM10	BCA + CMO	C	SP	Piezometer	
RSGM1	BW?	C	SP	Piezometer	

Borehole	Aquifer Monitored	Monitoring status	Function	Bore status	Reason for not monitoring
T10	BCA	C	SP	Piezometer	
T1-A	BCA	H	SP	Not in network	Bore removed (BCD)
T1-P	CMOB	H	SP	Not in network	Bore removed (BCD)
T2-A	BCA	C	SP	Piezometer	
T2-P	CMOB	C	SP	Piezometer	
T3-A	BCA	C	SP	Piezometer	
T3-P	CMOB	C	SP	Piezometer	
T4-A	BCA	C	SP	Piezometer	
T4-P	CMOB	C	SP	Piezometer	
T5	BCA	C	SP	Piezometer	
T6	BCA	C	SP	Piezometer	
T7	BCA	C	SP	Piezometer	
T8	BCA	H	SP	Not in network	Not monitored - Dry
T9	CMOB	H	SP	Not in network	Not monitored - Dry
WML106	Lem15, Lem19, PG	C	VW	VW Piezometer	
WML107A	Lem11, Lem15, Lem19	C	VW	VW Piezometer	
WML107B	Lem8-9,	C	SP	Piezometer	
WML108A	Lem11-12, Lem15	C	VW	VW Piezometer	
WML108B	Lem8-9,	C	SP	Piezometer	
WML109A	Lem8-9, Lem11-12, Lem15	H	SP	Not in network	Mined out
WML109B	Lem7	H	SP	Not in network	Decomissioned (cement)
WML110A	Lem6, Lem8-9, Lem10-12, Lem15	H	VW	Not in network	Mined out
WML110B	Lem6OB	H	SP	Piezometer	Not monitored - Dry
WML110C	BCA or BCC?	C	SP	Piezometer	
WML111A	Lem4, Lem7, Lem11-12, Lem15	H	SP	Not in network	Mined out
WML111B	Lem1-3	C	SP	Piezometer	
WML112A	Lem2-3, Lem6-7, Lem8, Lem15	H	SP	Not in network	Mined out
WML112B	BW	C	SP	Piezometer	
WML112C	BCA	C	SP	Piezometer	
WML113A	BW2, Lem4, Lem9, Lem11-12, Lem15	C	VW	VW Piezometer	
WML113B	BW1	C	SP	Piezometer	
WML113C	BCA	C	SP	Piezometer	
WML114A	Lem10-12, Lem15, Lem19	H	VW	Not in network	Mined out
WML114B	Lem6-9	H	SP	Not in network	Bore collapsed

Borehole	Aquifer Monitored	Monitoring status	Function	Bore status	Reason for not monitoring
WML115A	Lem7, Lem8-9, Lem15, Lem19, PG	H	SP	Not in network	Mined out
WML115B	CMOB & Lem3-4	C	SP	Piezometer	
WML115C	BCA	C	SP	Piezometer	
WML119	PG	C	SP	Piezometer	
WML120A	PG	C	SP	Piezometer	
WML120B	GCA	C	SP	Piezometer	
WML129	GCA	C	SP	Piezometer	
WML181	PG	C	SP	Piezometer	
WML182	PG	C	SP	Piezometer	
WML183	PG	C	SP	Piezometer	
WML184	PG	C	SP	Piezometer	
WML185	PG	C	SP	Piezometer	
WML186	PG	C	SP	Piezometer	
WML189	Lem15, Art, PG	C	VW	VW Piezometer	
WML19	UB	H	SP	Not in network	Not monitored - Dry
WML191	Lem15, PG, ULD, ULLD	C	VW	VW Piezometer	
WML20	PG	H	SP	Not in network	Decommissioned (cement)
WML21	PG	H	SP	Piezometer	Not monitored - Dry
WML213	BW, Lem8-9, Lem15, Lem19, PG ULD, ULLD, LB	C	VW	VW Piezometer	
WML22	PG	H	SP	Not in network	Not monitored - Dry
WML261	ULD	C	SP	Piezometer	
WML262	ULD	C	SP	Piezometer	
WML269B	CMOB	C	SP	Piezometer	Not monitored - Dry
WML269	Lem5, Lem7, Lem8-9, Lem11-12, Lem15, Lem19	C	VW	VW Piezometer	
WMLC144	ULD, MLD1, MLD, ULLD, LLL, UB, LB	C	VW	VW Piezometer	
WML172	GCA	C	SP	Piezometer	
WML173	GCA	C	SP	Piezometer	
WML174	GCA	C	SP	Piezometer	
WMLC248	ULD, ULLL, LB, Heb1	C	VW	VW Piezometer	
WMLP275	HRA	C	SP	Piezometer	
WMLP276	HRA	C	SP	Piezometer	
WMLP277	HRA	C	SP	Piezometer	
WMLP278	HRA	C	SP	Piezometer	

Borehole	Aquifer Monitored	Monitoring status	Function	Bore status	Reason for not monitoring
WMLP279	HRA	C	SP	Piezometer	
WMLP280	HRA	C	SP	Piezometer	
WMLP301	ART	C	SP	Piezometer	
WMLP302	ART	C	SP	Piezometer	
WMLP310	BCA	H	SP	Not in network	Bore removed (BCD)
WMLP312	BCC	H	SP	Not in network	Bore removed (BCD)
WMLP309	BCA	H	SP	Not in network	Bore removed (BCD)
WMLP308	BCA	C	SP	Piezometer	
WMLP307	BCA	H	SP	Not in network	Bore removed (BCD)
WMLP313	BCA	H	SP	Not in network	Bore removed (BCD)
WMLP323	BCA	C	SP	Piezometer	
WMLP324	CMOB	C	SP	Piezometer	
WMLP311	BCA	C	SP	Piezometer	
WMLP325	CMOB	C	SP	Piezometer	
WMLP314	BCA	C	SP	Not in network	Bore removed (BCD)
WMLP315	BCA	C	SP	Not in network	Bore removed (BCD)
WMLP320	BCA	C	SP	Piezometer	
WMLP316	BCA	C	SP	Piezometer	
WMLP326	BCA	C	SP	Piezometer	
WMLP327	CMOB	C	SP	Piezometer	
WMLP328	BCA	C	SP	Piezometer	
WMLC333	Lem15, Lem19, Art, ULD, ULLD, UB, LB	C	VW	VW Piezometer	
WMLC334	Lem10, Lem15, Lem19, ART, ULD, ULLD, UB, LB	C	VW	VW Piezometer	
WMLC335	Lem15A, Lem17, UPG, ART, ULDB, ULLD, UB, LB	C	VW	VW Piezometer	
WMLP336	GCA	C	SP	Piezometer	
WMLP337	HRA	C	SP	Piezometer	
WMLP338	GCA	C	SP	Piezometer	
WMLP339	GCA	C	SP	Piezometer	

APPENDIX E

BASELINE GROUNDWATER QUALITY DATA

Bore / Well / Spring / Soak			WML261	WML262	AP243	AP244	RM02				RM04				RM05			
Parameter	Units	LOR	24-Feb-11	24-Feb-11	25-Feb-11	25-Feb-11	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																		
pH Value (Lab)	pH unit	0.01																
pH Value (field)	pH unit	0.01	6.90	7.54	6.82	6.66	6.52	6.91	6.78	7.87	6.84	7.30	7.19	8.18	6.44	6.87	6.83	8.00
Conductivity (field)	µS/cm	1	932	6410	3400	852	2290	5228	5040	8400	722	1203	1150	1760	1070	2229	2270	2550
Lab Conductivity @ 25°C	µS/cm	1													1270	1372	1345	1470
Total Dissolved Solids (TDS)	mg/L	1	714	4510	2160	676	2560	4514	4240	9680	572	746	679	1060	28	406	45	1670
Suspended Solids (TSS)	mg/L	1	28	66	330	372	700	700	700	700	140	189	202	226	295	295	295	295
Total Hardness as CaCO3	mg/L	1	202	52	644	197					275	275	275	275				
Turbidity	NTU	0.01																
Major Ions																		
Calcium	mg/L	1	33	11	106	36	170	170	170	170	37	43	43	60	34	40	40	46
Magnesium	mg/L	1	29	6	92	26	236	236	236	236	17	21	19	30	44	48	48	51
Sodium	mg/L	1	162	1590	577	176	1130	1130	1130	1130	129	157	146	210	452	483	483	514
Potassium	mg/L	1	2	7	2	1	9	9	9	9	2	3	3	4	4	5	5	6
Chloride	mg/L	1	245	1830	938	90	1820	1820	1820	1820	148	188	170	280	468	532	532	596
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1												
Carbonate as CaCO3	mg/L	1	<1	<1	<1	<1	<1	1	1	1	<1	1	1	4	<1			<1
Bicarbonate as CaCO3	mg/L	1	188	861	368	374	135	135	135	135	144	202	204	231	317	344	344	371
Total Alkalinity	mg/L	1																
Sulphate	mg/L	1	38	<1	155	31	602	602	602	602	<1	67	76	80	107	126	126	145
Metals																		
Aluminum	mg/L	0.01	0.12	0.16	6.52	2.82												
Arsenic - Filtered	mg/L	0.001	<0.001	0.004	0.002	<0.001					<0.001	0.003	0.001	0.010				
Boron - Filtered	mg/L	0.05																
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00010	0.00040	<0.0001					<0.0001			<0.005				
Chromium - Filtered	mg/L	0.002	<0.001	0.003	0.006	0.002					<0.001	0.002	0.001	0.010				
Copper - Filtered	mg/L	0.0005	<0.001	0.002	0.011	0.009					<0.001	0.018154	0.004	0.14				
Iron - Filtered	mg/L	0.05	0.13	0.61	7.11	3.01												
Lead - Filtered	mg/L	0.00005	<0.001	0.005	0.008	0.003					<0.001	0.003	0.001	0.015				
Manganese - Filtered	mg/L	0.001	0.010	0.166	0.884	0.265												
Mercury - Filtered	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001					<0.0001	0.0001	0.0001	0.0002				
Nickel - Filtered	mg/L	0.001	0.001	0.002	0.011	0.004					<0.003	0.008	0.008	0.015				
Selenium - Filtered	mg/L	0.01	<0.01	<0.01	<0.01	<0.01												
Zinc - Filtered	mg/L	0.005	0.100	0.034	0.144	0.026					<0.005	0.046	0.016	0.309				
Nutrients																		
Ammonia as N	mg/L	0.01	0.03	0.66	0.12	0.07												
Nitrate as N	mg/L	0.01	0.16	<0.01	1.74	2.52	0.20	0.20	0.20	0.20	<0.01	0.20	0.21	0.35	<0.01			<0.01
Nitrite as N	mg/L	0.01	<0.01	<0.01	0.02	0.08												
Nitrite + Nitrate as N	mg/L	0.01																
Total Phosphorus as P	mg/L	0.01																
Other																		
Silica	mg/L						34.4	34.4	34.4	34.4	9.9	21.22143	21.5	24.9	38.3	38.3	38.3	38.3
Fluoride	mg/L	0.02	2.30	2.90	0.80	0.70												
Total Cyanide	mg/L	0.004																
Calculated Parameters																		
Total Anions	meq/L	0.01	11.10	70.40	38.00	11.60					13.60	13.60	13.60	13.60	26.20	26.20	26.20	26.20
Total Cations	meq/L	0.01	11.50	68.90	37.00	10.60					14.70	14.70	14.70	14.70	28.40	28.40	28.40	28.40
Ionic Balance	%	0.01	1.56	1.00	1.29	4.36					0.04	0.04	0.04	0.04				

Version D

Bore / Well / Spring / Soak			RM06				RM07				RM08	RM09				RM10			
Parameter	Units	LOR	Min	Mean	Median	Max	Min	Mean	Median	Max	29-Nov-00	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																			
pH Value (Lab)	pH unit	0.01																	
pH Value (field)	pH unit	0.01	7.15	7.40	7.26	8.18	6.94	7.30	7.21	8.17	7.10	6.77	7.22	7.10	8.18	6.83	7.23	7.11	8.15
Conductivity (field)	µS/cm	1	1170	1255	1240	1340	813	1671	1320	9920	1300	848	1248	1160	5810	883	1335	1260	3700
Lab Conductivity @ 25°C	µS/cm	1																	
Total Dissolved Solids (TDS)	mg/L	1	752	839	839	926	478	876	692	3610	736	536	823	668	3640	594	913	860	2240
Suspended Solids (TSS)	mg/L	1	7	7	7	7	4	19	11	63		2	11	8	28	18	91	65	192
Total Hardness as CaCO3	mg/L	1	257	257	257	257	133	181	148	274		165	202	201	269	160	231	202	390
Turbidity	NTU	0.01					5.30	40.40	17.90	98.00									
Major Ions																			
Calcium	mg/L	1	50	58	58	65	27	55	49	168	53	34	42	42	58	34	46	45	88
Magnesium	mg/L	1	32	34	34	35	16	38	29	218	34	17	22	22	30	15	21	20	41
Sodium	mg/L	1	172	176	176	180	129	243	158	1540	182	129	153	152	192	137	173	167	256
Potassium	mg/L	1	3	4	4	4	<1	3	3	5	3	2	3	2	7	2	4	3	8
Chloride	mg/L	1	204	213	213	222	130	378	235	3120	213	124	179	179	230	141	205	189	363
Hydroxide Alkalinity as CaCO3	mg/L	1					<1			<1		<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	146	182	182	217	<1	183	199	623	197	139	199	196	275	154	225	215	424
Total Alkalinity	mg/L	1					168	185	188	198									
Sulphate	mg/L	1	104	128	128	152	58	136	108	536	90	54	89	86	183	25.6	83	81	162
Metals																			
Aluminum	mg/L	0.01					0.28	0.28	0.28	0.28		0.42	0.42	0.42	0.42	<0.01	0.24	0.28	0.38
Arsenic - Filtered	mg/L	0.001					<0.001	0.004	0.001	0.040		<0.001	0.003	0.001	0.010	<0.001	0.003	0.001	0.010
Boron - Filtered	mg/L	0.05																	
Cadmium - Filtered	mg/L	0.00005					<0.0001	0.00078	0.00100	0.00200		<0.0001	0.00111	0.00100	0.00600	<0.0001	0.00094	0.00100	0.00500
Chromium - Filtered	mg/L	0.002					<0.001	0.023	0.002	0.191		<0.001	0.017	0.001	0.280	<0.001	0.010	0.001	0.155
Copper - Filtered	mg/L	0.0005					<0.001	0.015471	0.002	0.217		<0.001	0.00355	0.001	0.012	<0.001	0.00445	0.003	0.015
Iron - Filtered	mg/L	0.05					0.3	0.57	0.51	0.89		<0.05	0.33	0.25	0.95	<0.05	0.89	0.89	2.08
Lead - Filtered	mg/L	0.00005					<0.001	0.013	0.001	0.145		<0.001	0.002	0.001	<0.01	<0.001	0.002	0.001	0.010
Manganese - Filtered	mg/L	0.001					0.021	0.086	0.051	0.186		0.015	0.077	0.051	0.221	0.206	0.370	0.367	0.574
Mercury - Filtered	mg/L	0.0001					<0.0001	0.0001	0.0001	0.0002		<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0002
Nickel - Filtered	mg/L	0.001					<0.001	0.017	0.002	0.182		<0.001	0.004	0.002	0.012	<0.001	0.002	0.002	0.010
Selenium - Filtered	mg/L	0.01					<0.01	0.01	0.01	0.01		<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005					<0.001	0.075	0.009	0.911		0.003	0.015	0.009	0.056	0.003	0.021	0.017	0.069
Nutrients																			
Ammonia as N	mg/L	0.01					<0.01	0.02	0.01	0.03		<0.01	0.03	0.04	0.06	1.5	5.63	4.99	11.50
Nitrate as N	mg/L	0.01	<0.01			<0.01	<0.01	0.22	0.07	2.02	0.12	<0.01	0.09	0.09	0.39	<0.01	0.08	0.04	0.82
Nitrite as N	mg/L	0.01					<0.01	0.08	0.09	0.13		<0.01	0.15	0.09	0.39	<0.01	0.06	0.03	0.16
Nitrite + Nitrate as N	mg/L	0.01					0.05	0.09	0.09	0.13									
Total Phosphorus as P	mg/L	0.01					<0.01	0.04	0.05	0.06									
Other																			
Silica	mg/L		23.5	23.5	23.5	23.5	9.5	24.76429	22.4	74.7	19.3	11.5	23.46	23.5	27.7	0.05	22.17	24.4	27.9
Fluoride	mg/L	0.02					0.18	0.19	0.20	0.20		0.15	0.39	0.20	1.20	0.2	0.59	0.23	2.00
Total Cyanide	mg/L	0.004					<0.004	0.008	0.004	0.016									
Calculated Parameters																			
Total Anions	meq/L	0.01	12.40	12.40	12.40	12.40	9.07	10.46	9.12	14.00		9.70	10.64	10.60	12.80	10.10	12.76	12.10	16.70
Total Cations	meq/L	0.01	13.00	13.00	13.00	13.00	8.85	10.64	9.27	15.20		9.32	10.92	10.70	13.80	10.00	12.79	11.10	18.40
Ionic Balance	%	0.01					0.00	0.37	0.01	1.08		0.02	0.98	0.35	3.70	0.00	0.02	0.02	0.05

Version D

Bore / Well / Spring / Soak			PB1				PB2	GM1				GM2				GM3A			
Parameter	Units	LOR	Min	Mean	Median	Max	28-Nov-00	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																			
pH Value (Lab)	pH unit	0.01																	
pH Value (field)	pH unit	0.01	7.08	7.42	7.22	8.22	8.03	6.81	7.69	7.78	8.38	6.76	6.98	7.01	7.18	7.63	7.88	7.71	8.48
Conductivity (field)	µS/cm	1	1020	1386	1540	1600	1420	295	4882	5315	9370	1460	5504	6010	8600	5720	7343	7540	8660
Lab Conductivity @ 25°C	µS/cm	1						18	38	39	70								
Total Dissolved Solids (TDS)	mg/L	1	614	827	827	1040	852	216	2886	3280	5920	822	1934	2360	2620	3200	3833	3915	4300
Suspended Solids (TSS)	mg/L	1	6	6	6	6		21	65	29	183								
Total Hardness as CaCO3	mg/L	1	362	362	362	362		62	82	85	103								
Turbidity	NTU	0.01																	
Major Ions			81	81	81	81													
Calcium	mg/L	1	39	327	327	614	852	14	16	16	20								
Magnesium	mg/L	1	31	31	31	31	34	7	9	8	13								
Sodium	mg/L	1	189	224	224	258	265	1080	1258	1265	1420								
Potassium	mg/L	1	3	9	9	14	24	6	6	6	6								
Chloride	mg/L	1	69	213	213	356	86	1290	1493	1500	1680								
Hydroxide Alkalinity as CaCO3	mg/L	1						<1			<1								
Carbonate as CaCO3	mg/L	1	<1			<1	<1	<1	6	1	20								
Bicarbonate as CaCO3	mg/L	1	3	86	86	168	3	503	592	595	675								
Total Alkalinity	mg/L	1																	
Sulphate	mg/L	1	173	196	196	219	207	<1	15	12	34								
Metals																			
Aluminum	mg/L	0.01						0.25	0.50	0.52	0.74								
Arsenic - Filtered	mg/L	0.001	20	20.000	20.000	20.000	17.500	0.002	0.003	0.003	0.004								
Boron - Filtered	mg/L	0.05																	
Cadmium - Filtered	mg/L	0.00005						<0.0001	0.00033	0.00035	0.00050								
Chromium - Filtered	mg/L	0.002						<0.001	0.002	0.001	0.004								
Copper - Filtered	mg/L	0.0005						0.002	0.006	0.003	0.016								
Iron - Filtered	mg/L	0.05						<0.12	0.51	0.53	0.88								
Lead - Filtered	mg/L	0.00005						<0.001	0.002	0.002	0.002								
Manganese - Filtered	mg/L	0.001						0.134	0.141	0.136	0.158								
Mercury - Filtered	mg/L	0.0001						<0.0001	0.0801	0.0001	0.3200								
Nickel - Filtered	mg/L	0.001						<0.001	0.002	0.002	0.003								
Selenium - Filtered	mg/L	0.01						<0.01			<0.01								
Zinc - Filtered	mg/L	0.005						0.014	0.025	0.023	0.041								
Nutrients																			
Ammonia as N	mg/L	0.01						0.9	1.66	1.90	1.95								
Nitrate as N	mg/L	0.01	<0.01			<0.01	<0.01	<0.01	0.32	0.01	1.24								
Nitrite as N	mg/L	0.01						<0.01	0.04	0.04	0.06								
Nitrite + Nitrate as N	mg/L	0.01																	
Total Phosphorus as P	mg/L	0.01																	
Other																			
Silica	mg/L		146	146	146	146	216												
Fluoride	mg/L	0.02						<0.004	0.68	0.85	1.01								
Total Cyanide	mg/L	0.004																	
Calculated Parameters																			
Total Anions	meq/L	0.01						49.20	54.70	54.20	61.20								
Total Cations	meq/L	0.01						0.40	41.98	52.15	63.20								
Ionic Balance	%	0.01						0.01	0.01	0.01	0.02								

Bore / Well / Spring / Soak			T1-A				T1-P				T2-A				T2-P			
Parameter	Units	LOR	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																		
pH Value (Lab)	pH unit	0.01																
pH Value (field)	pH unit	0.01	7.08	7.37	7.29	7.82	6.91	7.25	7.33	7.50	7.09	7.26	7.26	7.49	6.77	7.19	7.25	7.60
Conductivity (field)	µS/cm	1	1080	1334	1120	2230	2740	7302	8000	9390	1160	1333	1270	1597	320	771	648	1308
Lab Conductivity @ 25°C	µS/cm	1	2040	2040	2040	2040	9220	9220	9220	9220	1680	1680	1680	1680	1070	1070	1070	1070
Total Dissolved Solids (TDS)	mg/L	1	590	806	684	1390	1600	4630	5130	5990	780	1435	1250	2580	194	475	426	854
Suspended Solids (TSS)	mg/L	1																
Total Hardness as CaCO3	mg/L	1																
Turbidity	NTU	0.01																
Major Ions																		
Calcium	mg/L	1	68	68	68	68	117	117	117	117	78	78	78	78	75	75	75	75
Magnesium	mg/L	1	49	49	49	49	247	247	247	247	40	40	40	40	36	36	36	36
Sodium	mg/L	1	377	377	377	377	1690	1690	1690	1690	242	242	242	242	74	74	74	74
Potassium	mg/L	1	4	4	4	4	11	11	11	11	<2			<2	2	2	2	2
Chloride	mg/L	1	608	608	608	608	2650	2650	2650	2650	393	393	393	393	237	237	237	237
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	1	1	1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1	1	1	1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	216	216	216	216	<855	855	855	855	154	154	154	154	102	102	102	102
Total Alkalinity	mg/L	1																
Sulphate	mg/L	1	176	176	176	176	<495	495	495	495	141	141	141	141	56	56	56	56
Metals																		
Aluminum	mg/L	0.01									<0.01			<0.01	0.15	0.15	0.15	0.15
Arsenic - Filtered	mg/L	0.001	0.001	0.001	0.001	0.001	<0.001			<0.001	<0.001	0.001	0.001	0.001	0.010	0.010	0.010	0.010
Boron - Filtered	mg/L	0.05	0.05	0.05	0.05	0.05	0.13	0.13	0.13	0.13	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium - Filtered	mg/L	0.00005	0.0003	0.00030	0.00030	0.00030	0.0001	0.00010	0.00010	0.00010	0.0003	0.00030	0.00030	0.00030	<0.0001			<0.0001
Chromium - Filtered	mg/L	0.002	<0.001	0.001	0.001	0.001	<0.001			<0.001	0.001	0.001	0.001	0.001	<0.001			<0.001
Copper - Filtered	mg/L	0.0005	<0.001	0.001	0.001	0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001
Iron - Filtered	mg/L	0.05	<0.05	0.05	0.05	0.05	<0.05			<0.05	0.06	0.06	0.06	0.06	5.08	5.08	5.08	5.08
Lead - Filtered	mg/L	0.00005	<0.001	0.001	0.001	0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001
Manganese - Filtered	mg/L	0.001	0.008	0.008	0.008	0.008	0.105	0.105	0.105	0.105	0.103	0.103	0.103	0.103	0.372	0.372	0.372	0.372
Mercury - Filtered	mg/L	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	<0.001	0.001	0.001	0.001	<0.001			<0.001	<0.001			<0.001	0.002	0.002	0.002	0.002
Selenium - Filtered	mg/L	0.01	<0.01	0.01	0.01	0.01	<0.01			<0.01	<0.001			<0.001	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	<0.005	0.005	0.005	0.005	<0.005			<0.005	0.015	0.015	0.015	0.015	0.031	0.031	0.031	0.031
Nutrients																		
Ammonia as N	mg/L	0.01																
Nitrate as N	mg/L	0.01																
Nitrite as N	mg/L	0.01																
Nitrite + Nitrate as N	mg/L	0.01																
Total Phosphorus as P	mg/L	0.01																
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02																
Total Cyanide	mg/L	0.004																
Calculated Parameters																		
Total Anions	meq/L	0.01	25.10	25.10	25.10	25.10	102.00	102.00	102.00	102.00	17.10	17.10	17.10	17.10	9.88	9.88	9.88	9.88
Total Cations	meq/L	0.01	23.90	23.90	23.90	23.90	99.90	99.90	99.90	99.90	17.80	17.80	17.80	17.80	9.96	9.96	9.96	9.96
Ionic Balance	%	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00

Bore / Well / Spring / Soak			T3-A				T3-P				T4-A				T4-P			
Parameter	Units	LOR	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																		
pH Value (Lab)	pH unit	0.01																
pH Value (field)	pH unit	0.01	6.69	6.91	6.95	7.02	7.48	9.05	8.50	11.97	6.76	7.06	7.14	7.20	7.38	7.61	7.69	7.84
Conductivity (field)	µS/cm	1	2110	2318	2400	2420	1280	1379	1320	1647	2270	3340	3470	4130	1751	1836	1850	1920
Lab Conductivity @ 25°C	µS/cm	1	2150	2150	2150	2150	2050	2050	2050	2050	2270	2270	2270	2270	2000	2000	2000	2000
Total Dissolved Solids (TDS)	mg/L	1	1390	1914	1700	3200	694	776	754	905	1490	2174	2120	2740	954	1032	1050	1100
Suspended Solids (TSS)	mg/L	1																
Total Hardness as CaCO3	mg/L	1																
Turbidity	NTU	0.01																
Major Ions																		
Calcium	mg/L	1	62	62	62	62	4	4	4	4	80	80	80	80	37	37	37	37
Magnesium	mg/L	1	59	59	59	59	0	0	0	0	58	58	58	58	35	35	35	35
Sodium	mg/L	1	354	354	354	354	211	211	211	211	383	383	383	383	378	378	378	378
Potassium	mg/L	1	0	0	0	0	80	80	80	80	0	0	0	0	4	4	4	4
Chloride	mg/L	1	669	669	669	669	200	200	200	200	694	694	694	694	367	367	367	367
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	84	84	84	84	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	128	128	128	128	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	211	211	211	211	0	0	0	0	209	209	209	209	468	468	468	468
Total Alkalinity	mg/L	1																
Sulphate	mg/L	1	92	92	92	92	33	33	33	33	189	189	189	189	10	10	10	10
Metals																		
Aluminum	mg/L	0.01	0.02	0.02	0.02	0.02	0.06	0.06	0.06	0.06	<0.01			<0.01	0.01	0.01	0.01	0.01
Arsenic - Filtered	mg/L	0.001	<0.001			<0.001	<0.001			<0.001	0.002	0.002	0.002	0.002	<0.001			<0.001
Boron - Filtered	mg/L	0.05	<0.05	0.05	0.05	0.05	<0.05			<0.05	0.06	0.06	0.06	0.06	0.08	0.08	0.08	0.08
Cadmium - Filtered	mg/L	0.00005	0.00040	0.00040	0.00040	0.00040	<0.0001			<0.0001	0.00010	0.00010	0.00010	0.00010	0.00100	0.00100	0.00100	0.00100
Chromium - Filtered	mg/L	0.002	<0.001			<0.001	0.002	0.002	0.002	0.002	<0.001			<0.001	0.001	0.001	0.001	0.001
Copper - Filtered	mg/L	0.0005	<0.001			<0.001	0.001	0.001	0.001	0.001	<0.001			<0.001	<0.001			<0.001
Iron - Filtered	mg/L	0.05	13.30	13.30	13.30	13.30	<0.05			<0.05	0.58	0.58	0.58	0.58	0.38	0.38	0.38	0.38
Lead - Filtered	mg/L	0.00005	<0.001	0.001	0.001	0.001	0.015	0.015	0.015	0.015	<0.001			<0.001	<0.001			<0.001
Manganese - Filtered	mg/L	0.001	3.200	3.200	3.200	3.200	<0.001			<0.001	0.788	0.788	0.788	0.788	0.015	0.015	0.015	0.015
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	0.0004	0.0004	0.0004	0.0004	<0.0001			<0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	<0.001			<0.001	<0.001			<0.001	0.001	0.001	0.001	0.001	<0.001			<0.001
Selenium - Filtered	mg/L	0.01	<0.010	0.01	0.01	0.01	<0.010			<0.01	<0.010			<0.01	<0.010			<0.01
Zinc - Filtered	mg/L	0.005	<0.005			<0.005	0.010	0.010	0.010	0.010	0.008	0.008	0.008	0.008	<0.005			<0.005
Nutrients																		
Ammonia as N	mg/L	0.01																
Nitrate as N	mg/L	0.01																
Nitrite as N	mg/L	0.01																
Nitrite + Nitrate as N	mg/L	0.01																
Total Phosphorus as P	mg/L	0.01																
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02																
Total Cyanide	mg/L	0.004																
Calculated Parameters																		
Total Anions	meq/L	0.01	25.00	25.00	25.00	25.00	10.60	10.60	10.60	10.60	27.70	27.70	27.70	27.70	19.90	19.90	19.90	19.90
Total Cations	meq/L	0.01	23.30	23.30	23.30	23.30	11.40	11.40	11.40	11.40	25.40	25.40	25.40	25.40	21.30	21.30	21.30	21.30
Ionic Balance	%	0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03

Bore / Well / Spring / Soak			T5				T6				T7				T9	T10			
Parameter	Units	LOR	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	13-Nov-07	Min	Mean	Median	Max
Physical Parameters																			
pH Value (Lab)	pH unit	0.01													7.36				
pH Value (field)	pH unit	0.01	6.88	7.11	7.04	7.30	6.74	6.97	7.01	7.11	6.74	7.18	7.12	7.76	7.70	7.04	1482.35	2180.00	2260.00
Conductivity (field)	µS/cm	1	1260	1330	1310	1420	1400	1408	1400	1420	4960	5574	5380	6410	2460	2160	2160	2160	2160
Lab Conductivity @ 25°C	µS/cm	1	1330	1330	1330	1330	1280	1280	1280	1280	6420	6420	6420	6420	2490	1140	1637	1720	2050
Total Dissolved Solids (TDS)	mg/L	1	754	806	792	910	774	836	816	950	3170	3428	3240	4180	3800	12400	12400	12400	12400
Suspended Solids (TSS)	mg/L	1																	
Total Hardness as CaCO3	mg/L	1																	
Turbidity	NTU	0.01																	
Major Ions																			
Calcium	mg/L	1	66	66	66	66	57	57	57	57	150	150	150	150	59	82	82	82	82
Magnesium	mg/L	1	29	29	29	29	24	24	24	24	149	149	149	149	42	57	57	57	57
Sodium	mg/L	1	202	202	202	202	193	193	193	193	1180	1180	1180	1180	479	313	313	313	313
Potassium	mg/L	1	2	2	2	2	2	2	2	2	1	1	1	1	2	0	0	0	0
Chloride	mg/L	1	293	293	293	293	288	288	288	288	2010	2010	2010	2010	711	478	478	478	478
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	145	145	145	145	161	161	161	161	568	568	568	568	341	245	245	245	245
Total Alkalinity	mg/L	1																	
Sulphate	mg/L	1	158	158	158	158	122	122	122	122	416	416	416	416	126	183	183	183	183
Metals																			
Aluminum	mg/L	0.01													<0.01	0.23	0.23	0.23	0.23
Arsenic - Filtered	mg/L	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
Boron - Filtered	mg/L	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	<0.05			<0.05	0.07	0.08	0.08	0.08	0.08
Cadmium - Filtered	mg/L	0.00005	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001	0.00030	0.00030	0.00030	0.00030
Chromium - Filtered	mg/L	0.002	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001	<0.001			<0.001
Copper - Filtered	mg/L	0.0005	<0.001			<0.001	<0.001			<0.001	0.002	0.002	0.002	0.002	<0.001	0.002	0.002	0.002	0.002
Iron - Filtered	mg/L	0.05	<0.05			<0.05	<0.05			<0.05	0.08	0.08	0.08	0.08	<0.05	1.54	1.54	1.54	1.54
Lead - Filtered	mg/L	0.00005	<0.001			<0.001	<0.001			<0.001	<0.001	0.001	0.001	<0.001	<0.001	0.004	0.004	0.004	0.004
Manganese - Filtered	mg/L	0.001	0.040	0.040	0.040	0.040	0.024	0.024	0.024	0.024	1.870	1.870	1.870	1.870	0.554	0.818	0.818	0.818	0.818
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001	0.0001	0.0002	0.0002	0.0002	0.0002
Nickel - Filtered	mg/L	0.001	0.001	0.001	0.001	0.001	<0.001			<0.001	0.005	0.005	0.005	0.005	0.002	0.006	0.006	0.006	0.006
Selenium - Filtered	mg/L	0.01	<0.010			<0.01	<0.010			<0.01	<0.010			<0.01	<0.010	<0.010			<0.01
Zinc - Filtered	mg/L	0.005	<0.005			<0.005	<0.005			<0.005	<0.005			<0.005	0.006	0.060	0.060	0.060	0.060
Nutrients																			
Ammonia as N	mg/L	0.01																	
Nitrate as N	mg/L	0.01																	
Nitrite as N	mg/L	0.01																	
Nitrite + Nitrate as N	mg/L	0.01																	
Total Phosphorus as P	mg/L	0.01																	
Other																			
Silica	mg/L																		
Fluoride	mg/L	0.02																	
Total Cyanide	mg/L	0.004																	
Calculated Parameters																			
Total Anions	meq/L	0.01	14.40	14.40	14.40	14.40	13.90	13.90	13.90	13.90	76.60	76.60	76.60	76.60	29.50	22.20	22.20	22.20	22.20
Total Cations	meq/L	0.01	14.50	14.50	14.50	14.50	13.30	13.30	13.30	13.30	71.10	71.10	71.10	71.10	27.30	22.40	22.40	22.40	22.40
Ionic Balance	%	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.04	0.04	0.04	0.04	0.04	0.00	0.00	0.00	0.00

Bore / Well / Spring / Soak			RA8				RA10				RA14				RA16			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters																		
pH Value (Lab)	pH unit	0.01																
pH Value (field)	pH unit	0.01	6.87	7.13	7.22	7.35	6.91	7.15	7.10	7.39	7.02	693.53	533.54	1700.00	6.57	6.88	7.00	7.08
Conductivity (field)	µS/cm	1	6800	7426	7660	7700	1576	1881	1940	2010	7	1564	2030	2190	11100	12412	12300	13860
Lab Conductivity @ 25°C	µS/cm	1	8370	8370	8370	8370	1780	1780	1780	1780	2050	2050	2050	2050	13400	13400	13400	13400
Total Dissolved Solids (TDS)	mg/L	1	4280	4846	4860	5380	1130	1200	1170	1360	7	2142	1780	5000	7540	9610	9300	12600
Suspended Solids (TSS)	mg/L	1																
Total Hardness as CaCO3	mg/L	1																
Turbidity	NTU	0.01																
Major Ions																		
Calcium	mg/L	1	102	102	102	102	68	68	68	68	68	68	68	68	20	20	20	20
Magnesium	mg/L	1	180	180	180	180	40	40	40	40	58	58	58	58	430	430	430	430
Sodium	mg/L	1	1460	1460	1460	1460	266	266	266	266	329	329	329	329	2450	2450	2450	2450
Potassium	mg/L	1	8	8	8	8	0	0	0	0	0	0	0	0	62	62	62	62
Chloride	mg/L	1	2540	2540	2540	2540	373	373	373	373	632	632	632	632	4750	4750	4750	4750
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	574	574	574	574	191	191	191	191	182	182	182	182	126	126	126	126
Total Alkalinity	mg/L	1																
Sulphate	mg/L	1	358	358	358	358	160	160	160	160	163	163	163	163	358	358	358	358
Metals																		
Aluminum	mg/L	0.01	<0.01	0.01	0.01	<0.01	<0.01			<0.01	0.18	0.18	0.18	0.18				
Arsenic - Filtered	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	<0.001	0.001	0.001	<0.001
Boron - Filtered	mg/L	0.05	<0.05			<0.05	0.06	0.06	0.06	0.06	<0.05			<0.05	<0.05			<0.05
Cadmium - Filtered	mg/L	0.00005	0.00040	0.00040	0.00040	0.00040	<0.0001			<0.0001	<0.0001			<0.0001	0.00040	0.00040	0.00040	0.00040
Chromium - Filtered	mg/L	0.002	<0.001	0.001	0.001	<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001
Copper - Filtered	mg/L	0.0005	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	0.002	0.002	0.002	0.002
Iron - Filtered	mg/L	0.05	0.43	0.43	0.43	0.43	<0.05			<0.05	0.17	0.17	0.17	0.17	<0.05			<0.05
Lead - Filtered	mg/L	0.00005	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001
Manganese - Filtered	mg/L	0.001	0.040	0.040	0.040	0.040	0.182	0.182	0.182	0.182	0.044	0.044	0.044	0.044	0.146	0.146	0.146	0.146
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	<0.001			<0.001	0.002	0.002	0.002	0.002	<0.001			<0.001	0.005	0.005	0.005	0.005
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.010			<0.01	<0.01			<0.01	<0.010			<0.01
Zinc - Filtered	mg/L	0.005	<0.005			<0.005	<0.005			<0.005	0.010	0.010	0.010	0.01	0.034	0.034	0.034	0.034
Nutrients																		
Ammonia as N	mg/L	0.01																
Nitrate as N	mg/L	0.01																
Nitrite as N	mg/L	0.01																
Nitrite + Nitrate as N	mg/L	0.01																
Total Phosphorus as P	mg/L	0.01																
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02																
Total Cyanide	mg/L	0.004																
Calculated Parameters																		
Total Anions	meq/L	0.01	90.60	90.60	90.60	90.60	17.70	17.70	17.70	17.70	24.80	24.80	24.80	24.80	144.00	144.00	144.00	144.00
Total Cations	meq/L	0.01	83.60	83.60	83.60	83.60	18.30	18.30	18.30	18.30	22.50	22.50	22.50	22.50	145.00	145.00	145.00	145.00
Ionic Balance	%	0.01	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00

Bore / Well / Spring / Soak			RA17	RA18				RA27				RA30				WML20			
Parameter	Units	LOR	14-Nov-07	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																			
pH Value (Lab)	pH unit	0.01	7.13																
pH Value (field)	pH unit	0.01	7.38	6.93	7.19	7.27	7.31	6.76	6.97	6.99	7.14	6.63	6.91	7.02	7.13	8.05	8.17	8.18	8.26
Conductivity (field)	µS/cm	1	1364	1650	1810	1765	2060	1960	2155	2060	2540	1450	1565	1600	1633	4940	6615	5850	9820
Lab Conductivity @ 25°C	µS/cm	1	1190	2100	2100	2100	2100	2550	2550	2550	2550	1560	1560	1560	1560	3200	5045	5370	6240
Total Dissolved Solids (TDS)	mg/L	1	702	1130	1415	1455	1620	856	1644	1710	2300	784	1115	1060	1580	8	1092	8	3260
Suspended Solids (TSS)	mg/L	1														20	35	35	49
Total Hardness as CaCO3	mg/L	1																	
Turbidity	NTU	0.01																	
Major Ions																			
Calcium	mg/L	1	47	78	78	78	78	132	132	132	132	68	68	68	68	6	6	6	6
Magnesium	mg/L	1	32	54	54	54	54	90	90	90	90	39	39	39	39	2	2	2	2
Sodium	mg/L	1	150	328	328	328	328	368	368	368	368	245	245	245	245	1340	1340	1340	1340
Potassium	mg/L	1	4	2	2	2	2	2	2	2	2	1	1	1	1	4	4	4	4
Chloride	mg/L	1	198	618	618	618	618	867	867	867	867	440	440	440	440	1300	1300	1300	1300
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1			<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1	<1			<1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	211	220	220	220	220	243	243	243	243	133	133	133	133	1050	1050	1050	1050
Total Alkalinity	mg/L	1																	
Sulphate	mg/L	1	58	138	138	138	138	170	170	170	170	140	140	140	140	1	1	1	1
Metals																			
Aluminum	mg/L	0.01	0.03	<0.01			<0.01	0.02	0.02	0.02	0.02								
Arsenic - Filtered	mg/L	0.001	0.005	<0.001			<0.001	0.005	0.005	0.005	0.005	<0.001	0.001	0.001	<0.001	<0.001			<0.001
Boron - Filtered	mg/L	0.05	0.05	<0.05			<0.05	<0.05			<0.05	<0.05			<0.05	0.18	0.18	0.18	0.18
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00080	0.00080	0.00080	0.00080	0.00030	0.00030	0.00030	0.00030	<0.0001			<0.0001	0.00010	0.00010	0.00010	0.00010
Chromium - Filtered	mg/L	0.002	<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.005			<0.005
Copper - Filtered	mg/L	0.0005	<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001
Iron - Filtered	mg/L	0.05	1.58	<0.05			<0.05	<0.05			<0.05	<0.05			<0.05	0.08	0.08	0.08	0.08
Lead - Filtered	mg/L	0.00005	<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001
Manganese - Filtered	mg/L	0.001	1.400	0.030	0.030	0.030	0.030	2.880	2.880	2.880	2.880	0.794	0.794	0.794	0.794	0.038	0.038	0.038	0.038
Mercury - Filtered	mg/L	0.0001	<0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	0.004	<0.001			<0.001	0.013	0.013	0.013	0.013	0.001	0.001	0.001	0.001	<0.001			<0.001
Selenium - Filtered	mg/L	0.01	<0.01	<0.01			<0.01	<0.010			<0.01	<0.010			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.015	0.011	0.011	0.011	0.011	0.010	0.010	0.010	0.010	0.005	0.005	0.005	0.005	<0.005			<0.005
Nutrients																			
Ammonia as N	mg/L	0.01																	
Nitrate as N	mg/L	0.01																	
Nitrite as N	mg/L	0.01																	
Nitrite + Nitrate as N	mg/L	0.01																	
Total Phosphorus as P	mg/L	0.01																	
Other																			
Silica	mg/L																		
Fluoride	mg/L	0.02																	
Total Cyanide	mg/L	0.004																	
Calculated Parameters																			
Total Anions	meq/L	0.01	11.00	24.70	24.70	24.70	24.70	32.90	32.90	32.90	32.90	18.00	18.00	18.00	18.00	57.60	57.60	57.60	57.60
Total Cations	meq/L	0.01	11.60	22.70	22.70	22.70	22.70	30.10	30.10	30.10	30.10	17.30	17.30	17.30	17.30	58.80	58.80	58.80	58.80
Ionic Balance	%	0.01	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01

Bore / Well / Spring / Soak			WML21				WML108B				WML109B				WML110B			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters																		
pH Value (Lab)	pH unit	0.01					6.05	6.51	6.43	7.17	6.90	6.90	6.90	6.90	7.04	7.19	7.19	7.33
pH Value (field)	pH unit	0.01	7.52	7.90	7.90	8.46	6.35	6.65	6.60	7.18	6.13	6.62	6.75	6.84	6.13	6.90	7.03	7.41
Conductivity (field)	μS/cm	1	6460	7721	7690	8700	12300	14448	14440	16400	11160	11765	11800	12300	9120	9333	9300	9610
Lab Conductivity @ 25°C	μS/cm	1	8140	8335	8335	8530	14700	15480	15300	16200	11500	11500	11500	11500	9260	9425	9425	9590
Total Dissolved Solids (TDS)	mg/L	1	3290	4412	4530	4890	8920	11096	11200	13100	6490	7700	7460	9390	5350	5823	5705	6530
Suspended Solids (TSS)	mg/L	1	5	47	23	138	577	5781	1850	26700	134	240	240	345	80	176	176	272
Total Hardness as CaCO3	mg/L	1	26	38	40	45	4460	4767	4740	5010	1950	2195	2195	2440	1430	1450	1450	1470
Turbidity	NTU	0.01					1800.00	4345.00	4345.00	6890.00	240.00	240.00	240.00	240.00	179.00	334.00	334.00	489.00
Major Ions																		
Calcium	mg/L	1	9	10	10	10	627	683	664	758	195	214	214	232	126	145	140	174
Magnesium	mg/L	1	4	4	4	4	604	727	749	779	330	391	391	452	253	274	273	298
Sodium	mg/L	1	1710	1823	1790	1970	1680	1857	1885	1930	1700	1960	1960	2220	1360	1518	1515	1680
Potassium	mg/L	1	5	5	5	6	30	34	34	37	16	17	17	17	11	13	14	15
Chloride	mg/L	1	1930	2140	2240	2250	4770	5398	5400	6140	3190	3525	3525	3860	2630	3088	3115	3490
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1	26	1	77	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	882	950	976	993	492	540	536	589	762	786	786	809	96	349	330	640
Total Alkalinity	mg/L	1					516	549	541	589	809	809	809	809	96	105	105	114
Sulphate	mg/L	1	0.58	1	1	1	632	852	864	970	719	980	980	1240	71.9	242	225	446
Metals																		
Aluminum	mg/L	0.01	0.26	0.26	0.26	0.26	1.82	4.56	5.74	6.12								
Arsenic - Filtered	mg/L	0.001	<0.001	0.001	0.001	0.001	<0.001	0.038	0.036	0.070	0.002	0.003	0.003	0.003	<0.001	0.003	0.003	0.005
Boron - Filtered	mg/L	0.05	0.14	0.14	0.14	0.14	0.06	0.06	0.06	0.06	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.11
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00010	0.00010	0.00010	0.0003	0.00113	0.00115	0.00220	0.0002	0.00075	0.00075	0.00130	0.0002	0.00028	0.00025	0.00040
Chromium - Filtered	mg/L	0.002	<0.001	0.002	0.001	<0.005	0.004	0.010	0.011	0.015	<0.005			<0.005	<0.001	0.003	0.002	0.005
Copper - Filtered	mg/L	0.0005	<0.001	0.001667	0.002	0.002	0.003	0.046	0.0285	0.159	0.002	0.006	0.006	0.01	0.001	0.01	0.007	0.025
Iron - Filtered	mg/L	0.05	0.1	0.31	0.37	0.45	<0.05	283.59	71.75	1420.00	<1.72	7.76	7.76	13.80	2.56	17.73	9.83	48.70
Lead - Filtered	mg/L	0.00005	<0.001	0.002	0.002	0.003	<0.001	0.077	0.044	0.265	<0.001	0.017	0.017	0.033	0.003	0.009	0.009	0.016
Manganese - Filtered	mg/L	0.001	0.006	0.011	0.009	0.018	0.071	2.615	2.865	4.100	1.58	1.740	1.740	1.900	0.009	1.272	1.479	2.120
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	<0.0001	0.0002	0.0001	0.0005	<0.0001	0.0001	0.0001	0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	<0.001	0.001	0.001	0.002	0.012	0.713	0.038	4.110	0.008	0.010	0.010	0.011	0.001	0.437	0.014	1.720
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01	0.02	0.02	0.05	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	<0.005	0.014	0.017	0.020	0.058	0.204	0.118	0.637	0.026	0.099	0.099	0.172	0.022	0.063	0.060	0.109
Nutrients			<															
Ammonia as N	mg/L	0.01	0.65	1.03	1.03	1.40	0.02	0.37	0.10	1.25	0.92	0.92	0.92	0.92	2.2	2.32	2.32	2.44
Nitrate as N	mg/L	0.01	<0.01			<0.01	<0.01	2.99	2.60	6.76	0.22	0.22	0.22	0.22	<0.01			<0.01
Nitrite as N	mg/L	0.01	<0.01			<0.01	<0.01	3.15	3.00	6.59	0.96	0.96	0.96	0.96	0.18	0.29	0.29	0.39
Nitrite + Nitrate as N	mg/L	0.01					4.85	5.596667	5.18	6.76	1.17	1.17	1.17	1.17	0.18	0.285	0.285	0.39
Total Phosphorus as P	mg/L	0.01					0.07	1.746667	0.64	4.53	0.37	0.37	0.37	0.37	0.18	0.22	0.22	0.26
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02	0.74	0.82	0.82	0.90	0.19	0.37	0.40	0.60	0.2	0.20	0.20	0.20				
Total Cyanide	mg/L	0.004					<0.004	0.004	0.004	0.004	<0.004			<0.004	<0.004	0.004	0.004	0.004
Calculated Parameters																		
Total Anions	meq/L	0.01	75.40	81.00	80.90	86.70	166.00	178.50	182.50	189.00	120.00	133.00	133.00	146.00	92.80	99.10	98.80	106.00
Total Cations	meq/L	0.01	75.20	79.17	78.90	83.40	155.00	174.00	175.50	201.00	112.00	131.50	131.50	151.00	87.50	96.00	97.25	102.00
Ionic Balance	%	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.04	0.02	0.03	0.03	0.04	0.02	0.03	0.04	0.04

Bore / Well / Spring / Soak			WML110C				WML111B				WML112B				WML112C			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters																		
pH Value (Lab)	pH unit	0.01	7.13	7.13	7.13	7.13	7.28	7.28	7.28	7.28	7.88	8.27	8.27	8.66	8.26	8.26	8.26	8.26
pH Value (field)	pH unit	0.01	6.56	6.56	6.56	6.56	7.28	7.50	7.43	7.90	6.97	7.75	7.53	8.89	6.96	7.66	7.60	8.61
Conductivity (field)	µS/cm	1	8620	8620	8620	8620	735	1761	1920	2640	1420	1885	1950	2050	1350	1623	1670	1850
Lab Conductivity @ 25°C	µS/cm	1	9340	9340	9340	9340	2580	2580	2580	2580	1720	6010	6010	10300	1360	1360	1360	1360
Total Dissolved Solids (TDS)	mg/L	1	5900	5980	5980	6060	540	1062	1060	1660	548	1025	1100	1230	720	845	822	1060
Suspended Solids (TSS)	mg/L	1	2210	2210	2210	2210	16	142	36	478	74	255	223	492	49	68	69	99
Total Hardness as CaCO3	mg/L	1	1340	1340	1340	1340	123	140	142	152	233	275	277	309	229	278	285	318
Turbidity	NTU	0.01	1140.00	1140.00	1140.00	1140.00	235.00	235.00	235.00	235.00	32.20	54.50	54.50	76.80	133.00	154.50	154.50	176.00
Major Ions																		
Calcium	mg/L	1	124	125	125	126	28	44	42	68	36	49	51	61	17	32	30	48
Magnesium	mg/L	1	250	251	251	252	8	21	12	61	8	27	31	39	22	43	46	51
Sodium	mg/L	1	1570	1610	1610	1650	70	327	378	494	126	308	338	355	215	229	232	242
Potassium	mg/L	1	10	12	12	13	6	19	10	47	10	16	14	26	6	11	13	13
Chloride	mg/L	1	2680	2700	2700	2720	70	473	479	824	167	357	383	446	157	186	184	230
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	763	786	786	809	76	159	115	318	83	389	511	572	264	615	669	803
Total Alkalinity	mg/L	1	809	809	809	809	76	127	127	178	426	505	518	572	537	666	658	803
Sulphate	mg/L	1	356	370	370	383	81	114	122	138	<1	44	17	143	0.53	8	1	42
Metals																		
Aluminum	mg/L	0.01					<0.01	0.13	0.13	0.25	0.13	0.45	0.45	0.76	<0.01	0.02	0.02	0.03
Arsenic - Filtered	mg/L	0.001	0.002	0.007	0.007	0.011	0.002	0.003	0.003	0.004	<0.001	0.004	0.003	0.010	<0.001	0.001	0.001	0.001
Boron - Filtered	mg/L	0.05	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08	<0.05			<0.05	0.06	0.06	0.06	0.06
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00010	0.00010	0.00010	<0.0001	0.00074	0.00020	0.00270	<0.0001	0.00511	0.00030	0.03140	<0.0001	0.00030	0.00015	0.00110
Chromium - Filtered	mg/L	0.002	<0.005	0.007	0.007	0.009	<0.001	0.003	0.003	0.008	<0.001	0.003	0.003	0.005	<0.001	0.001	0.001	0.001
Copper - Filtered	mg/L	0.0005	0.001	0.009	0.009	0.017	<0.001	0.005	0.002	0.017	<0.001	0.024143	0.01	0.088	<0.001	0.0015	0.0015	0.002
Iron - Filtered	mg/L	0.05	2.34	9.57	9.57	16.80	0.58	1.84	1.07	5.50	<0.05	2.12	1.36	6.61	1.75	14.41	14.85	26.40
Lead - Filtered	mg/L	0.00005	<0.001	0.017	0.017	0.032	<0.001	0.004	0.002	0.014	<0.001	0.005	0.001	0.022	<0.001			<0.001
Manganese - Filtered	mg/L	0.001	0.364	0.482	0.482	0.599	0.024	0.064	0.054	0.105	<0.001	0.119	0.178	0.212	<0.001	0.049	0.037	0.125
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001			<0.0001	<0.0001	0.0001	0.0001	0.0001
Nickel - Filtered	mg/L	0.001	0.001	0.009	0.009	0.016	<0.001	0.032	0.003	0.150	<0.001	0.020	0.004	0.122	<0.001	0.008	0.002	0.042
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01	0.01	0.01	0.01	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.008	0.075	0.075	0.142	0.008	0.040	0.030	0.103	<0.005	0.223	0.059	1.090	<0.005	0.007	0.006	0.010
Nutrients																		
Ammonia as N	mg/L	0.01	0.29	0.29	0.29	0.29	0.04	0.12	0.10	0.23	5.56	13.44	15.00	18.90	32.3	40.06	39.70	50.30
Nitrate as N	mg/L	0.01	<0.01			<0.01	<0.01	0.29	0.30	0.54	<0.01	0.02	0.01	0.06	<0.01			<0.01
Nitrite as N	mg/L	0.01	0.04	0.04	0.04	0.04	<0.01	0.98	0.57	2.78	<0.01	0.08	0.01	0.21	<0.01	0.02	0.01	0.05
Nitrite + Nitrate as N	mg/L	0.01	0.04	0.04	0.04	0.04	0.51	1.69	1.69	2.87	0.01	0.093333	0.06	0.21	<0.01	0.01	0.01	0.01
Total Phosphorus as P	mg/L	0.01	0.91	0.91	0.91	0.91	0.04	0.21	0.21	0.38	0.68	2.47	3.26	3.47	0.04	0.29	0.4	0.43
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02	0.3	0.30	0.30	0.30	0.14	0.83	0.23	2.70	0.17	0.37	0.20	1.10	0.04	0.45	0.10	1.90
Total Cyanide	mg/L	0.004	<0.004	0.004	0.004	0.004	<0.004	0.005	0.005	0.006	<0.004	0.008	0.009	0.011	<0.004	0.004	0.004	0.004
Calculated Parameters																		
Total Anions	meq/L	0.01	98.30	98.60	98.60	98.90	7.37	18.89	18.30	32.50	8.50	18.67	20.70	23.20	15.40	17.64	17.50	20.50
Total Cations	meq/L	0.01	95.50	98.25	98.25	101.00	7.08	18.60	19.80	30.00	8.59	18.76	20.60	22.50	16.00	17.32	16.30	20.10
Ionic Balance	%	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.01	0.03	0.02	0.05	0.01	0.03	0.03	0.05

Bore / Well / Spring / Soak			WML113B				WML113C				WML114B	WML115B				WML115C
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**20-Dec-07**	**Min**	**Mean**	**Median**	**Max**	**07-Nov-07**
Physical Parameters																
pH Value (Lab)	pH unit	0.01	7.36	7.36	7.36	7.36	7.06	7.06	7.06	7.06	7.06	7.57	7.68	7.68	7.78	7.28
pH Value (field)	pH unit	0.01	7.09	7.51	7.54	7.72	6.58	7.06	7.08	7.43	7.34	10.04	10.04	10.04	10.04	7.39
Conductivity (field)	µS/cm	1	731	907	905	1100	906	1149	1155	1368	6410	3003	3003	3003	3003	3860
Lab Conductivity @ 25°C	µS/cm	1	875	875	875	875	1450	1450	1450	1450	6730	3790	3880	3880	3970	4100
Total Dissolved Solids (TDS)	mg/L	1	490	566	563	660	702	999	977	1320	3580	2090	2195	2195	2300	2610
Suspended Solids (TSS)	mg/L	1	46	134	74	404	3050	9190	7730	18200						
Total Hardness as CaCO3	mg/L	1	153	169	168	184	231	254	252	288						
Turbidity	NTU	0.01	16.20	24.50	24.50	32.80	3420.00	5440.00	5440.00	7460.00						
Major Ions																
Calcium	mg/L	1	31	35	35	43	54	66	61	93	95	9	26	26	43	86
Magnesium	mg/L	1	18	21	21	26	23	27	25	37	166	7	21	21	34	47
Sodium	mg/L	1	89	129	135	142	138	147	149	154	1220	735	755	755	775	783
Potassium	mg/L	1	2	3	4	4	2	2	2	2	8	4	6	6	7	1
Chloride	mg/L	1	120	131	132	142	188	233	224	319	2060	1000	1075	1075	1150	1210
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1	<1			<1	<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1	<1			<1	<1
Bicarbonate as CaCO3	mg/L	1	213	263	275	282	07	168	186	196	646	285	332	332	378	237
Total Alkalinity	mg/L	1	257	269	274	276	141	176	191	196						
Sulphate	mg/L	1	1.02	8	5	24	88	106	100	146	259	74	80	80	86	325
Metals																
Aluminum	mg/L	0.01	0.01	0.32	0.32	0.63	<0.01	18.26	18.26	36.50	<0.01	<0.01	0.01	0.01	0.01	
Arsenic - Filtered	mg/L	0.001	<0.001	0.002	0.001	0.004	0.002	0.026	0.022	0.066	0.000	<0.001	0.001	0.001	0.001	0.002
Boron - Filtered	mg/L	0.05	<0.05	0.05	0.05	0.05					0.12	0.07	0.10	0.10	0.13	<0.05
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00042	0.00025	0.00140	0.0002	0.00175	0.00045	0.00810	0.00230	<0.0001			<0.0001	<0.0001
Chromium - Filtered	mg/L	0.002	<0.001	0.003	0.002	0.009	<0.001	0.064	0.048	0.197	0.002	<0.001			<0.001	<0.001
Copper - Filtered	mg/L	0.0005	<0.001	0.0035	0.003	0.008	<0.001	0.0715	0.0565	0.215	<0.001	<0.001			<0.001	0.001
Iron - Filtered	mg/L	0.05	1.29	3.56	2.19	11.60	<0.05	119.26	94.55	350.00	0.99	<0.05	0.31	0.31	0.57	<0.05
Lead - Filtered	mg/L	0.00005	<0.001	0.004	0.002	0.010	<0.001	0.099	0.067	0.308	<0.001	<0.001			<0.001	<0.001
Manganese - Filtered	mg/L	0.001	<0.001	0.330	0.358	0.522	0.015	2.622	1.885	8.570	0.194	0.003	0.074	0.074	0.144	0.004
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	<0.0001	0.0003	0.0002	0.0010	<0.0001	<0.0001			<0.0001	<0.0001
Nickel - Filtered	mg/L	0.001	<0.001	0.064	0.002	0.375	<0.001	0.491	0.092	2.440	0.001	<0.001			<0.001	<0.001
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01			<0.01	<0.01	<0.01			<0.01	<0.01
Zinc - Filtered	mg/L	0.005	<0.005	0.035	0.038	0.064	<0.005	0.308	0.230	0.966	0.009	<0.005	0.006	0.006	0.006	<0.005
Nutrients																
Ammonia as N	mg/L	0.01	0.76	1.39	1.55	1.79	0.02	0.06	0.05	0.14						
Nitrate as N	mg/L	0.01	<0.01	0.02	0.01	0.03	<0.01	0.27	0.01	1.30						
Nitrite as N	mg/L	0.01	0.01	0.08	0.04	0.23	<0.01	0.51	0.53	0.96						
Nitrite + Nitrate as N	mg/L	0.01	<0.01	0.033333	0.04	0.05	0.62	0.96	0.96	1.3						
Total Phosphorus as P	mg/L	0.01	0.46	0.536667	0.57	0.58	0.29	2.956667	3.26	5.32						
Other																
Silica	mg/L															
Fluoride	mg/L	0.02	0.27	0.59	0.30	1.80	0.2	0.30	0.25	0.60						
Total Cyanide	mg/L	0.004	<0.004	0.006	0.004	0.009	<0.004	0.005	0.004	0.007						
Calculated Parameters																
Total Anions	meq/L	0.01	8.15	9.16	9.34	9.53	10.90	12.08	11.75	14.20	76.40	35.40	38.60	38.60	41.80	45.60
Total Cations	meq/L	0.01	8.19	9.11	9.20	9.61	10.90	11.92	11.35	14.30	72.00	33.20	36.00	36.00	38.80	42.30
Ionic Balance	%	0.01	0.00	0.01	0.00	0.03	0.00	0.02	0.01	0.05	0.03	0.03	0.03	0.03	0.04	0.04

Version D

Bore / Well / Spring / Soak			WML119				WML120A				WML120B				WML129			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters																		
pH Value (Lab)	pH unit	0.01	7.26	7.66	7.60	8.19	6.77	6.98	6.99	7.16	6.87	7.06	7.07	7.24	7.06	7.21	7.25	7.27
pH Value (field)	pH unit	0.01	5.29	6.65	6.73	7.78	6.89	7.20	7.20	7.69	6.74	7.01	7.07	7.20	6.88	7.16	7.13	7.54
Conductivity (field)	µS/cm	1	86	615	126	1890	476	808	880	1040	438	795	779	1220	399	541	471	789
Lab Conductivity @ 25°C	µS/cm	1	2320	4205	4015	6470	742	2330	1114	6350	1020	1363	1250	1930	396	517	547	577
Total Dissolved Solids (TDS)	mg/L	1	62	1705	837	5160	306	1104	458	5620	348	638	534	1480	192	786	304	4080
Suspended Solids (TSS)	mg/L	1	48	163	90	498	5	23	25	37	186	1135	456	3260	956	1651	1340	3470
Total Hardness as CaCO3	mg/L	1	12	75	23	332	107	205	211	343	94	162	154	258	108	119	111	156
Turbidity	NTU	0.01	39.00	145.00	145.00	251.00	1.20	3.30	3.30	5.40	81.70	123.35	123.35	165.00	612.00	806.00	806.00	1000.00
Major Ions																		
Calcium	mg/L	1	3	17	11	39	18	50	33	203	18	41	33	123	18	25	23	33
Magnesium	mg/L	1	1	32	4	122	14	63	28	354	12	30	25	83	9	13	13	18
Sodium	mg/L	1	5	419	12	1570	60	236	123	1260	74	127	127	221	28	45	45	54
Potassium	mg/L	1	4	6	6	9	<1	3	2	13	0	1	1	2	2	3	3	3
Chloride	mg/L	1	5	492	17	1830	82	393	144	2300	75	202	160	610	44	65	60	102
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	29	369	54	1080	109	253	200	936	137	175	177	232	78	119	114	161
Total Alkalinity	mg/L	1	29	33	30	41	208	224	224	240	200	203	203	206	110	118	118	126
Sulphate	mg/L	1	0.74	40	10	167	19	78	28	462	16	44	39	111	3.94	17	21	26
Metals																		
Aluminum	mg/L	0.01	0.51	0.51	0.51	0.51	<0.01	0.16	0.16	0.30	<0.01	10.41	10.41	20.80	25.6	25.60	25.60	25.60
Arsenic - Filtered	mg/L	0.001	<0.001	0.001	0.001	0.002	<0.001	0.003	0.002	0.005	<0.001	0.002	0.002	0.005	0.001	0.003	0.004	0.005
Boron - Filtered	mg/L	0.05	0.11	0.11	0.11	0.11	<0.05			<0.05	<0.05			<0.05	<0.05	0.05	0.05	0.05
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00011	0.00010	0.00020	<0.0001	3.38382	0.00025	20.30000	<0.0001	0.00023	0.00020	0.00050	<0.0001	0.00031	0.00020	0.00080
Chromium - Filtered	mg/L	0.002	<0.001	0.002	0.002	0.005	<0.001	0.002	0.002	0.005	0.002	0.011	0.007	0.025	<0.001	0.010	0.010	0.022
Copper - Filtered	mg/L	0.0005	<0.001	0.004857	0.004	0.01	<0.001	0.002167	0.0015	0.005	<0.001	0.012333	0.007	0.034	<0.001	0.016	0.013	0.034
Iron - Filtered	mg/L	0.05	<0.05	1.34	1.60	2.63	0.47	1.16	0.76	3.46	<0.05	13.13	7.68	34.40	0.58	10.36	8.95	25.30
Lead - Filtered	mg/L	0.00005	<0.001	0.009	0.004	0.039	<0.001	0.002	0.001	0.008	<0.001	0.013	0.008	0.033	<0.001	0.013	0.008	0.026
Manganese - Filtered	mg/L	0.001	0.009	0.061	0.060	0.144	<0.001	0.048	0.044	0.081	0.004	0.403	0.159	1.410	0.012	0.701	0.799	1.260
Mercury - Filtered	mg/L	0.0001	<0.0001			<0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0003	0.0001	0.0010	<0.0001	0.0003	0.0001	<0.001
Nickel - Filtered	mg/L	0.001	<0.001	0.014	0.002	0.086	<0.001	0.010	0.002	0.049	<0.001	0.043	0.016	0.175	0.001	0.108	0.020	0.683
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01			<0.01	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.005	0.078	0.043	0.312	0.006	0.029	0.016	0.077	<0.005	0.047	0.033	0.109	<0.005	0.047	0.032	0.102
Nutrients																		
Ammonia as N	mg/L	0.01	0.09	0.37	0.25	0.92	0.02	0.09	0.09	0.17	0.05	0.14	0.13	0.27	0.06	0.15	0.16	0.24
Nitrate as N	mg/L	0.01	<0.01			<0.01	<0.01	0.16	0.01	0.53	<0.01	0.05	0.01	0.18	<0.01			<0.01
Nitrite as N	mg/L	0.01	<0.01	0.04	0.04	0.07	<0.01	0.04	0.02	0.14	<0.01	0.12	0.14	0.27	<0.01	0.03	0.01	0.08
Nitrite + Nitrate as N	mg/L	0.01	<0.01	0.023333	0.02	0.04	0.02	0.085	0.085	0.15	0.12	0.14	0.14	0.16	<0.01	0.035	0.035	0.06
Total Phosphorus as P	mg/L	0.01	0.22	0.246667	0.22	0.3	0.03	0.045	0.045	0.06	0.14	0.2	0.2	0.26	0.41	0.63	0.63	0.85
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02	<0.1	0.25	0.15	0.80	0.21	0.48	0.30	1.40	0.21	0.40	0.30	0.80	0.14	0.23	0.20	0.50
Total Cyanide	mg/L	0.004	<0.004			<0.004	<0.004	0.004	0.004	0.004	<0.004	0.004	0.004	0.004	<0.004	0.004	0.004	0.004
Calculated Parameters																		
Total Anions	meq/L	0.01	0.76	21.99	1.55	76.50	5.15	17.81	9.77	93.30	5.15	10.05	9.08	22.20	3.05	4.52	4.55	5.74
Total Cations	meq/L	0.01	0.72	21.87	1.56	80.70	4.96	17.99	9.40	94.40	5.20	10.11	9.32	22.60	2.96	4.41	4.35	5.55
Ionic Balance	%	0.01	0.02	0.03	0.03	0.03	0.01	0.02	0.02	0.05	0.01	0.01	0.01	0.02	0.00	0.02	0.01	0.04

Bore / Well / Spring / Soak			WML148	WML155	WML157	WML158	WML181	WML182				WML183			
Parameter	Units	LOR	29-Nov-07	29-Nov-07	29-Nov-07	29-Nov-07	24-Jun-07	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters															
pH Value (Lab)	pH unit	0.01	6.94	6.74	7.23	7.14	7.61	6.85	6.97	6.97	7.08	6.97	7.00	7.00	7.02
pH Value (field)	pH unit	0.01	7.24	6.92	7.77	7.63	6.16	6.80	6.86	6.86	6.91	6.81	6.93	6.93	7.04
Conductivity (field)	µS/cm	1	2170	978	842	745	3570	3840	6330	6330	8820	8140	8245	8245	8350
Lab Conductivity @ 25°C	µS/cm	1	2610	915	803	705	4920	4220	6450	6450	8680	8180	8375	8375	8570
Total Dissolved Solids (TDS)	mg/L	1	2180	5600	2250	2300	2700	2280	4110	4110	5940	5000	5155	5155	5310
Suspended Solids (TSS)	mg/L	1													
Total Hardness as CaCO3	mg/L	1													
Turbidity	NTU	0.01													
Major Ions															
Calcium	mg/L	1	103	61	53	37	15	50	84	84	118	83	102	102	120
Magnesium	mg/L	1	54	23	22	16	38	96	209	209	321	263	305	305	347
Sodium	mg/L	1	363	65	59	75	1010	727	1114	1114	1500	1240	1320	1320	1400
Potassium	mg/L	1	0	1	0	0	6	7	11	11	14	13	14	14	14
Chloride	mg/L	1	696	165	114	91	1110	929	1600	1600	2270	2150	2220	2220	2290
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	125	140	190	183	863	757	899	899	1040	916	1013	1013	1110
Total Alkalinity	mg/L	1													
Sulphate	mg/L	1	91	20	10	5	76	102	366	366	629	244	441	441	637
Metals															
Aluminum	mg/L	0.01	<0.01	<0.01	<0.01	<0.01									
Arsenic - Filtered	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	<0.001			<0.001
Boron - Filtered	mg/L	0.05	<0.05	<0.05	0.06	<0.05	0.13	<0.1	0.13	0.13	0.16	0.13	0.15	0.15	0.16
Cadmium - Filtered	mg/L	0.00005	0.00050	0.04550	0.00020	0.00050	0.00010	<0.0001			<0.0001	<0.0001			<0.0001
Chromium - Filtered	mg/L	0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005			<0.005	<0.005			<0.005
Copper - Filtered	mg/L	0.0005	0.002	<0.001	0.001	<0.001	0.002	<0.001	0.002	0.002	0.003	0.002	0.002	0.002	0.002
Iron - Filtered	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.27	0.27	0.49	0.08	0.25	0.25	0.42
Lead - Filtered	mg/L	0.00005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001			<0.001
Manganese - Filtered	mg/L	0.001	0.001	0.008	<0.001	0.986	0.010	0.061	0.073	0.073	0.084	0.027	0.042	0.042	0.057
Mercury - Filtered	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001			<0.001	<0.001	0.002	0.002	0.002
Selenium - Filtered	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.013	0.006	0.009	<0.005	0.007	<0.005			<0.005	<0.005	0.006	0.006	0.007
Nutrients															
Ammonia as N	mg/L	0.01													
Nitrate as N	mg/L	0.01													
Nitrite as N	mg/L	0.01													
Nitrite + Nitrate as N	mg/L	0.01													
Total Phosphorus as P	mg/L	0.01													
Other															
Silica	mg/L														
Fluoride	mg/L	0.02													
Total Cyanide	mg/L	0.004													
Calculated Parameters															
Total Anions	meq/L	0.01	24.00	7.85	7.22	6.34	50.00	43.50	70.70	70.70	97.90	91.80	92.00	92.00	92.20
Total Cations	meq/L	0.01	25.30	7.80	6.99	6.44	48.00	42.20	70.10	70.10	98.00	87.20	87.95	87.95	88.70
Ionic Balance	%	0.01	0.03	0.00	0.02	0.01	0.02	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.03

Bore / Well / Spring / Soak			WML184	WML185	WML186	WML239				WML240				WML241			
Parameter	Units	LOR	28-Nov-07	28-Nov-07	28-Nov-07	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max
Physical Parameters																	
pH Value (Lab)	pH unit	0.01	6.97	6.74	6.44												
pH Value (field)	pH unit	0.01	6.96	6.68	6.76	7.01	7.21	7.14	7.53	6.53	6.72	6.61	6.96	6.96	7.14	7.12	7.34
Conductivity (field)	µS/cm	1	3180	1852	463	707	876	903	984	1150	1532	1610	1700	431	560	549	687
Lab Conductivity @ 25°C	µS/cm	1	4560	4430	387												
Total Dissolved Solids (TDS)	mg/L	1	2960	2870	290	468	572	558	640	938	1081	1120	1240	304	508	348	1190
Suspended Solids (TSS)	mg/L	1				18	97	48	327	4	21	26	37	22	240	24	1090
Total Hardness as CaCO3	mg/L	1				216	232	230	245	383	445	450	476	50	64	68	80
Turbidity	NTU	0.01				16.60	72.30	72.30	128.00	13.40	340.20	340.20	667.00				
Major Ions																	
Calcium	mg/L	1	44	82	23	48	52	52	55	84	97	98	104	10	13	14	16
Magnesium	mg/L	1	70	120	8	23	25	24	26	42	49	50	53	6	7	8	9
Sodium	mg/L	1	532	622	29	83	90	89	96	129	139	138	149	90	101	97	124
Potassium	mg/L	1	5	5	2	1	2	2	2	1	1	1	2	<1	1	1	1
Chloride	mg/L	1	602	944	41	162	186	180	209	406	439	440	475	81	91	83	115
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1	<1	<1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	758	595	75	139	144.2	144	150	82	103	110	117	130	146	140	178
Total Alkalinity	mg/L	1				139	142	142	144	130	149	140	178				
Sulphate	mg/L	1	104	183	27	21	25	25	31	33	40	37	48	9.3	12	13	14
Metals																	
Aluminum	mg/L	0.01	<0.01	<0.01	0.04	0.86	0.86	0.86	0.86	0.23	0.23	0.23	0.23	0.06	0.06	0.06	0.06
Arsenic - Filtered	mg/L	0.001	<0.001	0.002	0.001	<0.001			<0.001	<0.001			<0.001	<0.001	0.001	0.001	0.002
Boron - Filtered	mg/L	0.05	0.10	0.07	<0.05												
Cadmium - Filtered	mg/L	0.00005	0.00010	<0.0001	0.00020	<0.0001	0.00024	0.00020	0.00040	0.0001	0.00038	0.00020	0.00090	<0.0001	0.00030	0.00040	0.00050
Chromium - Filtered	mg/L	0.002	<0.01	<0.005	<0.005	<0.001	0.002	0.002	0.002	<0.001	0.001	0.001	0.002	<0.001	0.002	0.001	0.005
Copper - Filtered	mg/L	0.0005	<0.001	<0.001	<0.001	<0.001	0.0026	0.002	0.007	0.002	0.003	0.003	0.005	<0.001	0.0022	0.001	0.006
Iron - Filtered	mg/L	0.05	0.94	3.96	0.80	0.19	0.85	1.11	1.36	0.12	0.40	0.32	0.69	0.66	4.19	5.44	7.03
Lead - Filtered	mg/L	0.00005	<0.001	<0.001	0.002	<0.001	0.002	0.001	0.005	<0.001	0.002	0.001	0.003	<0.001	0.002	0.002	0.002
Manganese - Filtered	mg/L	0.001	0.076	0.272	0.030	0.001	0.032	0.030	0.065	0.001	0.277	0.309	0.484	0.004	0.074	0.056	0.175
Mercury - Filtered	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001
Nickel - Filtered	mg/L	0.001	<0.001	0.001	0.002	<0.001	0.004	0.001	0.014	0.001	0.031	0.002	0.144	<0.001	0.023	0.001	0.112
Selenium - Filtered	mg/L	0.01	<0.01	<0.01	<0.01	<0.01			<0.01	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.006	<0.005	0.119	0.014	0.021	0.020	0.036	0.014	0.028	0.020	0.049	0.013	0.018	0.017	0.024
Nutrients																	
Ammonia as N	mg/L	0.01				<0.01	0.03	0.02	0.07	<0.01	0.06	0.03	0.16	0.04	0.07	0.09	0.10
Nitrate as N	mg/L	0.01				<0.01	0.05	0.01	0.21	<0.01	0.03	0.01	0.13	<0.01	0.02	0.01	0.04
Nitrite as N	mg/L	0.01				<0.01	0.28	0.22	0.83	<0.01	1.00	0.92	1.86	<0.01	0.07	0.05	0.20
Nitrite + Nitrate as N	mg/L	0.01				0.21	0.443333	0.29	0.83	0.02	0.036667	0.04	0.05				
Total Phosphorus as P	mg/L	0.01				<0.01	0.02	0.01	0.04	0.02	0.133333	0.19	0.19				
Other																	
Silica	mg/L																
Fluoride	mg/L	0.02				0.16	0.31	0.20	0.80	0.08	0.19	0.15	0.40	0.3	0.90	0.30	3.30
Total Cyanide	mg/L	0.004				<0.004	0.005	0.004	0.008	<0.004	0.006	0.004	0.009				
Calculated Parameters																	
Total Anions	meq/L	0.01	34.30	42.30	3.22	8.01	8.71	8.51	9.43	7.03	13.53	14.70	16.30	5.24	12.55	5.34	41.30
Total Cations	meq/L	0.01	31.20	41.10	3.14	7.97	8.56	8.34	9.13	7.07	13.51	15.20	15.40	5.10	12.24	5.21	39.90
Ionic Balance	%	0.01	0.05	0.02	0.01	0.00	0.01	0.01	0.02	0.00	0.02	0.03	0.03	0.00	0.01	0.01	0.02

Bore / Well / Spring / Soak			WML243				WML247				WML249				WML252			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters																		
pH Value (Lab)	pH unit	0.01																
pH Value (field)	pH unit	0.01	6.64	6.88	6.85	7.04	7.24	7.38	7.38	7.52	7.49	7.67	7.71	7.79	7.03	7.30	7.23	7.63
Conductivity (field)	µS/cm	1	3740	5090	5280	6200	14800	14900	14900	15000	13500	15000	15100	16300	3730	4885	4880	5830
Lab Conductivity @ 25°C	µS/cm	1																
Total Dissolved Solids (TDS)	mg/L	1	2820	3478	3610	4100	9260	9335	9335	9410	9650	10043	10010	10500	2630	3208	3235	3700
Suspended Solids (TSS)	mg/L	1	340	1048	532	3020	748	1234	1234	1720	307	821	554	1870	524	2045	2040	3740
Total Hardness as CaCO3	mg/L	1	634	860	951	1040	468	471	471	474	813	835	829	870	459	725	776	890
Turbidity	NTU	0.01	617.00	1073.50	1073.50	1530.00	624.00	713.00	713.00		182.00	464.00	464.00	746.00	545.00	1492.50	1492.50	2440.00
Major Ions																		
Calcium	mg/L	1	86	134	155	164	35	36	36	36	60	64	65	68	63	98	105	118
Magnesium	mg/L	1	92	128	137	154	92	93	93	93	161	164	162	170	73	117	125	144
Sodium	mg/L	1	648	890	971	1050	2970	3175	3175	3380	3100	3470	3305	4170	722	856	887	950
Potassium	mg/L	1	2	2	2	2	16	17	17	17	10	11	11	11	2	2	2	2
Chloride	mg/L	1	951	1338	1430	1690	4220	4405	4405	4590	4580	4788	4755	5060	995	1343	1395	1540
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	501	610	593	696	1430	1435	1435	1440	1080	1145	1140	1220	277	318	320	345
Total Alkalinity	mg/L	1	501	597	593	696	1430	1435	1435	1440	1080	1140	1120	1220	277	316	322	345
Sulphate	mg/L	1	149	234	245	282	50	52	52	54.3	335	764	841	1040	214	293	284	371
Metals																		
Aluminum	mg/L	0.01	10.6	10.60	10.60	10.60					4.48	4.48	4.48	4.48	18.5	24.30	24.30	30.10
Arsenic - Filtered	mg/L	0.001	0.003	0.012	0.010	0.023	0.004	0.007	0.007	0.009	0.006	0.009	0.008	0.014	0.006	0.014	0.011	0.024
Boron - Filtered	mg/L	0.05																
Cadmium - Filtered	mg/L	0.00005	0.0002	0.00062	0.00060	0.00130	0.0007	0.00450	0.00450	0.00830	<0.0001	0.00045	0.00035	0.00100	<0.0001	0.00075	0.00035	0.00300
Chromium - Filtered	mg/L	0.002	0.005	0.014	0.008	0.029	0.01	0.010	0.010	0.010	<0.005	0.011	0.009	0.021	0.006	0.023	0.018	0.048
Copper - Filtered	mg/L	0.0005	0.006	0.013	0.008	0.029	0.026	0.033	0.033	0.04	0.009	0.01325	0.0115	0.021	0.006	0.021667	0.015	0.042
Iron - Filtered	mg/L	0.05	7.72	24.14	14.40	52.30	15	26.80	26.80	38.60	5.58	11.68	8.21	24.70	11.1	47.12	37.50	91.50
Lead - Filtered	mg/L	0.00005	0.003	0.011	0.008	0.025	0.017	0.019	0.019	0.020	0.004	0.009	0.007	0.019	0.003	0.022	0.016	0.044
Manganese - Filtered	mg/L	0.001	0.006	0.702	0.736	1.450	0.031	0.187	0.187	0.342	0.008	0.153	0.096	0.413	0.017	0.706	0.618	1.910
Mercury - Filtered	mg/L	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001			0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001
Nickel - Filtered	mg/L	0.001	0.008	0.341	0.018	1.640	0.021	0.571	0.571	1.120	0.005	0.054	0.015	0.182	0.005	0.159	0.031	0.828
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01			0.01	0.01	0.02	0.02	0.02	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.034	0.071	0.055	0.131	0.101	0.127	0.127	0.153	0.024	0.048	0.042	0.084	0.024	0.108	0.084	0.219
Nutrients																		
Ammonia as N	mg/L	0.01	0.02	0.03	0.03	0.04	<0.01	0.06	0.06	0.10	<0.01	0.07	0.08	0.10	<0.01	0.05	0.06	0.10
Nitrate as N	mg/L	0.01	0.1	3.13	0.22	14.70	<0.01			0.01	<0.01	0.23	0.01	0.87	<0.01	1.73	0.04	5.42
Nitrite as N	mg/L	0.01	0.08	13.64	11.20	32.30	<0.01	0.02	0.02	0.02	<0.01	1.27	1.58	1.92	<0.01	3.23	3.96	6.10
Nitrite + Nitrate as N	mg/L	0.01	7.64	11.34667	11.6	14.8	0.02	0.02	0.02	0.02	0.87	1.53	1.8	1.92	<3.42	4.555	4.69	5.42
Total Phosphorus as P	mg/L	0.01	0.04	0.366667	0.34	0.72	0.34	0.835	0.835	1.33	0.76	1.136667	1.22	1.43	0.48	1.2025	0.96	2.41
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02	0.38	0.64	0.42	1.50	<0.02	0.41	0.41	0.8	1.77	2.36	2.19	3.30	0.13	0.36	0.35	0.80
Total Cyanide	mg/L	0.004	<0.004	0.005	0.004	0.006	<0.004	0.004	0.004		<0.004	0.004	0.004	0.004	<0.004	0.004	0.004	0.004
Calculated Parameters																		
Total Anions	meq/L	0.01	47.70	79.10	62.50	157.00	153.00	160.00	160.00	167.00	40.60	144.40	169.50	198.00	3.79	45.03	53.85	58.20
Total Cations	meq/L	0.01	47.40	76.40	62.60	148.00	139.00	153.00	153.00	167.00	39.10	134.03	157.00	183.00	3.92	45.12	52.90	59.10
Ionic Balance	%	0.01	0.00	0.01	0.00	0.04	0.00	0.02	0.02	0.05	0.02	0.03	0.03	0.05	0.00	0.01	0.01	0.03

Bore / Well / Spring / Soak			WML253				WML256				WML294				WML299			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters																		
pH Value (Lab)	pH unit	0.01																
pH Value (field)	pH unit	0.01	6.58	7.07	7.18	7.37	6.55	6.70	6.73	6.90	7.00	7.22	7.21	7.45	7.14	7.23	7.23	7.32
Conductivity (field)	µS/cm	1	300	396	411	453	2240	3650	3270	5930	4130	8338	9360	10500	947	1289	1289	1630
Lab Conductivity @ 25°C	µS/cm	1																
Total Dissolved Solids (TDS)	mg/L	1	236	294	256	472	1340	2008	1860	2580	2490	5315	5855	7060	822	961	961	1100
Suspended Solids (TSS)	mg/L	1	10	31	14	86	480	852	952	1130	5	46	52	76	96	130	130	164
Total Hardness as CaCO3	mg/L	1	101	112	112	124	372	568	582	747	599	1202	1290	1630	217	230	230	243
Turbidity	NTU	0.01	5.10	27.15	27.15	49.20					17.20	17.20	17.20	17.20				
Major Ions																		
Calcium	mg/L	1	20	25	25	28	85	132	139	174	72	104	100	145	44	50	50	55
Magnesium	mg/L	1	12	12	12	13	39	58	57	76	96	228	255	307	26	26	26	26
Sodium	mg/L	1	22	30	30	41	371	481	515	566	755	1551	1740	1970	181	236	236	290
Potassium	mg/L	1	<1			<1	1	1	1	2	2	6	7	8	3	4	4	4
Chloride	mg/L	1	45	51	49	63	517	793	829	987	1100	2443	2720	3230	201	236	236	271
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1	<1			<1
Bicarbonate as CaCO3	mg/L	1	96	103	98	120	223	277	292	306	317	743	870	915	224	225	225	226
Total Alkalinity	mg/L	1	96	97	98	98	223	262	261	302	317	616	615.5	914				
Sulphate	mg/L	1	6	9	9	11	126	167	171	208	260	604	674	809	86	150	150	214
Metals																		
Aluminum	mg/L	0.01	0.18	0.18	0.18	0.18	4.2	4.20	4.20	4.20	0.04	0.04	0.04	0.04	1.11	1.11	1.11	1.11
Arsenic - Filtered	mg/L	0.001	<0.001	0.001	0.001	0.001	<0.001	0.002	0.002	0.004	0.001	0.002	0.002	0.002	0.005	0.006	0.006	0.006
Boron - Filtered	mg/L	0.05																
Cadmium - Filtered	mg/L	0.00005	<0.0001	0.00118	0.00020	0.00440	0.0003	0.00286	0.00060	0.00880	0.0001	0.00125	0.00050	0.00390	0.0001	0.00015	0.00015	0.00020
Chromium - Filtered	mg/L	0.002	<0.001	0.001	0.001	0.002	0.002	0.005	0.003	0.010	<0.001	0.002	0.002	0.003	0.002	0.003	0.003	0.003
Copper - Filtered	mg/L	0.0005	<0.001	0.0016	0.001	0.003	0.002	0.0074	0.005	0.013	0.002	0.004	0.0035	0.007	0.002	0.0035	0.0035	0.005
Iron - Filtered	mg/L	0.05	0.11	0.60	0.23	2.07	0.47	5.20	5.46	9.40	0.14	0.57	0.33	1.48	1.06	2.10	2.10	3.14
Lead - Filtered	mg/L	0.00005	<0.001	0.002	0.001	0.004	<0.001	0.010	0.008	0.023	0.001	0.004	0.004	0.006	0.002	0.003	0.003	0.003
Manganese - Filtered	mg/L	0.001	0.002	0.170	0.217	0.282	0.003	0.367	0.424	0.640	0.006	0.064	0.069	0.114	2.01	2.080	2.080	2.150
Mercury - Filtered	mg/L	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001
Nickel - Filtered	mg/L	0.001	<0.001	0.021	0.001	0.100	0.004	0.027	0.012	0.101	0.001	0.011	0.003	0.038	0.002	0.003	0.003	0.003
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01			<0.01	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	<0.005	0.013	0.015	0.019	0.017	0.036	0.033	0.056	0.015	0.058	0.067	0.084	0.034	0.048	0.048	0.062
Nutrients															<0.0001	0.0001	0.0001	0.0001
Ammonia as N	mg/L	0.01	<0.01	0.01	0.01	0.03	0.04	0.60	0.13	2.21	0.18	0.61	0.32	1.64	0.29	0.29	0.29	0.29
Nitrate as N	mg/L	0.01	<0.01			<0.01	<0.01	0.01	0.01	0.02	<0.01	0.11	0.05	0.32	0.02	0.83	0.83	1.64
Nitrite as N	mg/L	0.01	<0.01	0.04	0.03	0.09	<0.01	0.04	0.01	0.10	0.09	1.39	0.90	3.67	<0.01	0.01	0.01	0.01
Nitrite + Nitrate as N	mg/L	0.01	<0.01	0.023333	0.03	0.03	0.01	0.043333	0.02	0.1	0.41	2.04	2.04	3.67				
Total Phosphorus as P	mg/L	0.01	<0.01	0.043333	0.05	0.07	0.15	0.253333	0.27	0.34	0.3	0.305	0.305	0.31				
Other																		
Silica	mg/L																	
Fluoride	mg/L	0.02	0.1	0.20	0.18	0.40	0.07	0.22	0.10	0.70	0.22	0.77	0.59	1.70	0.3	0.55	0.55	0.80
Total Cyanide	mg/L	0.004	<0.004	0.004	0.004	0.004	<0.004	0.005	0.004	0.007	<0.004	0.004	0.004	0.004				
Calculated Parameters																		
Total Anions	meq/L	0.01	3.38	9.75	3.77	34.20	23.40	33.60	33.60	42.60	102.00	109.00	108.00	118.00	12.30	57.15	57.15	102.00
Total Cations	meq/L	0.01	3.40	9.48	3.67	33.10	23.60	34.14	35.20	44.80	98.50	107.00	101.75	126.00	12.00	55.25	55.25	98.50
Ionic Balance	%	0.01	0.01	0.01	0.01	0.02	0.00	0.02	0.02	0.03	0.02	0.03	0.03	0.04	0.01	0.02	0.02	0.02

Bore / Well / Spring / Soak			WMLP300				WMLP301				WMLP302			
Parameter	**Units**	**LOR**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**	**Min**	**Mean**	**Median**	**Max**
Physical Parameters														
pH Value (Lab)	pH unit	0.01												
pH Value (field)	pH unit	0.01	7.29	7.29	7.29	7.29	7.85	7.94	7.94	8.03	6.35	6.51	6.51	6.67
Conductivity (field)	µS/cm	1	1400	1530	1530	1660	5920	6135	6135	6350	648	730	730	812
Lab Conductivity @ 25°C	µS/cm	1												
Total Dissolved Solids (TDS)	mg/L	1	898	999	999	1100	3590	4300	4300	5010	398	461	461	524
Suspended Solids (TSS)	mg/L	1	116	1353	1353	2590	12	16	16	20	30	37	37	44
Total Hardness as CaCO3	mg/L	1	307	315	315	322	108	113	113	118	135	135	135	135
Turbidity	NTU	0.01												
Major Ions														
Calcium	mg/L	1	58	58	58	58	14	18	18	21	16	17	17	17
Magnesium	mg/L	1	40	42	42	43	16	17	17	18	23	23	23	23
Sodium	mg/L	1	286	288	288	290	1540	1565	1565	1590	126	128	128	129
Potassium	mg/L	1	5	6	6	6	7	8	8	9	2	3	3	3
Chloride	mg/L	1	306	322	322	338	1610	1665	1665	1720	138	142	142	146
Hydroxide Alkalinity as CaCO3	mg/L	1	<1			<1	<1			<1	<1			<1
Carbonate as CaCO3	mg/L	1	<1			<1	<1	21	21	41	<1			<1
Bicarbonate as CaCO3	mg/L	1	322	380	380	437	968	999	999	1030	164	174	174	184
Total Alkalinity	mg/L	1												
Sulphate	mg/L	1	19	64	64	108	68	102	102	135	27	29	29	31
Metals														
Aluminum	mg/L	0.01	3.51	3.51	3.51	3.51	0.07	0.07	0.07	0.07	0.15	0.15	0.15	0.15
Arsenic - Filtered	mg/L	0.001	0.007	0.008	0.008	0.008	0.004	0.009	0.009	0.014	0.002	0.003	0.003	0.004
Boron - Filtered	mg/L	0.05												
Cadmium - Filtered	mg/L	0.00005	0.0002	0.00020	0.00020	0.00020	<0.0001	0.00035	0.00035	0.00060	<0.0001	0.00040	0.00040	0.00070
Chromium - Filtered	mg/L	0.002	0.003	0.005	0.005	0.007	<0.001	0.002	0.002	0.003	0.002	0.003	0.003	0.004
Copper - Filtered	mg/L	0.0005	0.007	0.009	0.009	0.011	<0.001	0.0025	0.0025	0.004	0.003	0.0045	0.0045	0.006
Iron - Filtered	mg/L	0.05	2.24	5.17	5.17	8.09	0.1	0.21	0.21	0.32	2.32	3.71	3.71	5.10
Lead - Filtered	mg/L	0.00005	0.003	0.005	0.005	0.006	0.001	0.003	0.003	0.004	0.002	0.007	0.007	0.011
Manganese - Filtered	mg/L	0.001	0.746	0.838	0.838	0.930	0.071	0.083	0.083	0.095	0.025	0.038	0.038	0.051
Mercury - Filtered	mg/L	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001			<0.0001
Nickel - Filtered	mg/L	0.001	0.006	0.008	0.008	0.010	0.002	0.003	0.003	0.003	0.001	0.002	0.002	0.002
Selenium - Filtered	mg/L	0.01	<0.01			<0.01	<0.01			<0.01	<0.01			<0.01
Zinc - Filtered	mg/L	0.005	0.022	0.053	0.053	0.083	<0.011	0.017	0.017	0.023	0.042	0.050	0.050	0.058
Nutrients			<0.0001	0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	0.0001				
Ammonia as N	mg/L	0.01	0.96	0.96	0.96	0.96	0.54	0.54	0.54	0.54	0.38	0.38	0.38	0.38
Nitrate as N	mg/L	0.01	0.07	0.86	0.86	1.64	<0.01	0.83	0.83	1.64	0.1	0.10	0.10	0.10
Nitrite as N	mg/L	0.01	0.01	0.02	0.02	0.02	<0.01	0.01	0.01	0.01	0.12	0.12	0.12	0.12
Nitrite + Nitrate as N	mg/L	0.01												
Total Phosphorus as P	mg/L	0.01												
Other														
Silica	mg/L													
Fluoride	mg/L	0.02	0.3	0.95	0.95	1.60	0.9	1.60	1.60	2.30	0.2	0.20	0.20	0.20
Total Cyanide	mg/L	0.004												
Calculated Parameters														
Total Anions	meq/L	0.01	19.20	60.60	60.60	102.00	71.70	71.70	71.70	71.70	8.20	8.20	8.20	8.20
Total Cations	meq/L	0.01	18.70	58.60	58.60	98.50	70.80	70.80	70.80	70.80	7.97	7.97	7.97	7.97
Ionic Balance	%	0.01	0.01	0.02	0.02	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01

APPENDIX F

BOWMANS CREEK DIVERSION MANAGEMENT PLAN

ASHTON COAL MINE

WATER MANAGEMENT PLAN

BOWMANS CREEK DIVERSION

Ashton Coal Operations Pty Limited

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Version	Date	Description	Author	Reviewer	Approved
1	5/12/11	Construction Water Management Plan – Bowmans Creek Diversion	M Moore Ashton Coal	L Richards Ashton Coal S. Perrens Evans & Peck	M Moore Ashton Coal
2	24/7/12	Revisions to address agency consultation comments	M Moore Ashton Coal	L Richards Ashton Coal	M Moore Ashton Coal

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1.0 INTRODUCTION

1.1. Background

Development consent DA 309-11-2001 for the Ashton Coal Project (ACP) was modified on 24 December 2010 (MOD 6) to allow for:

- Longwall mining that will result in a direct hydraulic connection between the Bowmans Creek alluvium and the underground workings due to connective cracking.
- Amendment of the underground mine plan to optimise resource extraction.
- Diversion of two sections of Bowmans Creek.

The combination of the creek diversions with the revised mine layout will effectively mitigate the impact on Bowmans Creek surface flows that may otherwise result from subsidence associated with the underground mine.

In approving the modification, the Executive Director of Planning (under delegation from the Minister) amended DA 309-11-2001 to include additional and revised conditions of consent, including conditions that relate (inter alia) to the water management requirements for the construction of the Bowmans Creek diversions.

1.2. Document Purpose and Scope

Condition 4.7(d) to Schedule 2 of DA 309-11-2001 (as modified on 24 December 2010), requires a Bowmans Creek Diversion Management Plan to be prepared and implemented for the proposed creek diversions in the underground mining area. The plan must:

- be consistent with any related requirements in future Extraction Plan(s); and
- include:
  - a vision statement for the creek relocations;
  - an assessment of the surface water and groundwater quality, ecological, hydrological and geomorphic baseline conditions within the creek;
  - the detailed design specifications for the creek relocations;
  - a construction program for the creek relocations, describing how the work would be staged, and integrated with mining operations;
  - a revegetation program for the relocated creeks using a range of suitable native species;
  - water quality, ecological, hydrological and geomorphic performance and completion criteria for the creek relocations based on the assessment of baseline conditions; and
  - a program to monitor and maintain surface water and groundwater quality, ecological, hydrological and geomorphic stability of the creek diversions.

This document has been prepared to address the requirements of condition 4.7(d) and to describe the environmental management measures that will be put in place to ensure that ACOL establishes and maintains best practice controls to manage potential environmental impacts in establishing the creek diversions.

This environmental management plan is not a standalone document. It forms part of the site wide Water Management Plan and is designed to be consistent with and draw on:

- The Environmental Assessment prepared in support of the modification application for the creek diversions (Evans & Peck, 2009).

- Commitments (Schedule C to DA 309-11-2001) made by ACOL in relation to constructing and managing the creek diversions and revised underground mine plan more generally.
- Ashton Coal Mine Construction Mining Operations Plan Bowmans Creek Diversion.
- Existing approved (or future replacement) environmental management plans for the operation of the Ashton Coal Project, particularly:
  - Erosion and Sediment Control Management Plan.
  - Soil-Stripping Management Plan.
  - Landscape and Revegetation Management Plan.
  - Flora and Fauna Management Plan.
  - Weed Management Plan.
  - Water Management Plan.

This Bowmans Creek Diversion Management Plan sets out the measures that will be implemented during the construction stage of the creek diversion project.

Following development consent modification, Ashton Coal Operations Limited (ACOL) prepared and gained approval for a Construction Mining Operation Plan (CMOP) for the Bowmans Creek diversions from the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS), Division of Resources and Energy (DRE). It has also obtained the necessary relevant water licences for the diversions from the NSW Office of Water (NOW).

There are obvious synergies between the information presented in the approved CMOP for the Bowmans Creek diversions and that required for the Bowmans Creek Diversion Management Plan. Consequently, to avoid duplication of management plans required under separate legislative instruments, this document seeks to utilise the approved CMOP as the basis upon which this management plan (Bowmans Creek Diversion Management Plan) is based. The CMOP also includes a Rehabilitation Strategy specific to the Bowmans Creek Diversions (Appendix D to the CMOP).

This document has been prepared with input from Evans & Peck and RPS Aquaterra and addresses the construction stage of the creek diversions. It also forms part of the site wide ACP Water Management Plan.

This document should be read in conjunction with the approved Bowmans Creek Diversion CMOP (Appendix A) and site wide Water Management Plan.

1.3. Consultation

ACOL has consulted with the Office of Environment and Heritage (OEH), NOW, DTIRS-DRE, Department of Planning and Infrastructure (DP&I) and Singleton Council on the design, construction and management aspects of the creek diversions and on the revised site wide Water Management Plan (including this Bowmans Creek Diversion Water Management Plan) subsequent to the approval of the development consent modification application (MOD 6), including:

- OEH:
  - Consultation on the interaction of the creek diversions (and underground mine) during the preparation and approval of an Aboriginal Heritage Impact Permit for the area.
  - Consultation on the revised site wide Water Management Plan (including the Bowmans Creek Diversion Water Management Plan).
- NOW:

  - Consultation on water licensing and approval requirements, including subdivision and conversion of part of an existing Bowmans Creek Water Access Licence (WAL) to an Aquifer Access Licence (AAL), controlled activities and water management approvals.
  - Consultation on the revised site wide Water Management Plan (including this Bowmans Creek Diversion Water Management Plan).
- DRE:
  - Consultation on preparation and approval of the CMOP for the creek diversions.
  - Consultation on the revised site wide Water Management Plan (including this Bowmans Creek Diversion Water Management Plan).
- DP&I:
  - Consultation on the approved modification and CMOP with Singleton compliance officers.
  - Consultation on the revised site wide Water Management Plan (including this Bowmans Creek Diversion Water Management Plan).
- Council:
  - Consultation through ACOL's Community Consultation Committee which includes two representatives from council.
  - Consultation on the revised site wide Water Management Plan (including this Bowmans Creek Diversion Water Management Plan).

A copy of written correspondence following consultation on the Water Management Plan (including this Bowmans Creek Diversion Water Management Plan) is included as an appendix to the Water Management Plan.

This management plan has been revised in response to the outcomes of this consultation process.

1.4. Plan Review

ACOL will review this plan upon completion of the construction stage of the diversions, or, if so directed by the Director-General (Planning and Infrastructure) as per the requirements of condition 1.21 to Schedule 2 of DA 309-11-2001, or, in response to the requirements of any other condition of the development consent that triggers a review of the plan.

2.0 CREEK DIVERSION VISION AND OBJECTIVES

The creek diversions will be constructed and landscaped to establish an ecologically healthy riparian corridor between the New England Highway and the Hunter River, on land owned by ACOL. Fulfilment of this vision includes the construction, landscaping and ongoing monitoring and management which, compared to the characteristics and conditions of the pre-diverted creek, will:

- Provide flow channels that mimic the hydraulic and geomorphic characteristics and provide similar resilience.
- Provide for fish passage and a diversity of aquatic habitat.
- Provide an enlarged area of ecologically diverse naturally vegetated riparian corridor.
- Provide a free draining floodplain that is vegetated to a standard consistent with the final intended land use.

The key design objectives for the creek diversions are summarised in the following tables (Table 1 and Table 2).

Table 1: Key Physical Design Objectives

	Design Objective	Criteria/Strategy	Features of the Proposal
1	**Conveyance**		
1.1	Divert flows up to 5 year ARI	152 m^3/s	152 m^3/s
1.2	Minimise seepage losses in 80th – 100th percentile low flow range	Seal under low flow channel (80th percentile flow = 2 ML/day (0.023 m^3/s)	Seal under channel to convey flow up to 10 m^3/s (865 ML/day)
2	**Channel Morphology and Stability**		
2.1	Channel shear stress	Comparable to existing	Comparable to existing
2.2	Low flow channel cross section and long profile	Mimic existing	Channel sections copied. Longitudinal profile with similar variation
2.3	Floods inundate low level floodplain	Inundation at least once per year	Low level floodplain inundated once per year
3	**Channel Alignment and Geometry**		
3.1	Maximise channel length with sinuosity within defined corridor	Existing E channel grade 0.17% Existing W channel grade 0.39%	E channel grade 0.24% W channel grade 0.40%
3.2	Batter slopes comparable to existing channel	1:3.5 - 1:11	Typical batter slopes 1:4 – 1:7
3.3	Maintain comparable lower active flood plain	Range 21 - 35+m	Channels sections copied
3.4	Maintain comparable width of incised creek corridor	Range 50 - 100m	Channels sections copied
3.5	Sinuosity	Mimic existing channel sinuosity as far as possible	Comparable channel alignment
4	**Flood Levels and Flood Storage**		
4.1	100 year ARI flood level at Highway	No increase	No increase
4.2	Flow velocity at Highway	Peak 100 year ARI velocity 4.3 m/s	Peak 100 year ARI velocity 4.5 m/s
4.3	Floodplain storage	No significant loss of storage	Increased flood storage

Table 2: Key Design Objectives for Aquatic Habitat and Low Active Floodplain

	Design Objective	Criteria/Strategy	Features of the Proposal
1	**Fish Passage and Aquatic Habitat**		
1.1	Fish passage when creek flowing	Passage possible in moderate flow	Flow conditions similar
1.2	Provide appropriate pool and riffle sequence	Mimic existing channel	Pool and riffles mimic existing creek
1.3	Maximum bed slope of riffles	Approximately 5%	Approximately 5%
1.4	Maintain comparable pool area	0.9 ha	1.1 ha
2	**Riparian and Low Active Floodplain Ecology**		
2.1	Maintain area of lower active floodplain area inundated in 1 year ARI flood	6.7 ha	6.4 ha
2.2	Improve habitat value of lower active floodplain	Revegetate and exclude domestic stock	Establish plant communities characteristic of those present prior to European colonisation
2.3	Ecosystem resilience	Create robust, relatively self-sustaining ecosystem	

3.0 PROJECT STAGING

Constructing and establishing stable and ecologically diverse creek diversions will be carried out via a staged approach that is commensurate with staging of underground mining and ecological establishment requirements. These aspects have been taken into account in the planning and scheduling of the construction and rehabilitation stages of the project.

Establishment of the creek diversions has two distinct elements:

Stage 1 – Earthworks construction, involving the following major elements:

- Bulk earthworks and channel bed forming to create the diversion channels and place excess material in temporary stockpiles.
- Construction of low level block banks to direct low flows into the diversion channels.
- Construction of permanent block banks approximately 3 years after construction of the initial temporary banks, or as otherwise required.
- Following the mining of each seam and monitoring of subsidence, relocation of stockpile material to maintain a free draining landscape.

Stage 2 – Staged rehabilitation, involving the following phases:

- Phase 1 – Site stabilisation and enhancement of vegetation in and along the constructed creek channels and remaining active sections of the creek (years 1-3).
- Phase 2 – Provision of vegetation community structure (years 3-6).
- Phase 3 – Enrichment of species diversity (year 6 onwards).

The first stage, involving construction of the diversion channels, is expected to take approximately three to four months for each of the diversion channels (Eastern and Western), at which stage it is expected the channels will be sufficiently stable and capable of accepting diverted creek flows.

The second stage, involving post-construction landscape restoration and habitat augmentation, will be carried out in phases according to a specific rehabilitation program.

Landscape restoration and habitat augmentation is planned to be implemented upon completion of the construction stage and will potentially continue for the remaining duration of the underground mine.

The timing of the construction and landscape restoration activities and their relationship to longwall mining of successive seams is notionally illustrated in Figure 1.

3.1. Stage 1 – Construction

The construction stage of the creek diversions (to which this plan relates) encompasses the following activities:

- Site establishment including construction compounds, set-out survey and fencing to delineate areas of ecological and heritage significance.
- Installation of erosion and sediment control facilities prior to clearing and soil stripping.
- Bulk earthworks (total about 350,000 m^3) to form the diversion channels.
- Channel bed forming and stabilisation.
- Initial bank stabilisation.
- Construction of low level block banks to direct flow into the diversion channels.

These elements are described in the approved CMOP, which is provided in Appendix 1. The purpose of the CMOP is to describe:

- Construction activities relevant to the establishment of the creek diversions.
- General staging of creek diversion construction activities.
- Completion criteria for the constructed creek diversion channels.
- Environmental risks associated with the construction activities.
- Management practices and control measures to be implemented during construction of the creek diversions to minimise the risk of environmental impact.
- Monitoring and performance of impact control measures.
- Post-construction landscape rehabilitation objectives.

3.1.1. Diversion Construction Completion Criteria

ACOL has developed completion criteria for the construction of the creek diversion channels. These criteria are summarised in Tables 3, 4 and 5.

Table 3: Diversion Construction Completion Criteria

Key Construction / Diversion Element	Completion Criteria and Performance Assessment	Corrective Action
Channel Geometry and Form		
Channel geometry	"As constructed" survey of channel cross sections and longitudinal profile for validation against: • Engineering drawings. • Key physical design objectives (EA Table 2.4). Ten permanent monitoring cross-sections to be established.	Reconstruction of non-conforming elements.
Bed forming	Adequate clay, sand, gravel and cobble materials available. GCL installed with adequate overlap and anchoring as defined by the manufacturer. Bed depth and form constructed to specification, as per design drawings – to be checked by qualified fluvial geomorphologist and certifying engineer during construction.	Import additional select materials. GCL checked by supervising manager against manufactures guidelines and engineering drawings. Reconstruction of non-conforming elements.
Bed load	Sample channel bed for particle size analysis at same time as survey – statistics of data from the diversion channels to be within 20% of that from the existing channel	As determined by qualified fluvial geomorphologist.
Rock bars, rock ramps	Construction as per design drawings – to be checked by qualified fluvial geomorphologist and certifying engineer during construction.	Import additional select materials. Repair as necessary.

Table 3: Diversion Construction Completion Criteria (cont'd)

Key Construction / Diversion Element	Completion Criteria and Performance Assessment	Corrective Action
Stockpiles		
Presence of silt fencing	Required silt fencing in place.	Install / repair silt fencing.
Revegetation	External bund face vegetation achieves 70% ground cover within 2 months of seeding.	Re-seed any bare patches. Water as necessary.
Construction Infrastructure		
Haul / access roads and construction compound	Haul roads and construction compound removed, including temporary waterway crossings, and all disturbed areas topsoiled, revegetated and stabilised	Repair erosion as necessary and re-topsoil and seed any bare patches.
Rehabilitation		
Site stabilisation (initial works only)	At the completion of channel construction, banks and batters are stabilised with jute mesh and seeded with appropriate cover grasses. Seeding to achieve 70% ground cover within 2 months.	Re-topsoil and re-seed any bare patches. Water as necessary. Augment with additional / alternate erosion control measures, where required.
Other		
Stock Management	Stock exclusion fencing installed. Stock watering troughs installed, where required.	Install / repair fencing and watering troughs

These completion criteria are generally consistent with the rehabilitation objectives described in condition 3.49 to Schedule 2 of DA 309-11-2001 and the Statement of Commitments in Schedule C of the development consent.

It is ACOL's intention to divert creek flows into the constructed diversion channels immediately following the initial post-construction stabilisation work (i.e. once upper banks and batters are stabilised with jute mesh and seeded with appropriate cover grasses).

3.1.2. Channel Bed Leakage Control

As the multi-seam underground mine develops it is expected that some direct connection between the goaf (caved strata) and overlying Bowmans Creek alluvial aquifer will occur.

The design of the diversions incorporates a geo-synthetic clay liner (GCL) as the primary mechanism to minimise leakage from the constructed channels into the surrounding alluvium and to preserve creek through flow. The requirement to maintain a setback (horizontally) of at least 40 m between longwall voids and the creek high bank (in its diverted functioning form) will also ensure the potential for inadvertent mine subsidence related damage to the constructed channels is minimised.

GCL is a manufactured hydraulic barrier system comprising a layer of bentonite clay sandwiched between, and bonded to, layers of geo-synthetic fabric. This type of channel bed liner has been chosen specifically because of its inherent advantages over other hydraulic barrier materials (such as compacted clay or other synthetic liners). The key advantages of GCLs are that they:

- Have very low permeability (<5 x 10^{-11} m/s).

- Provide a hydraulic barrier with uniform properties over a large area. (Compared to compacted clay liners which are subject to variation in the source material and construction quality).
- Have high tensile strength and flexibility and can conform to irregular surfaces.
- Are resistant to puncturing because of the geo-synthetic fibre.
- Are self sealing if punctured.

GCLs have been widely used in place of compacted clay for leachate barrier systems in landfills due to the permeability of the liner being more than an order of magnitude less than that required by the NSW Environment Protection Authority for such developments.

Although the GCL is inherently resistant to puncturing and is self sealing, the GCL will be isolated from the overlying channel cobble bed by a 200 mm layer of fine silty-sand material and a layer of geotextile fabric. The depth of the overlying cobble bed has been determined from analysis of the hydraulic conditions that will occur in the channel, including flood events. A similar protective layer beneath the GCL is included in the channel bed design. The channel bed design also incorporates rock protection at either end of riffle zones, which will provide protection against bed scouring.

The emplacement procedure will involve laying strips of GCL with each successive strip overlapped over the top of the downstream strip. The initial bed design specified an overlap between successive GCL strips of 0.4 m (based on the manufacturer's recommendations). This overlap has since been increased to 1.0 m, providing greater tolerance and increased leakage control performance for the GCL in the channel bed. The start and end points of the liner in each channel will be anchored and each GCL strip will secured in a trench on either side of the channel. This method of construction will ensure that, should damage or undermining of one section of liner occur, the damage will not propagate downstream.

Once emplaced, the GCL will be subject to minimal movement. Notwithstanding, the inherent flexibility of the GCL combined with its self sealing properties and the increased overlap between successive strips will allow the GCL to accommodate unforseen ground movements. Further, the channel bed design and GCL emplacement procedure ensures the risk of puncturing and permanent puncture damage to the GCL is minimised to the greatest extent possible.

Contingencies associated with the construction of the diversion channels have been carefully considered in the design process in order to provide a design that is highly conservative and inherently resilient to the effects of flood, mine and other damage.

Nevertheless, in the course of the channel geometry survey and geomorphic monitoring, any significant change in flow regime will be observed and further investigations and repairs instigated where necessary.

3.1.3. Construction Sign-off

Condition 4.6 to Schedule 2 of DA 309-11-2001 requires an as executed report certified by a practising engineer to be submitted to the Director-General (Planning and Infrastructure) and to NOW within six months of completing construction of the diversions.

To enable ACOL to satisfy this condition, a specialist advisory project team has been engaged to regularly inspect the creek diversions during construction and to provide advice to the certifying engineer. This team consists of each of the technical specialists engaged in the design of the diversions, whose detailed assessment reports were included in the environmental assessment (EA) for the development consent modification application (Evans & Peck, 2009).

The team will be led by Hyder Consulting, as the certifying engineer, with support and advice provided by Evans & Peck (hydrological specialists), RPS Aquaterra (groundwater specialists), Fluvial Systems (fluvial geomorphology specialists) and Marine Pollution Research (aquatic ecology specialists).

The objective of the as executed report is to confirm the diversions, as constructed, will remain sufficiently hydraulically and geomorphically stable.

An indicative construction inspection and certifying approval regime is summarised in Table 4.

Table 4: Indicative Construction Inspection and Certifying Approval Regime

Design/Construction Element	Site Inspection	Approver	Documentation
Base Protective Layer – Silty Clay or Geofabric Layer			
Material (Silty clay or geofabric)	Sampling of stock piles and subgrade for grading and type	Geotechnical Engineer (to be nominated by Ashton Coal and Approved by Hyder Consulting)	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works
Preparation (0.15m thickness - only necessary where creek bed subgrade is inappropriate material)	Proof rolling and compaction testing	Geotechnical Engineer (to be nominated by Ashton Coal and Approved by Hyder Consulting)	As above
	Geometry and levels	Hyder Consulting	Contractor to provide Hyder with 12D model at each stage of works
Geosynthetic Clay Liner			
Integrity	Undamaged, not water affected	Supplier and Hyder Consulting	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works
Laps and anchoring	Comply with design drawings and supplier guidelines	Supplier and Hyder Consulting	As above
Preparation	Geometry and levels	Hyder Consulting	Contractor to provide Hyder with 12D model at each stage of works
Upper Protective Layer - Silty Clay Layer			
Material	Sampling of stock piles and subgrade for grading and type.	Geotechnical Engineer (to be nominated by Ashton Coal and Approved by Hyder Consulting)	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works
Upper Protective Layer - Silty Clay Layer (cont'd)			
Preparation	Compaction testing	Geotechnical Engineer	As above
	Geometry and levels	Hyder Consulting	Contractor to provide Hyder with 12D model at each stage of works
Geofabric Liner			
Integrity	Undamaged	Hyder Consulting	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works
Laps and anchoring	Comply with design drawings and supplier guidelines	Hyder Consulting	As above
Preparation	Geometry and levels	Hyder Consulting	Contractor to provide Hyder with 12D model at each stage of works

Table 4: Indicative Construction Inspection and Certifying Approval Regime (cont'd)

Design/Construction Element	Site Inspection	Approver	Documentation
Cobble Layer, Bed Slope Protection, Rock Bars, and Bank Protection on Outside of Meander Bends			
Material	Sampling of stock piles and subgrade for grading and type	Fluvial Systems and Marine Pollution Control	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works
Preparation	Locating and placement	Fluvial Systems and Marine Pollution Control	As above
	Geometry and levels	Hyder Consulting	Contractor to provide Hyder with 12D model at each stage of works
Large Woody Debris			
Material and location	Placement, dimensions and level	Fluvial Systems, Marine Pollution Control and Hyder Consulting	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works
Vegetation (Initial Bank Stabilisation)			
Type, location and maintenance measures	Coverage and stabilisation performance	ACOL and Hyder Consulting	Inspection locations and comments are to be forwarded to/reviewed by Hyder Consulting at each stage of works

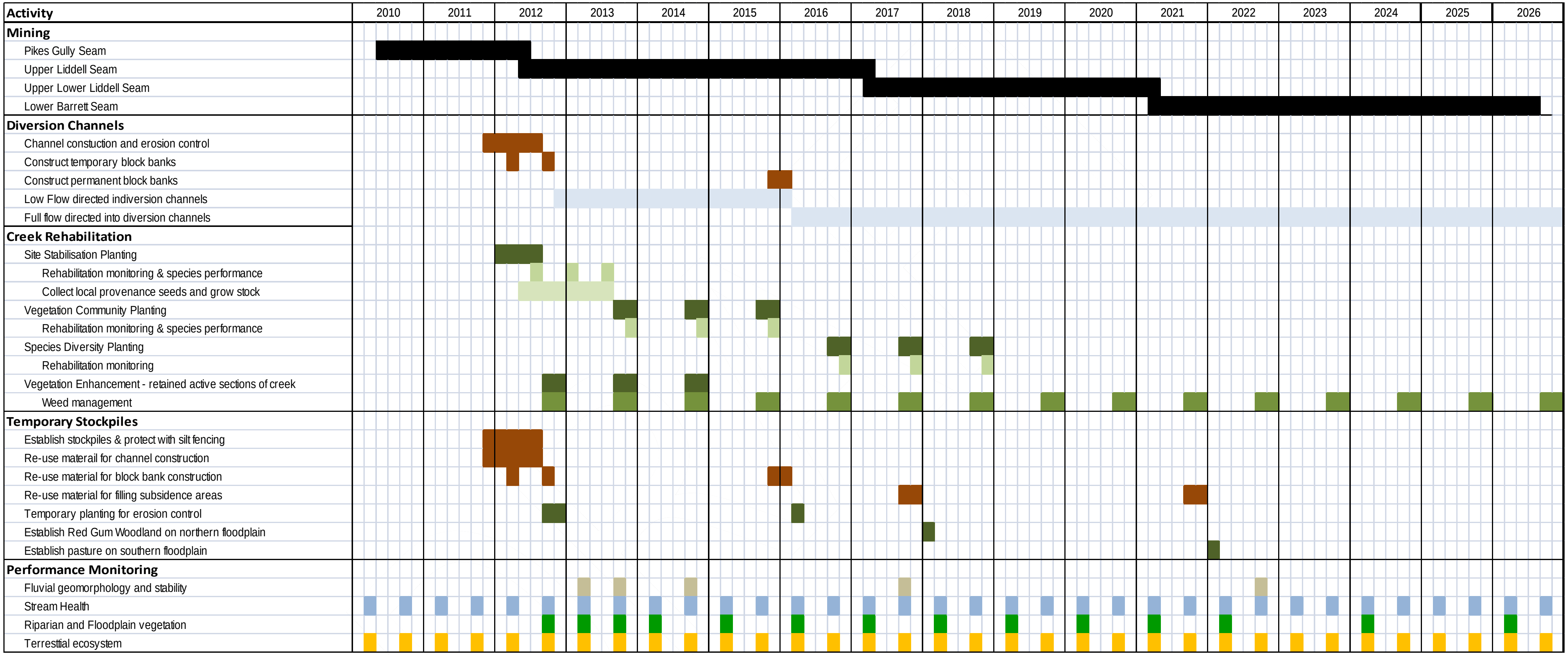

Figure 1 Indicative Creek Diversion Construction and Landscape Restoration Schedule

3.2. Stage 2 – Rehabilitation

Successful landscape restoration and rehabilitation of Bowmans Creek and its alluvial floodplain will be achieved through the application of the following guiding principles:

- Adoption of completion criteria based on creek and landform design, erosion control, drainage, soil processes, flora, fauna and ecosystem function.
- Selectively stockpile gravel/cobbles, topsoil and other alluvial fill extracted during excavation of the channels. These materials will be re-used in the reconstruction of the creek channels (e.g., gravel/cobbles for bed and bars, topsoil for upper batters).
- Seed and manage temporary stockpiles with appropriate species to provide erosion control.
- Retain as much of the existing riparian vegetation as possible as well as habitat trees with hollows.
- Where possible, reuse removed trees for large woody debris within both the retained and new sections of the creek.
- Progressively implement the rehabilitation strategy in line with the sequence of underground mining and consequential subsidence of the floodplain.
- Use other vegetation for respreading on the batters of the constructed channels and temporary stockpiles, in either a mulch or directly spread form.
- Contour and infill subsided areas of the floodplain, as required, to create a stable, adequately drained landscape that complies with rehabilitation and erosion control guidelines and post-mining land use objectives.
- Continue the existing pest and weed control program to eliminate existing weeds and prevent the introduction of pests and noxious weeds in rehabilitated areas.
- Use an adaptive management approach with continuous improvement.
- Provide access necessary for the suppression of fires, control of competitive native and exotic fauna and noxious weeds, and monitoring of rehabilitated areas.

ACOL has prepared a Bowmans Creek Diversion Rehabilitation Strategy (ACOL 2010) which includes species selection, rehabilitation scheduling, completion and performance criteria, and monitoring, including for establishment of aquatic and riparian habitat, stream health, geomorphology and channel stability.

The strategy is included as Appendix D to the CMOP, which is provided as Appendix 1 to this document.

The strategy and final completion criteria for the post-construction stage (including staged revegetation and monitoring) will be reviewed prior to completion of the construction stage and the ACP Rehabilitation Plan (or Landscape and/or Flora and Fauna Management Plans) updated where appropriate.

4.0 BASELINE DATA

An assessment of the surface water and groundwater quality, ecological, hydrological and geomorphic baseline conditions within Bowmans Creek was included in the EA prepared in support of the development consent modification application (Evans & Peck, 2009). An updated summary of baseline data is provided below. Sampling locations are illustrated on Figures 2, 3 and 4.

4.1. Surface Water

Table 5: Bowmans Creek Baseline Surface Water Quality Data Summary

Bowmans Creek Sample Location	pH			EC (µS/cm)			TDS (mg/L)			Hardness ($CaCO_3$)		
	Obs	Mean	Range	Obs	Mean	Range	Obs.	Mean	Range	Obs	Mean	Range
SM3	105	7.6	4.5 - 8.8	113	1127	386 - 1750	104	629	264 - 984	85	225	85 - 336
SM4	107	7.9	7.2 - 8.8	118	2663	175 - 14400	106	1243	212- 8080	89	390	39 - 1210
SM4A	75	7.9	7.5 - 8.5	69	996	396 - 1980	75	596	308 - 920	22	207	85 - 232
SM5	35	7.8	7.4 - 8.3	92	1244	381 - 2040	34	725	419 - 926	48	236	39 - 314
SM6	35	8.0	7.5 - 8.5	92	970	367 - 2000	33	485	333 - 668	48	230	43 - 343

4.2. Groundwater

Table 6: Bowmans Creek Alluvial Baseline Groundwater Quality Data Summary 2007 - 2011

Aquifer Screened	Piezometers	pH (pH units)		Electrical Conductivity (µS/cm)	
		Mean	Range	Mean	Range
Bowmans Creek Alluvium	RM04, RM06, RM07, RM09, RM10, PB1, RA10, RA14, RA15, RA18, RA30, WML110C, WML112C, WML113C, WML115C, WML275, T1-A, T2-A, T3-A, T4-A, T5, T6, T7, T10	7.23	6.44 - 10.04	1622.6	722 - 9920

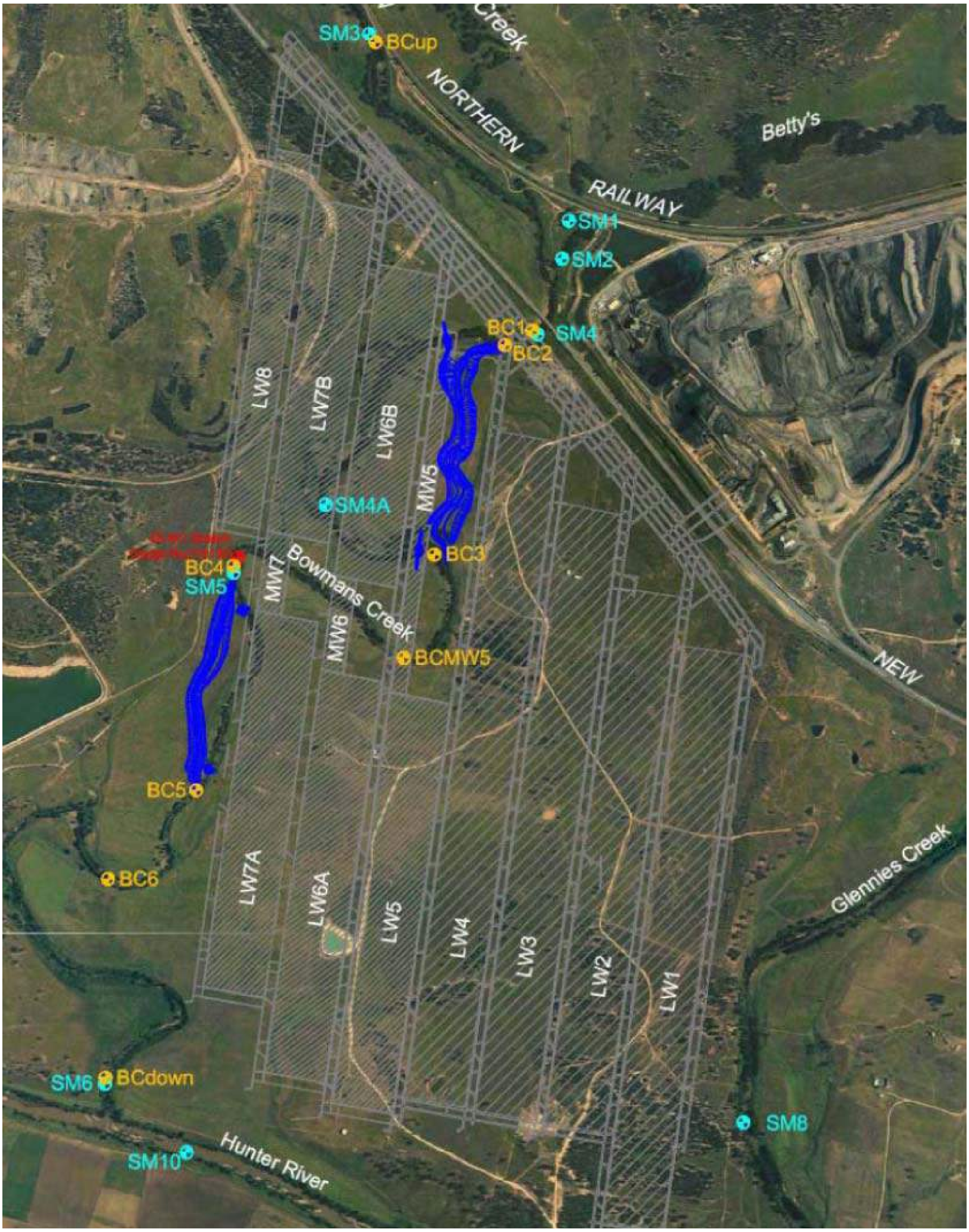

Figure 2 Surface Water and Stream Health Monitoring Locations

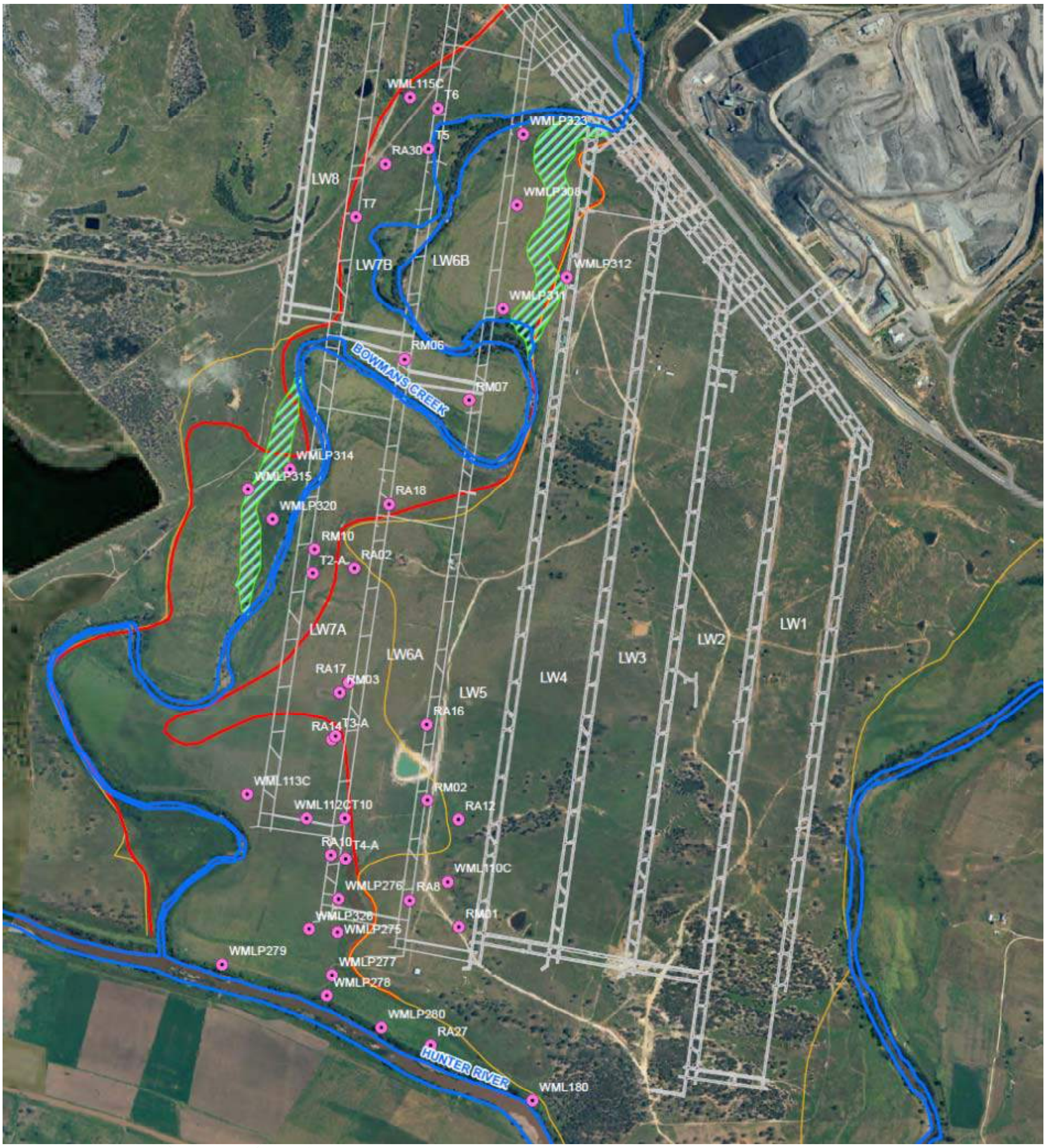

Figure 3 Groundwater Monitoring Locations

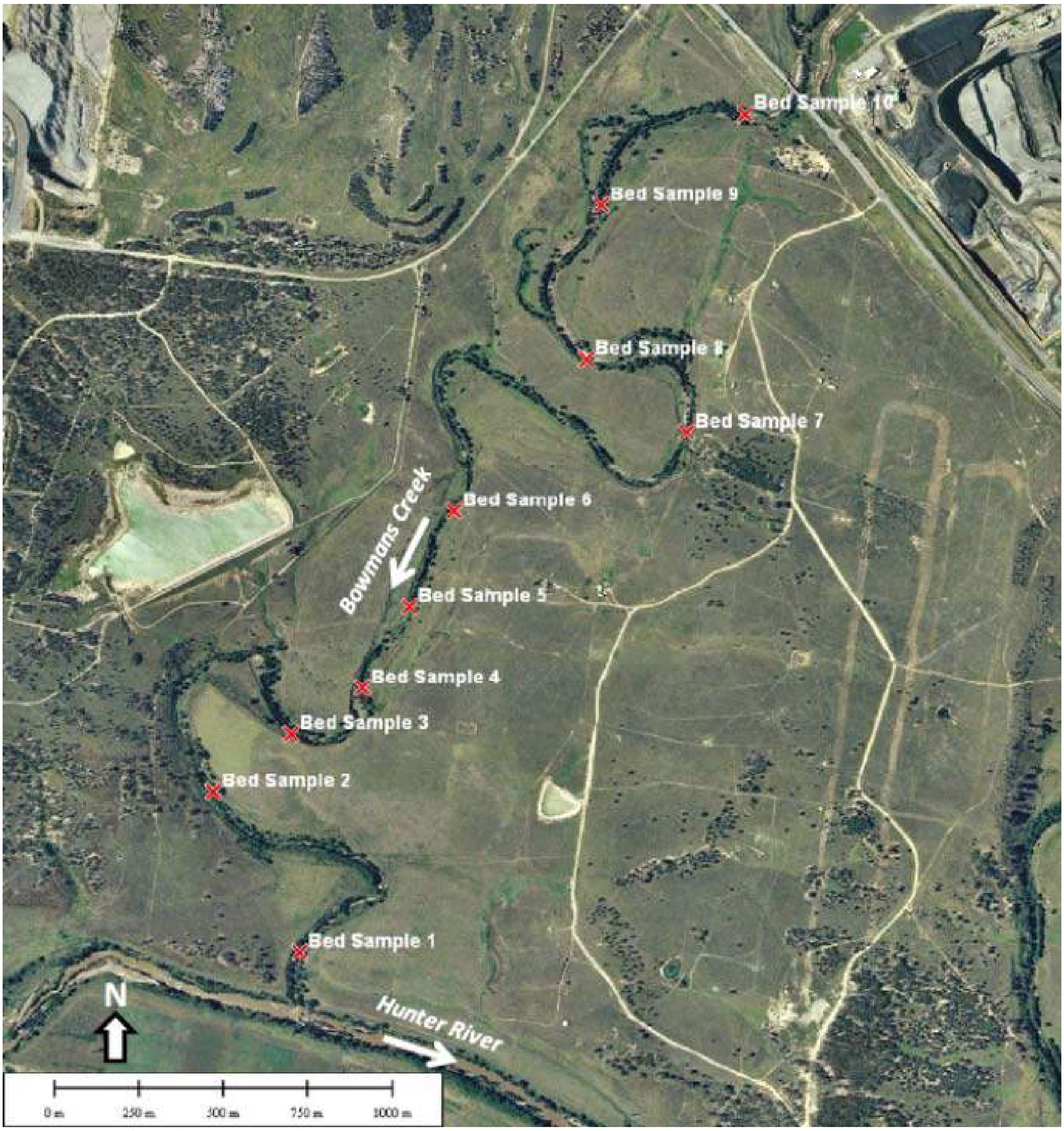

Figure 4 Bed load particle size distribution sample locations

4.3. Geomorphology

Table 7: Average Dimensions of Existing Channel Associated with Eastern Diversion

Variable	Source of Data	Mean	Standard Deviation
Side slope (m/m)	Cross-sections	1:7.3	3.8
Side slope height (m)	Cross-sections	2.3	1.8
Top width of macro-channel at floodplain terrace level (m)	Cross-sections	62	15
Width of base of channel across low active floodplain from base of side slopes (m)	Cross-sections	27	8
Width of low flow channel at pools, between bank edges (m)	Field survey	11.0	3.7
Width of low flow channel at riffles, between bank edges (m)	Field survey	10.6	5.3
Depth of low flow channel from bank top to thalweg (m)	Cross-sections	1.1	0.4
Height of vertical bank to bank toe (m)	Cross-sections	0.4	0.1
Low flow water depth pool (m)	Field survey	0.7	0.3
Low flow water depth riffle (m)	Field survey	0.3	0.2

Table 8: Average Dimensions of Existing Channel Associated with Western Diversion

Variable	Source of Data	Mean	Standard Deviation
Side slope (m/m)	Cross-sections	1:3.4	2.2
Side slope height (m)	Cross-sections	3.1	1.0
Top width of macro-channel at floodplain terrace level (m)	Cross-sections	43	16
Width of base of channel across low active floodplain from base of side slopes (m)	Cross-sections	17	5
Width of low flow channel at pools, between bank edges (m)	Field survey	11.3	2.3
Width of low flow channel at riffles, between bank edges (m)	Field survey	5.7	2.0
Depth of low flow channel from bank top to thalweg (m)	Cross-sections	0.9	0.4
Height of vertical bank to bank toe (m)	Cross-sections	0.5	0.3
Low flow water depth pool (m)	Field survey	0.9	0.4
Low flow water depth riffle (m)	Field survey	0.3	0.1

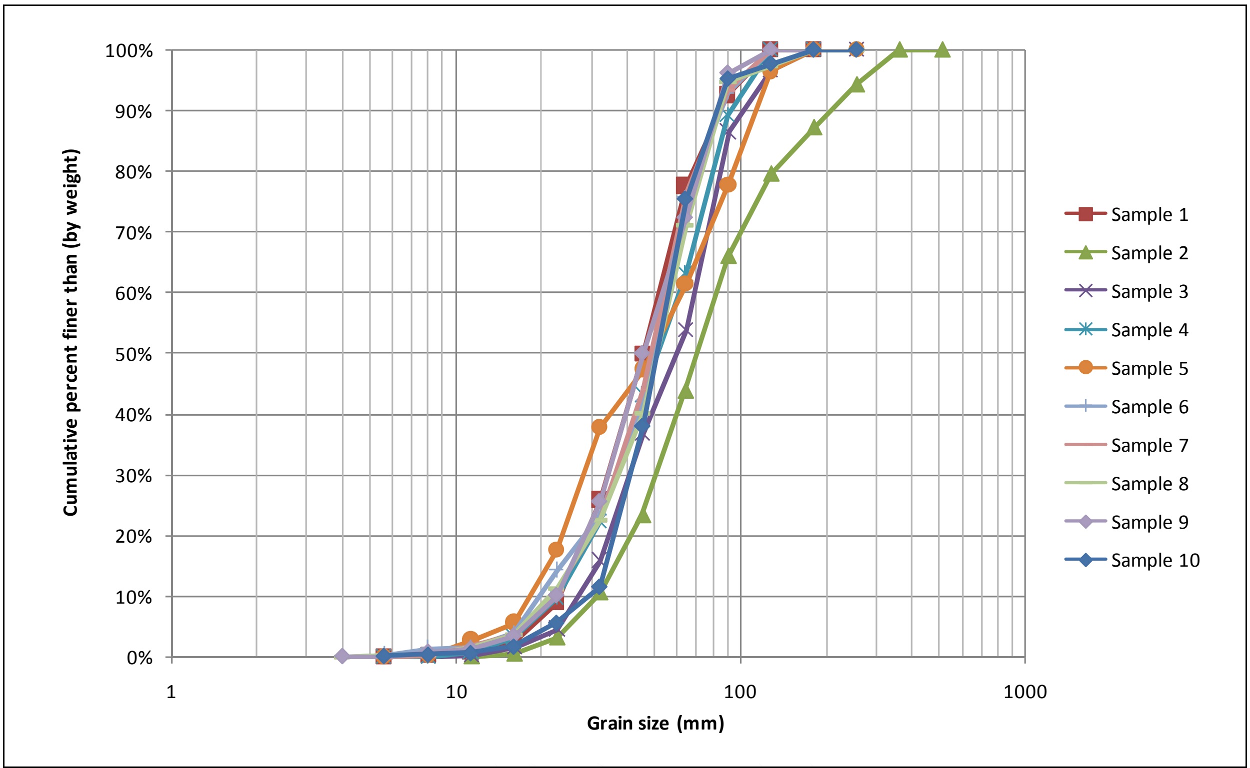

Figure 5 Particle Size Distributions of Riffle Crest Bed Material

Table 9: Locations of Bed Sediment Sampling Points, and Median and Standard Deviation of Particle Size

Sample Number	Chainage (m from Hunter River)	Median Size (mm)	Arithmetic Standard Deviation (mm)	Median Class
1	188	45.3	24.0	Very coarse gravel
2	1,120	70.5	59.8	Small cobble
3	1,948	59.3	28.0	Very coarse gravel
4	2,280	50.9	28.7	Very coarse gravel
5	2,574	48.3	40.0	Very coarse gravel
6	2,900	49.1	25.7	Very coarse gravel
7	4,329	48.2	24.2	Very coarse gravel
8	4,834	50.5	25.6	Very coarse gravel
9	5,404	45.3	25.0	Very coarse gravel
10	5,990	50.6	20.2	Very coarse gravel

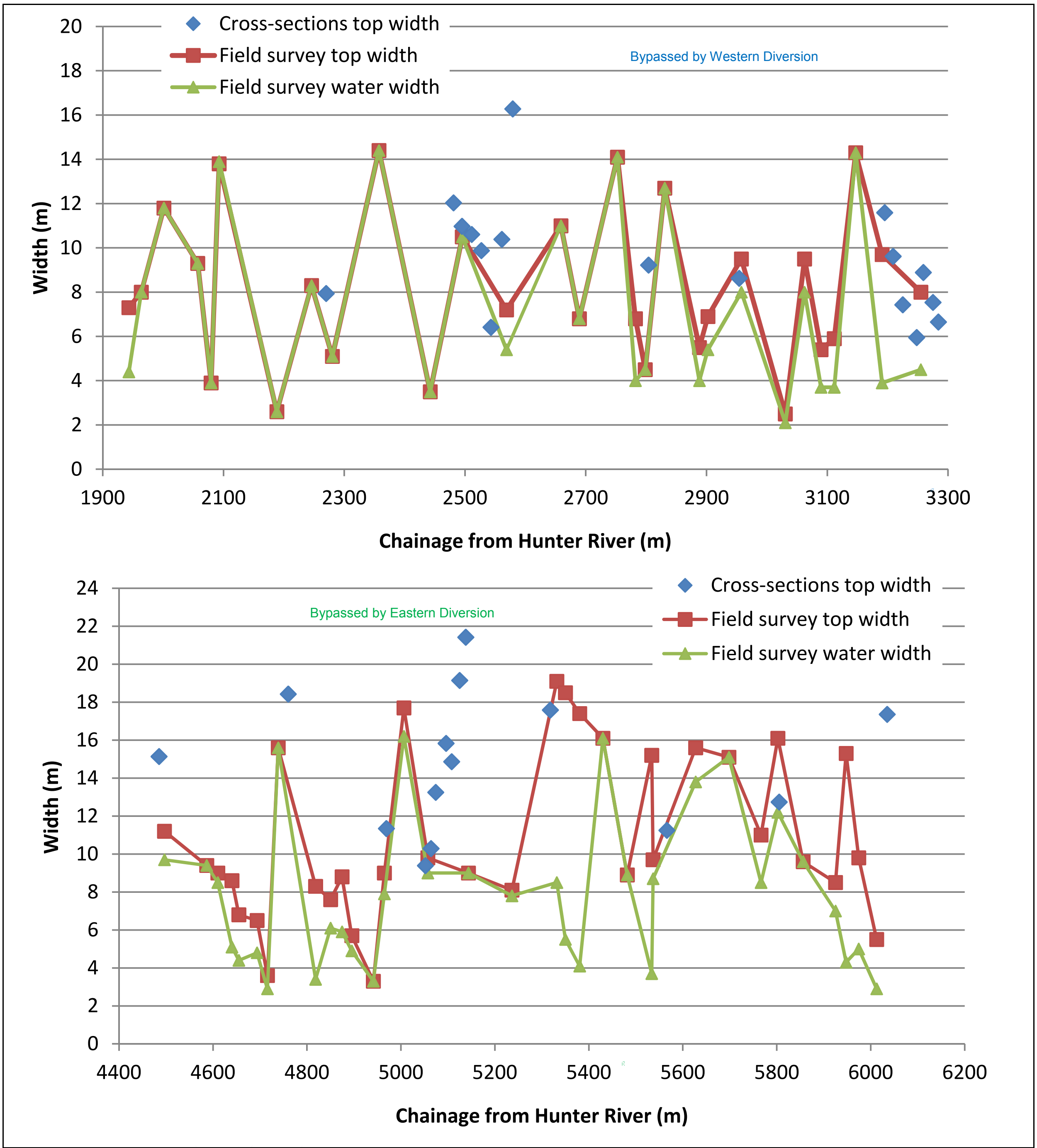

Figure 6 Downstream Pattern of Width of Low Flow Channel

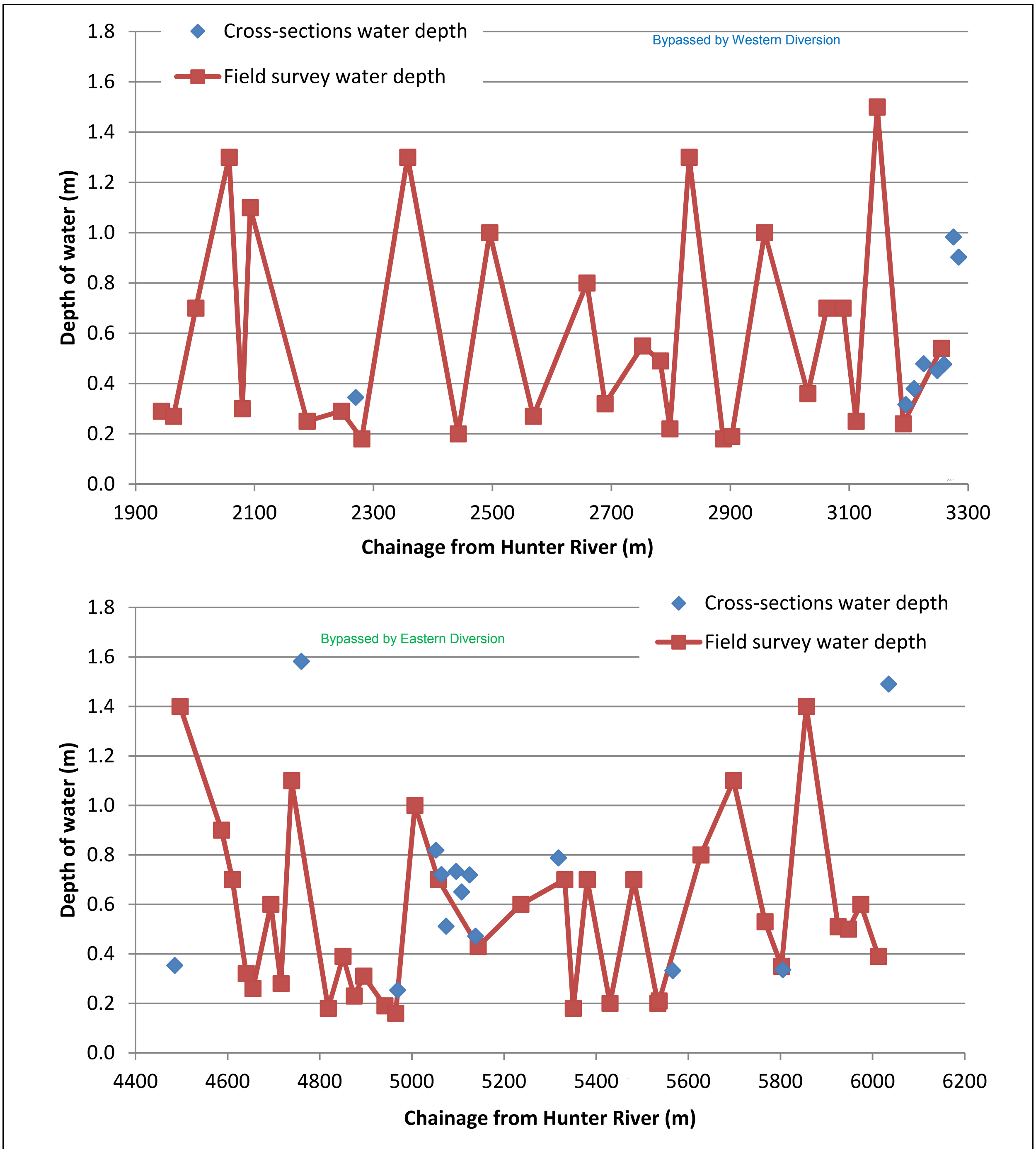

Figure 7 Downstream Pattern of Depth of Water in Low Flow Channel

4.4. Aquatic Ecology

Table 10: Seasonal Macrophyte Occurrence in Bowmans Creek

Type	Common Name	Year >	'07	'07	'08	'08	'09	'09	'10	'11
		Season†	Au	Sp	Au	Sp	Au	Sp	Au	Sp
		Number of sites	4	4	4	6	6	6	6	5
		Species								
Emergent	Cumbungi	*Typha sp*	2	4	4	4	4	5	4	3
Emergent	River Clubrush	*Schoenoplectus validus*					1	3	3	2
Emergent	Common Reed	*Phragmites australis*		3	3	3	3	1	2	1
Emergent	Slender Knotweed	*Persicaria decipens*		3	4				2	
Emergent	Water Ribbon	*Triglochin sp. (T.microtuberosum?)*			1	1	3	3	1	
Emergent	Watercress*	*Nasturtium officinale*							3	
Floating	Duckweed	*Sprirodela spp*							3	
Floating	Pacific Azolla	*Azolla filiculoides*							1	
Floating attached	Water Primrose	*Ludwigia peploides*					1	1	2	
Submerged	Sago Pondweed	*Stuckenia pectinata*			1	3	2	1	4	
Submerged	Clasped Pondweed	*Potamogeton perfoliatus*			2	2	1	1	2	1
Submerged	Curly Pondweed	*Potamogeton crispus*		1	1				1	
Submerged	Watermilfoil	*Myriophyllum sp*				3	5	4	5	4
Submerged	Elodea*	*Elodea canadensis*			2					
		Total Number per Season	1	4	8	6	8	8	13	5

† Sp=spring, Au=autumn
* Introduced species

Table 11: Amphibians Recorded from Bowmans Creek

Species	Common Name	Records	Dates
Crinia signifera	Common eastern froglet	(all surveys)	
Limnodynastes tasmaniensis	Spotted marsh frog	1	Summer 06
Paracrinia haswellii	Red-groined froglet	1	Spring 07
Litoria peronii	Emerald spotted treefrog	??	Spring 07 to spring 08
Litoria latopalmata	Broad-palmed frog	3	Spring 07 to spring 08
Litoria leseuri	Leseur's frog	1	Spring 07
Uperoleia laevigata	Smooth toadlet	1	Autumn 05

Table 12: Fish Species Recorded from Bowmans Creek

Family	Species	Common name/s	Life cycle*	Recorded	Native/ Introduced
Anguillidae	*Anguilla australis*	Short-finned Eel	C	√	N
Anguillidae	*Anguilla reinhardtii*	Long-finned Eel	C	√	N
Atherinidae	*Craterocephalus amniculus*	Darling River Hardyhead	U	√	N (species of concern)
Cyprinidae	*Cyprinus carpio*	Common Carp	L	√	I
Eleotridae	*Gobiomorphus australis*	Striped Gudgeon	A	√	N
Eleotridae	*Gobiomorphus coxii*	Cox's Gudgeon	P	√	N
Eleotridae	*Hypseleotris compressa*	Empire Gudgeon	U	√	N
Eleotridae	*Hypseleotris galii*	Firetail Gudgeon	U	√	N
Eleotridae	*Philypnodon grandiceps*	Flathead Gudgeon	U	√	N
Eleotridae	*Philypnodon macrostomus*	Dwarf Flathead Gudgeon	U	√	N
Mugilidae	*Mugil cephalus*	Sea Mullet	A	√	N
Percichthyidae	*Macquaria novemaculeata*	Australian Bass	C	√	N stocked
Plotosidae	*Tandanus tandanus*	Freshwater Catfish	L	√	N (species of concern)
Poeciliidae	*Gambusia holbrooki*	Plague Minnow	L	√	I
Retropinnidae	*Retropinna semoni*	Australian Smelt	P	√	N

Key:

A - Amphidromous (fish that migrate between the estuary and the sea, but not for breeding purposes).

C - Catadromous (fish that spend most of their lives in freshwater but migrate to the sea to breed).

P - Potadromous (fish that migrate wholly within freshwater).

L - Local (species that require fish passage only in their immediate environment).

U - Unknown

* Life cycle characteristics referenced from Thorncraft & Harris 2000.

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Table 13: Macroinvertebrate Summary Statistics for Bowmans Creek (2005 to 2009)

	Flow Conditions**												
	Dry	Dry	Dry	Low	Low	Low	Low	Low	Med	Med	High	High	High
Flow rate at NOW gauge (ML/d)	N/A	0.4	0.4	0.8-0.9	0.7-0.8	1.7	3.4-3.7	4.9-3.8	20-26	28-25	123-129	370- 636	840-158
Sampler	MPR	TEL	MPR	MPR	TEL	MPR	MPR	MPR	MPR	MPR	MPR	MPR	MPR
No of Sites	2	4	2	6	4	3	6	6	6	4	4	6	4
Year	2001	2006	2006*	2009	2005	2005*	2010	2008	2009	2008	2007	2010	2007
Season and Year	Spring	Autumn	Autumn	Spring	Spring	Spring	Autumn	Spring	Autumn	Autumn	Autumn	Spring	Spring
Total number invertebrate taxa:	8	31	31	46	33	33	40	37	44	32	25	39	30
Mean number of taxa per site:	5.0	15.5	16.3	21.2	20.5	23	17.5	18.8	19.8	18.8	14	19.0	17
Standard Error:	0.0	1.8	4.7	2.6	1.9	3	2.4	1.8	1.9	1.1	2.5	2.0	1.9
Creek SIGNAL scores:	3.88	3.83	4.59	3.55	4.06	4.43	3.35	3.93	3.75	4.00	2.95	3.55	3.64

*Represents aquatic ecology surveys undertaken from upstream Bowmans Creek locations.

** Flow Conditions

Dry = no surface flows during time of sampling between most site pools.

Low = surface flow between all sites, but with generally only trickle flow through riffle zones in the shallow cobble and boulder beds between most pools.

Med = sufficient flow to allow fish passage through most to all of the site

High = sufficient flow to allow fish passage through all of the site with no impediments

5.0 MONITORING – CONSTRUCTION PHASE

5.1. Site Inspections and Maintenance

Construction areas and works will be regularly inspected and checked (using a standardised check sheet) by the Environmental Coordinator and/or Site Superintended and other relevant ACOL staff, where required. Inspections will be carried out:

- Daily.
- Immediately following rainfall events greater than 5 mm in any one 24 hour period.

During site inspections the following will be checked and noted:

- The condition and performance of all erosion and sediment control measures employed, including clean water diversions.
- Low points where ponding could or does occur.
- Blockages in drains are cleared.
- Areas of erosion are repaired (e.g. lined with a suitable material) and/or velocity controls are provided, such as the installation of rock check dams (see Appendix B).
- Any maintenance requirements for erosion and sediment controls (where required).
- The location and type of any additional control requirements.
- Previously identified maintenance or additional control requirements have been implemented.
- Free board and available holding capacity of sediment retention ponds.
- Volume of water and sediment removed from sediment retention ponds, where applicable.
- A copy of the inspection sheet will be provided to the Environment and Community Relations Manager for their records.

All sedimentation systems will be maintained in good working order, with particular attention given to:

- Recent works to ensure that they have not resulted in diversion of sediment laden water away from them.
- Degradable products to ensure they are replaced as required.
- Sediment removal, to ensure the design capacity or less remains in the settling zone of the sediment basin.
- Stabilised areas will be inspected and monitored to ensure that the erosion hazard has been effectively reduced. Any repairs will be initiated as appropriate.

5.2. Surface Water Monitoring Program

The surface water monitoring program provides a means of assessing ongoing surface water flows and quality, impacts on water users, stream health, and the overall performance of the Site water management system and associated infrastructure. It has also been designed to monitor the surface water movements throughout the Mine Water System, and sediment control devices. The data is also utilised to identify trends, potential impacts on natural surface waters, and compare pre- and post-mining conditions. This management plan focuses on the monitoring associated with the activities in the area of the Bowmans Creek Diversions.

Further details of the surface water monitoring program are provided in the ACP Water Management Plan.

5.2.1. Surface Water Quality

Surface water quality and flows are monitored in a range of locations both internal and external to the active ACP operations. The onsite monitoring program is designed to:

- Provide pre-mining baseline flow and quality data and provide a comparison with post-mining conditions.
- Identify potential physical and/or chemical water quality impacts external to the mining area related to mining.
- Identify and confirm trends.
- Assess potential long term mining impacts on stream flow and or quality.
- Provide a holistic view of overall stream health.
- Ensure that the onsite WMS has adequate capacity for the ongoing supply of the operation, storage capacity and to prevent discharges from site.

A rigorous suite of water quality parameters are measured from samples collected (when possible) at all of the surface water monitoring sites.

The water quality in the area of Bowmans Creek is monitored at the locations shown in Figure 2 and listed in Table 15 for the range of parameters shown in Table 14.

Table 14: Surface Water Quality Monitoring Parameters

Analysis Undertaken	Frequency	Monitoring Sites
Screening Analysis: • pH, Electrical Conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), Total Hardness (CaCO3) and Oil and Grease	Monthly/ Opportunistic	All surface water monitoring sites
Comprehensive Analysis: • Physical Parameters – pH, EC, TDS, TSS, Total Hardness ($CaCO^3$) and turbidity • Major Ions – Ca, Mg, Na, K, Cl, SO_4, HCO_3 and CO_3 • Dissolved Metals – Al, As, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se and Zn • Nutrients/other – Ammonia, Nitrate and Fluoride	Annually	

5.2.2. Surface Water Flow

A visual inspection, as per the parameters detailed in Table 16, of streams is recorded at each water quality monitoring site to:

- Provide baseline flow data.
- Assess long term mining impacts on stream flow (potential loss to underground operations).
- Identify and confirm trends.
- Provide a holistic view, along with water quality chemistry, of overall stream health.

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Table 15: Bowmans Creek Water Quality Monitoring

Site No	Location Description	Purpose	Monitoring and Frequency		
			Event Triggered	Monthly	Annually
SM3	Upstream of ACP	Background Provides upstream point for comparison to identify any downstream impacts of mine infrastructure area and/or longwall panels.	Flood event: • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website, compare to flood frequency projections). • Visual observation of areas of increased flooding or unusual ponding or visible areas with surface flooding. • Photo points. Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is an indicator of flow to be correlated with downstream flow gauge 210130). • Areas of increased flooding (large events or unusual ponding). • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.
SM4	At highway crossing	Impact of mine infrastructure area/upstream of longwall panels. Also to identify if the PWD is discharging worked water into the creek system.	Flood event: • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website, compare to flood frequency projections). • Areas of increased flooding or unusual ponding or visible areas with surface flooding or the unlikely occurrence of unexpected surface water drainage to underground. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is an indicator of flow to be correlated with downstream flow gauge 210130). • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis. •	• Water Quality – comprehensive analysis. • Photo points.

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Table 15: Bowmans Creek Water Quality Monitoring (cont'd)

Site No	Location Description	Purpose	Monitoring and Frequency		
			Event Triggered	Monthly	Annually
SM5	At flow gauge weir	Impact of longwall panels/upstream of Narama Mine Dam Discharge	Flood event or level exceeds channel bank and flooding extends over longwall mining areas: • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (record level and check flood flow rate at gauge 210130 using NSW Water Information website: www.waterinfo.nsw.gov.au). • Compare trigger level flood line maps to visible extent of flooding if access is safe and note discrepancies. If comparable to ARI flood event, compare observed extent of flooding to flood maps and note discrepancies. • Areas of increased flooding or unusual ponding. • Visual check in surrounding longwall areas for unlikely flow losses from drainage lines and ponded / flooded areas as indicated by visible ingress of water into subsidence cracks that need urgent repair. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is an indicator of flow to be correlated with flow gauge 210130). • Areas of increased flooding or unusual ponding. • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

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Table 15: Bowmans Creek Water Quality Monitoring (cont'd)

Site No	Location Description	Purpose	Monitoring and Frequency		
			Event Triggered	Monthly	Annually
SM6	Proximal to Hunter River confluence	Cumulative Impact of project and other mines	Flood event or water levels exceed channel bank: • Water level (read gauge plate if access is safe or peg evidence of high water once access is safe). • Flow (if water level is high and Bowmans creek is flooding then flood extent could be affected if flooding also occurs in Hunter River. Check for Hunter River flood conditions by contacting SES and checking BOM websites for floods information and forecasts for Hunter River flooding). • Areas of increased flooding extent relative to maps of floodlines and longwall subsidence zones. • Visual check in surrounding longwall areas for (unlikely) flow losses from drainage lines and ponded / flooded areas as indicated by visible areas of ingress of water to subsidence cracks that need urgent repair. • Photo points. • Field analysis of EC and pH once access is safe.	• Water level – read gauge plate. • Stream flow (gauge plate is indicator of flow to be correlated with flow gauge 210130 for periods when Hunter River is not flooding). • Visual observation of changes to stream banks and surrounding areas. • Observable water quality issues. • Water quality screening analysis.	• Water Quality – comprehensive analysis. • Photo points.

Bowmans Creek Diversion
Management Plan

Table 16: Bowmans Creek Flow Monitoring

Site No	Location description	Purpose	Monitoring Undertaken and Frequency			
			Continuous	Event triggered	Monthly	Annually
BC1	Pool 1 above LW 6B	Level results to be guide the construction of block banks to their final level and to check levels of water in the pool to ascertain needs to supplement pools for ecological purposes	NA	Water level – using installed monitoring staffs for visual recording. Weekly monitoring to be triggered by and continued during mining of LW 6B.	Water level – using installed monitoring staffs for visual recording	NA
BC2	Pool 2 above LW 6B	Level results to be guide the construction of block banks to their final level and to check levels of water in the pool to ascertain needs to supplement pools for ecological purposes	NA	Water level – using installed monitoring staffs for visual recording. Weekly monitoring to be triggered by and continued during mining of LW 6B.	Water level – using installed monitoring staffs for visual recording	NA
FG1	Upstream of Diversions (monitoring site to be installed)	Continuous water level recorder to be used as indicator of flow above the diversion. Levels to be compared and calibrated against NOW gauge 210130.	Flow	Continuous recording data loggers to be checked and data downloaded.	Continuous recording data loggers to be checked and data downloaded.	NA
FG2	Downstream of Diversions (monitoring site to be installed)	Continuous water level recorder to be used as indicator of flow above the diversion. Levels to be compared and calibrated against NOW gauge 210130.	Flow	Continuous recording data loggers to be checked and data downloaded .	Continuous recording data loggers to be checked and data downloaded	NA
	NOW Flow Gauging Station (210130)	Long-term NOW flow gauging. Provides publicly available flow (and water salinity) data.	Flow	Flood event or water levels exceed channel bank Download real time data for flood flow at gauge 210130 using NSW Water Information website. Compare to flood frequency projections	• Download data from NOW website. • Visual observation of changes to stream banks and surrounding areas • Observable water quality issues. • Water quality screening analysis.	Water Quality – comprehensive analysis

5.3. Stream Health, Riparian Vegetation and Groundwater Dependent Ecosystems

Aquatic and ecological monitoring is undertaken to determine if:

- There are measurable differences in aquatic ecological attributes between creek pools upstream, alongside and downstream of the ACP.
- There are observed differences attributable to either mining impacts, spatial reasons (between-site) and/or temporal situations (between-survey).;
- The creeks provide (and continue to provide) a suitable aquatic habitat.
- The creeks continue to provide a suitable fish passage.
- Mining is impacting Groundwater Dependent Ecosystems (GDEs).

The parameters for monitoring stream health, riparian vegetation and GDEs are provided in Table 17. Further details are available in the site wide Flora and Fauna Management Plan.

Table 17: Bowmans Creek Stream Health, Riparian Vegetation and GDE Monitoring

Inspection / Analysis Undertaken	Frequency	Monitoring Sites
Stream health sampling for fish passage and/or field water quality as necessary	Bi-annual (spring / autumn)	Refer Figure 2
Riparian weed levels and as per bi-annual surveys		Refer Figure 2
GDEs as per bi-annual surveys		BCUp, BCDown, BCMW5, BCMW7
Monitoring groundwater levels of the alluvium adjacent to River Red Gum stands (GDEs) on the lower reaches of Bowmans Creek	As per piezometer monitoring schedule	RA15, WML113C, WMLP279 (Figure 3)

5.4. Geomorphology

The bed and bank of the diverted creek will be surveyed:

- Six months, one year and two years after completing construction of the diversion channels.
- At five yearly intervals, or immediately after a flood with a peak flow greater than 150 m^3/s (about 5 years ARI), at existing cross sections in the retained sections of the existing creek. For the purposes of this commitment, flow will be determined from the Office of Water gauging station.
- At five yearly intervals, or immediately after a flood event with a peak flow greater than 150 m^3/s (about 5 years ARI), at ten new cross section locations and along the thalweg of each of the diversion channels. The cross section locations will be established to be representative of the various geomorphic forms within the diverted channels.

At the same time as cross sectional and longitudinal (thalweg) surveys, bed samples will be collected from four locations in each diversion channel (two pools and two riffles).

Samples will also be collected from eight comparable representative sites in the remaining functional sections of the creek for statistical comparison.

If there is a variation of more than 20% in the statistics of the data from the diversions compared to the existing channel, ACOL will commission an appropriately qualified geomorphologist to investigate the causes and recommend any remedial actions.

5.5. Groundwater Monitoring

An extensive and comprehensive monitoring program is in place across the ACP which includes (inter alia) measures to monitor:

- Groundwater levels in the alluvium associated with Bowmans Creek.
- Bowmans Creek alluvial groundwater quality.
- The effects of subsidence on Bowmans Creek alluvial groundwater levels.
- The effects of subsidence on hydraulic conductivity (permeability) of the rock strata underlying Bowmans Creek alluvium.

The locations of groundwater monitoring bores are shown in Figure 3 and a summary of representative Bowmans Creek alluvium monitoring bores is presented in Table 18.

ACOL has undertaken a detailed pre-project inspection of Bowmans Creek, and a water quality study to assess exchange/discharge rates of local groundwater to Bowmans Creek. This assessment will be repeated bi-annually until at least five years after completion of longwall mining.

The trigger level for requiring a revision of impacts against predicted groundwater levels and quality will be an assessed leakage rate from the Bowmans Creek alluvium into the mine that is 1.5 times higher than the rate predicted in the 2009 EA or any subsequent revised prediction.

Further details of the groundwater monitoring program are provided in the ACP Water Management Plan.

Table 18: Bowmans Creek Alluvium Groundwater Monitoring (Representative Bore Locations)

Representative Bowmans Ck Alluvium Monitoring Bores	Purpose	Monitoring and Frequency			
		Event triggered	Fortnightly	Quarterly	Annually
T2A, T5, T7, RA02, RA15, RA18, RA20, RA30, RM6, RM7, RM10, WML113C, WMLP308, WMLP311, WMLP316, WMLP320, WMLP323	• To provide pre-mining baseline water quality data and to compare with post mining • To identify any groundwater level impact due to mining	**Water Level** Prior to mining in proximity to Bowmans Creek and alluvium **Water Quality** Prior to mining in proximity to Bowmans Creek and alluvium: • EC, TDS and pH (in field testing)	**Water Level** Fortnightly during mining activities in proximity to Bowmans Creek and alluvium *(Note some bores are fitted with data loggers and record water levels at 6 hourly intervals)*	**Water Quality** • EC, TDS and pH (in field testing)	**Water Quality** • Analysis

Note a full list of alluvial groundwater monitoring bores is provided in the ACP Water Management Plan

6.0 ROLES AND RESPONSIBILITIES

Responsibilities for particular staff and contractors are provided below:

General Manager

- Has the overall responsibility for works undertaken at the ACP.

Environment and Community Relations Manager (reports to the *General Manager*)

- Engages appropriately qualified personnel to undertake required actions;
- Engages stakeholders to assist with actions as relevant;
- Acts as the interface for environmental and heritage matters between government authorities, private industry, contractors, community groups and the wider community;
- Develops the AEMR;
- Develops solutions to any unplanned events that may potentially result in (or have caused) adverse environmental impacts; and
- Implements the site wide environmental monitoring plans.

Environmental Coordinators (reports to the *Environment and Community Relations Manager*)

- Maintain the environmental monitoring program to gauge the effects of mining operations on surface water and groundwater resources;
- Undertake regular inspections of surface disturbance areas, erosion and sediment control structures and sensitive natural features within the impact envelope of the mining activities;
- Ensure that all personnel onsite conform to the requirements of relevant environmental laws, regulations, consents, approvals, systems and plans;
- Oversee any remediation works and/or the installation of devices and ensure they remain until a area is stabilised; and
- Ensure that contractors on site are appropriately trained and inducted.

All employees and contractors

- Are to abide by the requirements of this Plan;
- Are required to undertake environmental training, including site specific rules and procedures, prior to commencing work onsite. The training will include erosion and sediment control objectives and incident response procedures;
- Are to report defective water management systems and infrastructure to management; and
- Contractors are required to follow the directions of ACOL personnel whilst working onsite and demonstrate that they are trained in the management of erosion and sediment control. In addition, they are to provide an Environmental Control Plan and/or risk assessment if applicable.

7.0 Emergency Contacts

Emergency contacts relevant to this management plan are detailed in Table 19.

Table 19: Emergency Contacts Relevant to the WMP

Role	Contact	Telephone Contact
ACOL		
Ashton Coal Mine	General Enquiries	Hotline: 1800 657 639
ACOL General Manager	Brian Wesley	Tel: (02) 6576 1111 Mob: 0407 025 379
ACOL Environment and Community Relations Manager	Lisa Richards	Tel: (02) 6570 9219 Mob: 0427 462 650 Email: lrichards@ashtoncoal.com.au
Emergency Services and Government Agencies		
Police (Singleton)	-	000 ((02) 6578 7499)
Ambulance	-	000
Office of Environment & Heritage	Environment Line	131 555
Department of Planning & Infrastructure	Mining and Industry Projects	(02) 9228 6111
	Compliance	(02) 6575 3401
Singleton Council	General Enquiries	(02) 6578 7290

8.0 REFERENCES

ACOL (2011) Ashton Coal Mine Construction Mining operations plan Bowmans Creek Diversion

Evans & Peck (2009) Bowmans Creek Diversion Environmental Assessment

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Appendix A

Construction Mining Operations Plan
Bowmans Creek Diversion

(Note: ACOL has made two minor amendments to the approved CMOP. These amendments are described in the attached correspondence to DRE provided in Appendix B)

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ASHTON COAL MINE

CONSTRUCTION MINING OPERATIONS PLAN

BOWMANS CREEK DIVERSION

Version A

Ashton Coal Operations Pty Limited

Glennies Creek Road
Camberwell NSW 2330
Tel: 02 6576 1111
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Version	Date	Description	Author	Reviewer	Approved
A	11/02/11	Ashton CMOP – Bowmans Creek Diversion	M Moore Ashton Coal	L Richards Ashton Coal	M Moore Ashton Coal
A	1/03/11	Ashton CMOP – Bowmans Creek Diversion Revised Plan 6 & new Plan 7	M Moore Ashton Coal	-	M Moore Ashton Coal

Addendum to:

Ashton Coal Mine Mining Operations Plan 2007-2012

Name of Mine	Ashton Coal Mine
Titles / Mining Leas	ML1526, ML 1533 and ML 1623
MOP Commencement Date MOP Completion Date	1/03/2011 31/12/2011
AEMR Commencement Date AEMR Completion Date	1/09/ in each year for the term of the MOP 2/09/ in each subsequent year for the term of the MOP
Name of Leaseholder(s)	White Mining (NSW) Pty Limited Austral - Asia Coal Holdings Pty Ltd ICRA (Ashton) Pty Ltd
Name of Mine Operator	Ashton Coal Operations Pty Limited
Reporting Officer	Brian Wesley
Title	General Manager
Signature	Brian Wesley
Date	11 February 2011

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1.0 INTRODUCTION

1.1. Background

Development consent for the Ashton Coal Project (ACP) was modified on 24 December 2010 (DA 309-11-2001-i MOD 6). The modification allows for:

- Longwall mining that will result in a direct hydraulic connection between the Bowmans Creek alluvium and the underground workings due to connective cracking.
- Amendment of the underground mine plan to optimise resource extraction.
- Diversion of two sections of Bowmans Creek.

Prior to diverting Bowmans Creek the approved creek diversion works need to be incorporated into a Mining Operations Plan (MOP) for the mine, to encompass the approved mine development changes, in accordance with the requirements of mining lease (ML) 1533.

1.2. Document Purpose and Scope

This *Construction Mining Operations Plan* (CMOP) has been prepared as an addendum to the currently approved MOP for the *Ashton Coal Mine, Mining Operations Plan 2007 – 2012* (Hansen Bailey, 2008), as amended on 17 January 2011.

The purpose of this CMOP addendum is to describe:

- Construction activities relevant to the establishment of the creek diversions.
- General staging of creek diversion construction activities.
- Completion criteria for the constructed creek diversion channels.
- Environmental risks associated with the construction activities.
- Management practices and control measures to be implemented during construction of the creek diversions to minimise the risk of environmental impact.
- Monitoring and performance of impact control measures.
- Post-construction landscape rehabilitation objectives.

Specific refinements have been developed within this CMOP to ensure Ashton Coal Operations Pty Limited (ACOL) and its contractors meet all regulatory and statutory requirements associated with the construction of the creek diversions.

This CMOP only covers those activities required to construct the two creek diversions to a point that will enable water to be diverted into the constructed channels. It does not include activities associated with ongoing maintenance, rehabilitation and monitoring of the diversion channels, post construction, or activities or impacts associated with the development and mining of the amended underground mine layout. These will be addressed in detailed management plans, where required, and within an updated MOP for the ACP underground mine. (Note: it is ACOL's intention to revise the existing ACP MOP prior to 30 December 2011).

Construction of each diversion channel is expected to take approximately three months, at which stage it is expected the channels will be hydraulically and geomorphologically stable and capable of accepting diverted creek flows.

Post-construction landscape restoration and habitat augmentation will be carried out in stages according to a specific rehabilitation program, to be implemented for the remaining duration of the mine. This will be described in the revised ACP MOP.

This CMOP should be read in conjunction with the following reports:

- *Ashton Coal Mine Mining Operations Plan 2007 - 2012* (Hansen Bailey, 2008).
- *Bowmans Creek Diversion Environmental Assessment* (EA) (Evans & Peck, 2009).
- *Bowmans Creek Diversion Engineering Design Drawings* C000 to C047 in EA Volume 2, Plan Set 2, as amended (Hyder, 2011).
- *Bowmans Creek Diversion Rehabilitation Strategy* (ACOL, 2010).
- *Bowmans Creek Diversion Landscape Design Drawings* in EA Volume 2, Plan Set 3 (AECOM, 2009).

1.3. Approvals and Licences

The ACP operates under a range of licences and approvals, a full list if which is provided in Table 1 of the current approved MOP (as amended on 17 January, 2011).

The two diversions will be constructed entirely within mining lease (ML) 1533.

1.4. Key Project Contacts

Contact details for key personnel responsible for construction of the diversion channels are provided in Table 1. These are in addition to the contacts provided for the Ashton coal mine in Table 2 of the current approved MOP (as amended on 17 January, 2011).

Table 1: Project Contacts

Title / Responsibility	Contact
Project Manager	Michael Moore Tel: (02) 6576 1111 Email: mmoore@ashtoncoal.com.au
Site Superintendent	Dennis Mann Tel: (02) 6576 1111 Email: dmann@ashtoncoal.com.au
Construction Contractor (Hardy Brothers)	Grant Roach Engineering Manager Tel: (02) 4934 4003 Email: g.roach@hardybros.net.au
Environment and Community Relations Manager	Lisa Richards Tel: (02) 6576 1111 or 1800 657 639 Email: lrichards@ashtoncoal.com.au

1.5. Land Ownership

The two diversions will be constructed on Lot 3 DP 1114623, which is ACOL-owned land.

2.0 PRE-CONSTRUCTION MOP ENVIRONMENT

The pre-MOP environment is described in the current approved ACP MOP (Section 2.1.3), the environmental assessment (EA) for the Bowmans Creek Diversion development consent modification application (Evans & Peck, 2009) and presented on the attached combined MOP Plan 2/3.

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3.0 CREEK DIVERSION CONSTRUCTION ACTIVITIES

3.1. Diversion Design Overview

The design and layout of the approved creek diversions (Eastern and Western Diversions) is shown in Figures 1 to 11, and described briefly as follows:

- Eastern Diversion:

  The Eastern Diversion involves the excavation of a meandering channel in alluvial material east of the existing creek, commencing about 175m south of the New England Highway and extending 955m to the south to join the existing creek. About 140,000m^3 of material will be excavated to a maximum depth of about 5.5m.

- Western Diversion:

  The Western Diversion involves the excavation of a meandering channel in alluvial material west of the existing creek, commencing just downstream of the stream flow monitoring station 210130 (operated by the Office of Water) and extending about 780m to the south to join the existing creek. About 180,000m^3 of material will be excavated to a maximum depth of about 7m.

The diversions have been designed to best practice principles by technical specialists in the fields of hydrology, geomorphology and ecology. The reconstructed creek channels will comprise meanders, rock bars, pool and riffle structures, woody debris, low and high flow channels, variable bed level and variable channel cross section similar to the sections of creek the diversions will replace. The design will ensure that the diverted creek remains stable within the constructed channel section, and that the constructed channels remain stable within the alluvial floodplain.

Following bulk earthworks, the bed of the excavated channels will be backfilled with 200mm of fine silty clay or similar material and shaped to form the base of the creek. This will be overlain with a geosynthetic clay liner (GCL) to form an impermeable barrier[1]. The GCL will extend up the bank to a height greater than 500mm above the permanent ponding water level. A further 200mm of fine silty clay will be placed over the GCL. This will be covered by a single layer of geotextile material. Up to 600mm of a mix of sand gravel and cobble material will be placed on top of the geotextile material to form the bed of the diverted creek channel.

Large rocks will be positioned up and downstream of the pool and riffle structures to prevent bed scour. Bank stability will be enhanced through use of rip-rap on the outside of the tighter bends. Jute mesh and quick growing soil holding cover crops will be used to stabilise the constructed banks. Water will be introduced into the constructed creek channels once these initial bank stabilisation works are complete.

Block banks will be constructed to direct water into the diversion channels and to prevent backwater flooding of the excised sections of the existing creek. The block banks will be constructed to about the same level as the adjacent floodplain. This corresponds to the level of a 1 in 5 year average recurrence interval (ARI) flood. Flows in excess of a 1 in 5 year ARI flood will overtop the block banks and flow across the floodplain and into the excised sections of the creek.

Channel banks will be landscaped and planted with indigenous species to establish a stable but ecologically diverse riparian zone. The objective is to create plant communities that establish rapidly, are species rich, have dense plant cover and naturally resist weed colonisation. A further objective is to provide quick ground-holding characteristics, sufficient to withstand flooding early within the plant establishment period. Landscape restoration, including establishing a functioning riparian zone, will be

[1] GCL will be used to form an impermeable barrier where the diversion channel is constructed within unconsolidated material. However, where the diversion channel is excavated into bedrock, clay will be used as a replacement to the GCL.

staged over a period of about eight years. (Note with the exception of bank stabilisation and erosion control measures, landscape restoration is beyond the scope of this CMOP).

The diversions will be constructed outside the predicted zone of direct connective fracturing resulting from mining of longwall panels. Notwithstanding, the use of a GCL to form an impermeable liner will ensure the preservation of flow transmission, particularly under low flow conditions, and in the unlikely event that longwall mining induced connective cracking impacts on the diversions.

A detailed description of the existing creek and proposed diversion channels, including detailed engineering and landscape drawings, was provided in the publicly exhibited Bowmans Creek diversion EA (Evans and Peck, 2009).

3.2. Construction Hours

Construction activities will be restricted to the following times:

- 7am – 6pm Monday to Saturday
- 8am – 6pm Sunday and Public Holidays

3.3. Construction Staging

Construction will be generally staged as follows:

- Site establishment, including:
  - Site construction compounds and hard stand areas.
  - Survey marks, including diversion channel and material stockpile locations, access tracks, etc.
  - Site fencing, including demarcation of environmentally significant areas (i.e., Aboriginal heritage areas, habitat trees and water course elements to be retained).
- Installation of erosion and sedimentation controls, including clean and dirty water diversions, to be done in accordance with ACOL's existing *Erosion and Sediment Control Management Plan* and DECCW's *Managing Urban Stormwater, Soils and Construction* (DECC, 2008) (see MOP Plan 4/5).
- Stripping and stockpiling of topsoil, to be done in accordance with ACOL's existing *Soil Stripping Management Plan* (White Mining Limited, 2003)(see MOP Plan 4/5).
- Bulk earthworks, using scrapers, bulldozers, excavators and trucks.
- Segregated stockpiling of suitable and non-suitable materials. Suitable materials, such as clays, fine sandy silt, gravel and cobbles, will be individually stockpiled within designated areas for reuse during the reconstruction of the creek channels.
- Ripping and blasting of bedrock, where required. (Note the northern end of the Western Diversion will be excavated into sandstone bedrock).
- Dewatering of saturated alluvium and collection and containment of sediment laden water (from groundwater inflow or rainfall runoff) within and at the downstream end of each channel excavation. All extracted water will be pumped to existing ACP water storages via existing water transfer pipelines.
- Detailed channel shaping involving over-excavation of the low flow channel and trimming of batters. The channel base will be shaped to include deeper pool areas and shallow riffle zones.
- Channel bed forming, comprising (from bottom to top) (refer to Engineering Drawing C002):

- An initial 200mm of fine silty sand or clay bedding material.
- Laying of the GCL (or clay where bedrock is encountered) in accordance with the manufacturers guidelines. This will commence at the downstream end of each channel and progress upstream to ensure the overlapping edge is on the downstream side. The GCL will be anchored at the top of each batter and at the ends of each channel.
- A subsequent layer of fine silty sand material.
- Placement of a geotextile fabric (Bidim A29 or similar) over the fine silty sand material within the area of the stream bed zone.
- Cobbles and gravel to form riffles and pool beds within the low flow channel and inset benches.
- Construction of rock bars upstream and downstream of riffle sections
- Rock armouring on bank outside bends.

- Topsoiling of channel batters, using stockpiled topsoil.
- Stabilisation of channel batters, using jute mesh and seeding with fast growing sterile cover grasses. This may be augmented with spray mulching, turf, or other soil stabilising techniques where required.
- Construction of the initial block banks and installation of additional bank scour protection, where required. Water will be diverted into the constructed creek diversion channels at this stage.
- Landscaping and revegetation works will be carried out on a progressive basis over a number of years, including placement of aquatic and terrestrial habitat features (e.g., woody debris), seeding, tree and shrub tube planting, and weed and feral animal control. (Note this aspect of creek rehabilitation works will be detailed in the revised ACP MOP).

3.4. Site Access

Site access will be via Brunkers Lane (Western Diversion) and Dairy Lane (Eastern Diversion).

Access to site compounds and construction areas will be formed using road base or crushed aggregate

Vehicle access to construction areas (including light and heavy vehicles) will be strictly controlled.

3.5. Erosion and Sediment Control

Erosion and sediment controls will be installed in all areas where runoff from construction and stockpile areas could drain into Bowmans Creek, particularly:

- Along the toe of the stockpile areas closest to the creek.
- Around the area of the block banks.
- At the downstream end of each diversion.
- Around site compounds and access tracks.
- Erosion and sediment control will be undertaken in accordance with ACOL's existing *Erosion and Sediment Control Management Plan* (ACOL 2006a), this CMOP, Engineering Drawings C046 and C047, and MOP Plan 4/5

3.6. Clearing and Vegetation Management

Prior to clearing and disturbance, the flood terrace within 50m of the diversion channels will be slashed or otherwise managed for weeds. This will minimise potential for weeds to invade work areas.

Habitat trees in close proximity to construction activities will be clearly marked and protected. Trees to be cleared will be collected and stockpiled for use as habitat features in the completed channels and for landscaping. All other vegetation will be retained for use in the rehabilitation of the channel batters.

Clearing will be undertaken in accordance with ACOL's existing *Flora and Fauna Management Plan* (ACOL 2006b).

3.7. Soil Stripping

Topsoil will be stripped and stockpiled separately for rehabilitation and revegetation of the diversion batters.

Topsoil stripping, stockpiling and re-spreading will be planned to make optimal use of the available resource and minimise the time that soil is held in a stockpile.

Topsoil stripping and stockpiling will be undertaken in accordance with ACOL's existing *Soil Stripping Management Plan* (White Mining Limited 2003).

3.8. Bulk Earthworks

The majority of the materials required to construct the channel bed, bank batters and block banks will be sourced from excavated materials, which will be stockpiled separately for subsequent re-use.

The volumes and types of materials to be excavated and then re-used in constructing the diversion channels is summarised in Table 2.

Table 2: Estimated Earthworks Quantities

Item	Eastern Diversion (m^3)	Western Diversion (m^3)	Stockpile Areas (m^3)	Total (m^3)
Extraction				
Topsoil stripping (assume 150 mm)	9,200	5,500	14,800	29,500
Bulk earthworks	131,000	175,000	-	306,000
Excavation for stream bed zone	20,000	15,000	-	35,000
Construction				
Sandy silt layer below and above GCL	6,000	3,000		9,000
Cobble backfilling to form channel and terraces	14,500	12,500		27,000
Topsoil on channel batters	7,500	4,500		12,000
Block banks – upstream bulk earthworks	2,000	2,200		4,200
Block banks – downstream bulk earthworks	1,600	1,400		3,000
Topsoil on temporary stockpiles			14,800	14,800
Available for subsidence trough emplacement				360,000
"Spare" topsoil				2,700

Separate stockpiles for these materials will be constructed within the designated stockpile areas (MOP Plan 4/5).

Materials for construction of the block banks will be separately stockpiled close to the location of the block banks (MOP Plan 4/5).

Ripping and blasting of sandstone bedrock will be required where bedrock is encountered, particularly at the northern end of the Western Diversion. Where blasting is required, this will be designed to minimise impacts outside the extent of the diversion channel.

3.9. Stockpiles

Excess material not required for the channels and block banks will be stockpiled separately in one of the designated stockpile areas (MOP Plan 4/5). This material will be used for spreading into subsidence troughs on alluvial flood plain areas to assist create a free-draining post-mine landscape.

The following management measures will be implemented to ensure stockpiles are stable and non-eroding in the long-term:

- Outside batters will be initially formed into bunds, with subsequent stockpiling of materials to occur behind this bunding.
- Sediment fencing will be installed around the toe of stockpile areas, with double fencing along the side facing the existing creek.
- Stockpiles will be developed and shaped to drain away from the outer bund facing the creek.
- Short-term stabilisation will be achieved using jute mesh and grass-seeding.
- Regular inspection, particularly after intense storm events, will be undertaken to ensure the integrity of stockpiles, vegetation and erosion and sediment controls are maintained.
- Regular weed control.

3.10. Block Banks

Block banks will be constructed progressively, in a manner that minimises the risk of flood damage to the diversion channels while providing moderate flow and fish passage through the diversion channels. Block banks will be generally constructed as follows:

- Initially, temporary low level banks (about 1m high) will be constructed in the existing creek near the upstream end of each diversion channel. This will divert all flows up to and including the 6 month ARI. Flows in excess of this will be able to spill over the block banks into the excised section of creek.
- Block banks will be developed to a final height that allows flows up to the 1 in 5 year ARI flood level to be diverted into the diversion channels. This will be done just prior to mining the Upper Liddell seam (approximately 3 years after construction of the temporary banks). However, the permanent block banks may be constructed earlier if monitoring indicates significant inflows into the underground workings from the excised creek channel.
- Downstream block banks will be constructed just prior to mining of the Upper Liddell seam (approximately 3 years after construction of the temporary banks). The downstream block banks will include a culvert with a one-way flap gate to allow water to drain downstream, and prevent ingress of backwater.
- Each permanent block bank will have a small concrete levelling inset into the top to provide a fixed level for overflow of flood water (refer Engineering design Drawing C016).

- Apart from concrete for the levelling wall and large rip-rap for scour protection, all materials required for construction of the block banks will be derived from channel excavation areas.
- The location of block banks is shown on MOP Plan 4/5.

3.11. Materials Import

Materials not sourced on site and required to be imported include:

- Boulders for construction of rock bars and scour protection at selected locations on bends and block banks.
- Additional cobbles for lining the low flow channel and the inset benches, where excavated volumes are deficient.
- Logs to form aquatic habitat features, where insufficient material is available on site.
- Geotextile materials including the GCL and erosion control matting.
- Plant materials, seed and soil ameliorants for revegetation of the diversion channels and excess spoil.

4.0 DIVERSION CONSTRUCTION COMPLETION CRITERIA

ACOL has developed completion criteria for the construction of the creek diversion channels. These criteria are summarised in Table 3.

Table 3: Diversion Construction Completion Criteria

Key Construction / Diversion Element	Completion Criteria and Performance Assessment	Corrective Action
Channel Geometry and Form		
Channel geometry	"As constructed" survey of channel cross sections and longitudinal profile for validation against: • Engineering drawings. • Key physical design objectives (EA Table 2.4). Ten permanent monitoring cross-sections to be established.	Reconstruction of non-conforming elements.
Bed forming	Adequate clay, sand, gravel and cobble materials available. GCL installed with adequate overlap and anchoring as defined by the manufacturer. Bed depth and form constructed to specification, as per design drawings – to be checked by qualified fluvial geomorphologist during construction.	Import additional select materials. GCL checked by supervising manager against manufactures guidelines and engineering drawings. Reconstruction of non-conforming elements.
Bed load	Sample channel bed for particle size analysis at same time as survey – statistics of data from the diversion channels to be within 20% of that from the existing channel	As determined by qualified fluvial geomorphologist.
Rock bars, rock ramps	Construction as per design drawings – to be checked by qualified fluvial geomorphologist post-construction.	Import additional select materials. Repair as necessary.
Rehabilitation		
Site stabilisation (initial works only)	At the completion of channel construction, banks and batters are stabilised with jute mesh and seeded with appropriate cover grasses. Seeding to achieve 70% ground cover within 2 months.	Re-topsoil and re-seed any bare patches. Water as necessary. Augment with additional / alternate erosion control measures, where required.

Table 3: Diversion Construction Completion Criteria

Key Construction / Diversion Element	Completion Criteria and Performance Assessment	Corrective Action
Stockpiles		
Presence of silt fencing	Required silt fencing in place.	Install / repair silt fencing.
Revegetation	External bund face vegetation achieves 70% ground cover within 2 months of seeding.	Re-seed any bare patches. Water as necessary.
Construction Infrastructure		
Haul / access roads and construction compound	Haul roads and construction compound removed, including temporary waterway crossings, and all disturbed areas topsoiled, revegetated and stabilised	Repair erosion as necessary and re-topsoil and seed any bare patches.
Other		
Stock Management	Stock exclusion fencing installed. Stock watering troughs installed, where required.	Install / repair fencing and watering troughs

It is ACOL's intention to divert creek flows into the constructed diversion channels immediately following the initial post-construction stabilisation work (i.e. once upper banks and batters are stabilised with jute mesh and seeded with appropriate cover grasses).

Additional completion criteria have been developed for subsequent rehabilitation activities, establishment of aquatic and riparian habitat and long-term monitoring of channel geometry and bed load. These activities are outside the scope of this CMOP and will be addressed by subsequent management plans (in preparation) and in the revised ACP MOP. Further detail of these additional rehabilitation activities is provided in the *Bowmans Creek Diversion Rehabilitation Strategy* (ACOL 2010) attached as Appendix D.

5.0 REHABILITATION

5.1. Rehabilitation Objectives

The modified development consent (DA 309-11-2001-i) includes rehabilitation objectives for Bowmans Creek and the Eastern and Western Diversions. These objectives require the diversions and retained creek sections to be:

Hydraulically and geomorphologically stable, with riparian vegetation that is the same or better than existing in the adjacent channel prior to mining.

In addition, ACOL has made various commitments in relation to constructing and rehabilitating the two diversion channels (see Appendix A).

5.2. Rehabilitation Strategy and Techniques

A rehabilitation strategy has been developed to complement the physical foundations inherent in the design and construction of the diversion channels, including:

- Mimicking existing channels to provide comparable hydraulic conditions.
- Cobble lining of low flow channel and low active floodplain to provide bed stability comparable to the existing creek.
- Extensive use of erosion control matting to provide additional stabilisation during the plant establishment phase.
- Staged diversion of flow into diversion channels to reduce the risk of damage during the early phases of rehabilitation.

The overall objective of the rehabilitation strategy is to re-establish plant communities that are characteristic of those present prior to European colonisation, including River Red Gums. The strategy also aims to create plant communities that establish rapidly, are species rich and have dense plant cover, so as to achieve:

- Quick ground-holding characteristics sufficient to withstand flooding early within the plant establishment period.
- Resistance to on-going weed colonisation, maximising the potential for natural colonisation / regeneration of the planted species, particularly the native grasses.
- A diverse suite of endemic species that maximise the potential for colonising of new niches as they become available within the developing community.
- High plant cover rates to ensure the communities will have natural resistance to weed colonisation, good ground-holding characteristics sufficient for a range of periodic flood events, and sufficient species diversity to develop into an appropriate climax community.

A key aim of the project is to provide a flexible, cost effective and adaptive approach to the restoration process, which takes advantage of the opportunities offered by the relatively long life of the project (i.e., over a period of about 14 years). However, rehabilitation and revegetation activities post initial construction are beyond the scope of this CMOP.

Revegetation will be undertaken in accordance with ACOL's approved management plans (i.e., *Landscape and Revegetation Management Plan* (ACOL 2006c) *Weed Management Plan* (ACOL 2006d) as well as the site specific requirements set out in -

- *Landscape Restoration Report* (EA - Appendix 10) (AECOM 2009a).
- *Landscape Design Drawings* (EA - Plan Set 3) (AECOM 2009b).

Rehabilitation and landscape restoration works will be undertaken gradually and in a staged and adaptive manner. As previously indicated, the initial focus will be on site stabilisation. This will be followed by native grass planting and a gradual building up of community structure and species richness, until a robust, and relatively low maintenance, self-perpetuating corridor community is created.

A typical section of the rehabilitated diversion channels showing planting zones is provided in Figure 12.

5.3. Post-Construction Site Stabilisation

Initial site stabilisation works will be undertaken progressively, generally in an upstream direction as the channels are completed. The aim of this phase is to quickly stabilise the constructed channels. This will be achieved using jute mesh and direct seeding on topsoiled batter slopes and flood terrace edge.

The performance of site stabilisation and initial seeding will be regularly assessed to ensure:

- Adequate plant cover is achieved and maintained with minimal exotic species cover.
- Batter slopes are stabilised and scour on the low active floodplain and inset benches is minimised.
- Corrective actions will be implemented where monitoring indicates poor functioning of this initial stabilisation phase (see Section 6.3 of the *Rehabilitation Strategy* in Appendix D).

Water will be introduced into the constructed creek channels once these initial bank stabilisation works are complete.

5.4. Planting Methods

5.4.1. Direct Seeding

Direct seeding of a select suite of grasses will be undertaken on batter slopes and flood terrace edge to provide a dense, weed resistant cover, into which later staged planting will be undertaken.

The aim is to achieve a dense cover of native grasses to provide a robust weed barrier between the constructed channels and the adjoining existing pasture grass and weed community on the adjacent flood terrace. Select native grass species to be used in direct seeding will include:

- *Capillipedium spicigerum* (Scented-top Grass).
- *Cynodon dactlyon* (Common Couch).
- *Sorghum leiocladum* (Wild Sorghum).
- *Themeda australis* (Kangaroo grass).

These are species that have previously performed well in direct seeding applications.

Alternatively, a sterile cover crop may be judiciously used to assist in topsoil stabilisation and weed suppression, without unduly compromising the growth of subsequently planted young native seedlings.

If large areas of direct seeding fail to colonise the following actions will be undertaken:

- In areas where there is a risk of erosion and weed infestation, direct seeding will be repeated but with a greater focus on sterile stabilising grasses. Once the area is stabilised, the area will be planted with a combination of seeding and tube stock.
- In more stable areas, direct seeding of native local species will be repeated and followed up with increased maintenance and watering.

5.4.2. Long-stem Tubes

Following the initial stabilisation works, additional floristic and structural diversity will be progressively achieved over a greater time frame, through targeted seeding and tube stock planting. (This is beyond the scope of this CMOP).

This will include the sequenced planting of long-stem River Oak tubes (developed specifically for riparian situations) followed by planting of other common Hunter Valley River Oak Forest community native species.

5.5. Weed Control

Weed control will be regularly undertaken to ensure uptake of native species is optimised. Initially this will require regular inspection and active control. However, in the longer-term, the aim will be to use native species selection and plantings that provide natural weed control.

5.6. Watering

Watering will generally be required at least in the few months directly following each direct seeding and planting event. This will either be achieved using water carts or through establishment of irrigation works.

5.7. Fencing

Stock proof fencing will be installed along the length of and down both sides of each diversion channel to exclude cattle and to protect landscape and revegetation works.

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6.0 ENVIRONMENTAL RISK

Table 4 outlines potential impacts that may result from the construction of the diversion channels, including impacts related to restoration of Bowmans Creek (both retained and excised creek sections).

Table 4: Creek Diversion CMOP Risk Matrix

Issue	Land preparation	Construction activities (including earth moving)	Operation	Use / maintenance of roads, tracks and vehicles	Water management (including storm event)	Hazardous materials & spill management	Other infrastructure use and operation	Rubbish disposal	Rehabilitation activities	Rehabilitation maintenance	Rehabilitated land and remaining features	Comments
Erosion and Sediment Control	X	X	X		X				X	X		Erosion and sediment control for the construction works will be undertaken in accordance the relevant aspects of ACOL's existing *Erosion and Sediment Control Management Plan* and *Soil Stripping Management Plan*. Additional specific erosion and sediment control measures have been incorporated into this CMOP and include reference to the DECCW's *Managing Urban Stormwater, Soils and Construction*. This includes use of clean water diversions, sediment fencing, hay bales, jute mesh and direct seeding to stabilize disturbed areas.

Issue	Land preparation	Construction activities (including earth moving)	Operation	Use / maintenance of roads, tracks and vehicles	Water management (including storm event)	Hazardous materials & spill management	Other infrastructure use and operation	Rubbish disposal	Rehabilitation activities	Rehabilitation maintenance	Rehabilitated land and remaining features	Comments
Surface Water	X	X	X	X	X	X			X	X		Potential for loss of water from the diverted creek will be minimised by providing an impermeable liner in the bed of the diversion channels. All construction and restoration works will be undertaken generally in accordance with the Rehabilitation Strategy (Appendix D). Storage and handling of fuel, oil and other potential water contaminants will be restricted to designated areas within construction compounds away from surface water sources. The constructed channels and channel bed will be assessed by a suitable qualified and experienced fluvial geomorphologist. The existing ACOL surface water quality monitoring program will continue to be implemented. Operational response plans will be implemented. (Note this is outside the scope of this CMOP).

Issue	Land preparation	Construction activities (including earth moving)	Operation	Use / maintenance of roads, tracks and vehicles	Water management (including storm event)	Hazardous materials & spill management	Other infrastructure use and operation	Rubbish disposal	Rehabilitation activities	Rehabilitation maintenance	Rehabilitated land and remaining features	Comments
Groundwater		X				X						Potential impacts on groundwater quality will be avoided through management of construction activities and placement of contamination sources away from the alluvial aquifer. The existing ACOL groundwater quality monitoring program will continue to be implemented. Take of groundwater will be appropriately licensed.
Flora and Fauna	X	X	X						X	X		Clearing will be undertaken in accordance with ACOL's existing *Flora and Fauna Management Plan* (ACOL 2006a) The diversion channels are designed to maintain fish passage under at least moderate flow conditions and to provide rest pools and other habitat (such as woody debris) features. (Note installation of aquatic habitat features is outside the scope of this CMOP).
Weeds	X	X	X						X	X	X	Weed management will be undertaken in accordance with ACOL's existing *Weed Management Plan*, including regular monitoring of construction disturbance areas, stockpiles and rehabilitated areas.

Issue	Land preparation	Construction activities (including earth moving)	Operation	Use / maintenance of roads, tracks and vehicles	Water management (including storm event)	Hazardous materials & spill management	Other infrastructure use and operation	Rubbish disposal	Rehabilitation activities	Rehabilitation maintenance	Rehabilitated land and remaining features	Comments
Aboriginal Heritage	X	X							X			The management of Aboriginal heritage will be undertaken in accordance with ACOL's existing *Archaeology and Cultural Heritage Management Plan*, which includes consultation with the registered Aboriginal Stakeholders. All workers will be inducted to be aware of Aboriginal heritage and informed of appropriate site management procedures. Construction work will comply with the requirements of an approved AHIP and section 90 certificates (*National Parks and Wildlife Act 1974*).
Noise	X	X							X	X	X	Construction noise will be minimised by limiting use of heavy machinery for construction to daylight hours (7am to 6pm Monday to Saturday and 8am to 6pm Sunday and public holidays). Mitigation and management will be undertaken in accordance with ACOL's existing EMS.

Issue	Land preparation	Construction activities (including earth moving)	Operation	Use / maintenance of roads, tracks and vehicles	Water management (including storm event)	Hazardous materials & spill management	Other infrastructure use and operation	Rubbish disposal	Rehabilitation activities	Rehabilitation maintenance	Rehabilitated land and remaining features	Comments
Air Quality	X	X							X			Construction activities will generate dust emissions. Air quality will be managed and monitored in accordance with ACOL's existing EMS, which includes use of dust suppression techniques, such as use of water carts.
Traffic	X	X										Construction traffic will be managed in accordance with a *Construction Traffic Management Plan* prepared to the satisfaction of the RTA.
Waste	X	X						X				Waste management will be undertaken in accordance with ACOL's existing *Waste Management Plan*, including reuse of salvaged vegetation in the final landscape.

7.0 Environmental Management

7.1. Site Inductions

Construction activities will be undertaken in close proximity to Bowmans Creek and known Aboriginal sites, hence a high standard of environmental management will be required to be implemented.

Consequently, all workers entering the site for the first time will be given an induction that makes specific reference to:

- "No-go" Aboriginal heritage areas adjacent to the defined works area.
- Awareness of the potential for discovery of Aboriginal artefacts during the excavation process and the requirement to immediately stop work and seek expert advice.
- The purpose of site barrier fencing and the requirement for all workers and machinery to remain within fenced areas, unless otherwise authorised.
- The requirement to avoid contamination of surface water within Bowmans Creek.
- The requirement to avoid damage to specifically identified trees that will be appropriately marked and fenced (e.g., with orange safety fencing).
- The requirement to minimise removal of existing trees wherever possible, even if these are located within the designated works area.
- The requirement to minimise site disturbance as much as practically possible, without compromising safety.
- Site health and safety policy.
- Site environmental policies including avoidance of fuel spills, erosion and sediment control and waste management.

7.2. Erosion and Sediment Control

7.2.1. Overview

Erosion and sediment control measures contained within this CMOP have been designed in accordance with the following guidelines and management plans:

- *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) "Blue Book".
- *Managing Urban Stormwater: Soils and Construction Volume 2E* (DECC, 2008).
- *Erosion and Sediment Control Plan, Ashton Coal Mine* (ACOL, 2006a).
- *Soil Stripping Management Plan, Ashton Coal Project* (White Mining Limited, 2003).

In addition, erosion and sediment control measures will be implemented in accordance with the following general principles:

- Implementing erosion and sediment control measures prior to disturbance, wherever practicable.
- Diverting clean water away from disturbance areas, wherever practicable.
- Maintaining erosion controls for the duration of construction activities until such time that the site is considered stable.
- Implementing measures to prevent erosion from within disturbed and rehabilitating areas.
- Capturing runoff from disturbed areas and transferring to ACOL's surface operations for use within the existing ACP water management system.

- Regularly (daily) inspecting and maintaining all erosion and sediment controls for the duration of construction activities.
- Reviewing implementation of the erosion and sediment control plan where necessary.

A summary of site soil characteristics and design criteria adopted for the erosion and sediment control works is provided in Table 5 and Table 6 respectively.

Table 5: Site Characteristics

Constraint / Characteristic	Value	Source
Rainfall R-factor	R = 1410	Calculation
Rainfall Zone	Zone 6	Blue Book Vol 1, Figure 4.9
Potential Erosion Hazard	Low (for slopes below 15%)	Blue Book Vol 1, Figure 4.6
Soil Erodibility	K = 0.037	Adopted worst case for 'hu – Hunter Soil Landscape'
Soil Texture Group	Type D	Adopted worst case
Soil Dispersiveness	Unknown	
Soil Hydrologic Group	Group C	Typical for hu – Hunter soil landscape
Duration of Disturbance	6 – 12 months	
Sensitivity of Receiving Environment	"Sensitive"	Proximity to Bowmans Creek

Table 6: Erosion Controls Design Criteria

Control Measure	Design Standard
Temporary drainage (erosion) controls:	1 in 10yr ARI
Temporary sediment control measures:	1 in 10yr ARI
Sediment retention basin (designed to achieve required water quality for storms up to nominated five-day duration percentile event): Embankment and spillway structurally sound in:	85^{th} percentile 1 in 50 year ARI

Site and activity specific erosion and sediment control measures will be implemented for each of the following work phases:

- Site establishment, clearing and bulk earthworks, comprising:
  - Vegetation clearing and associated disturbance of topsoil.
  - Large areas of exposed soils and handling/movement of alluvial material.
  - Potential for stormwater runoff to enter the site from upslope areas.
  - Proximity of natural watercourse (Bowmans Creek) and potential for off-site migration of sediment.
- Channel construction, comprising:
  - Ongoing handling / movement of alluvial materials.
  - Progressive rehabilitation as construction of diversion progresses upstream.

  - Cut and fill batters rehabilitated but not yet established / stabilised.
  - Ongoing handling of large quantities of fill material and stockpile management.
- Post-Construction, comprising:
  - Vegetation of batters and other erosion prevention measure will require monitoring and maintenance until fully established / stabilised.

7.2.2. Soil Stripping and Topsoil Handling

ACOL's existing *Soil Stripping Management Plan* describes the following measures to be implemented to control erosion and offsite sediment release during stripping and stockpiling of topsoil material:

- Keep vehicular traffic to a minimum on the soils to be stripped.
- During the stripping process there may be some unexpected changes in the depth and the nature of the soil. Avoid where practical the inclusion of obviously poorer quality material such as sub-soil clay with mottles, saline material and material dominated with stones.
- Strip material when it is in a lightly moist condition. Avoid stripping material in either dry or wet conditions in order to minimise degradation of soil structure.
- Use a combination of dozer and front-end loader, or less preferably a scraper, to strip soil material.
- Where possible, place soil material directly onto completed sections of the channel diversion works or long-term stockpiles and spread immediately to maximise the retention of soil quality.
- Topsoil stockpiles will be developed to minimise problems with anaerobic conditions.
- When placing topsoil over rehabilitation areas, scarify the ground surface along the line of the contour to a depth of 50 to 100mm to break up any hard setting / compacted surfaces and to provide a good bond between the topsoil and subsoil.
- Ensure that the soil stripping and spreading process is managed by a competent supervisor who is aware of the above principles and familiar with the handling of soil materials.

7.2.3. Construction Access Roads and Compound

During the construction of haul roads and site compounds the following erosion controls will be applied as a minimum:

- All work will remain within the disturbance boundary, as designated by exclusion fencing.
- Install sediment fencing (see typical details in Appendix B) on the down slope side of all roads and around the construction compound and maintain for the duration of works.
- Strip topsoil to the limits of the proposed road / compound footprint, plus allowance each side for access where applicable, and haul topsoil to the designated stockpile location.
- Construct haul roads and compound area using standard stabilised access of road base or crushed aggregate.
- Where access roads cross minor drainage lines, provide temporary waterway crossing with rock check dams placed downstream of pipe outlet (typical detail provided in Appendix B).
- Access roads and construction compound to be removed at the completion of construction, with all disturbed areas to be topsoiled, revegetated and stabilised prior to temporary erosion controls being removed.

7.2.4. Stockpile Areas

Topsoil and fill materials excavated during channel construction will be stockpiled in designated areas (see MOP Plan 4/5). All stockpiles will be located at least 40m from the top bank of Bowmans Creek. At this distance, stockpiles will generally be sited above the 1 in 20 year ARI flood level.

All stockpile areas will be managed as follows:

- Two separated lines of silt fencing will be installed between the exterior limits of each stockpile area and Bowmans Creek (or minor waterway) and maintained for the life of the stockpile.
- Initial stockpile material will be placed and compacted to create a bund around the exterior of the stockpile area. This bund will form a barrier between subsequent stockpiling and soil handling areas and Bowmans Creek.
- The outer batter of the bunds will be topsoiled, grass-seeded and covered with jute mesh as soon as practical to establish adequate grass coverage.
- Access to the stockpile areas will be via designated locations only.
- Designate each topsoil stockpile with appropriate signage (e.g., 'Topsoil Stockpile') to ensure the resource is identifiable to all construction staff.
- Stockpiles of excess non-suitable excavated material will be shaped to be free-draining and revegetated as soon as practicable to minimise loss of soil quality. The minimum works involve placement of biodegradable matting (i.e. jute mesh) and under sowing of a cover crop.
- Ensure a good vegetative cover is maintained on stock piles and on top dressed areas.
- The development of the stockpiles within a stabilised earthen bund will provide added protection from the risk of potential flood damage, in the event of a major flood (i.e., greater than 1 in 20 year ARI flood event).

7.2.5. Clean Water Drain

A temporary shallow channel will be constructed to divert water from undisturbed catchments around the construction zone for the Eastern Diversion. The diversion will be implemented as soon as practicable prior to the commencement of clearing and site preparation phase. Details of the clean water diversion are shown in MOP Plan 4/5. The diversion has been sized to safely convey 1 in 10 year local catchment flows, in accordance with *Managing Urban Stormwater: Soils and Construction Volume 2E* (DECCW, 2008).

Other temporary clean water diversions are not required elsewhere due to the nature of the local topography. However, if areas of potential inflows (i.e. overland sheet flow) are noted during construction, then small temporary berms will be formed at the top of the cut batters to prevent scour of the batters and to divert water around the excavation.

Hay bale filters (or similar) will be installed at intervals to control the velocity of water and prevent scouring of the channel bed. Where concentrated inflows occur from local drainage depressions, additional hay bales or rock will be used to minimise scour potential.

Clean water will be directed along the diversion to an area that is stable and with good vegetative cover for outflow to a local drainage line outside the construction area. Scour protection in the form of placed rock will be provided, where required. The temporary diversion will be remediated and revegetated once the bulk earthworks and construction phase stabilisation works are completed.

7.2.6. Creek Diversion Channel Bulk Earthworks

A barrier of existing alluvial material will be maintained at both the upstream and downstream ends of each diversion channel. This will ensure creek flow does not enter the excavation and sediment laden water within the excavation does not enter the creek. These barriers will be maintained until construction and initial rehabilitation works are stabilised, prior to opening the channel and diverting flow.

A sump and temporary pump arrangement will be established at the downstream end of each channel to manage runoff and groundwater inflow into the excavation. Constrained sediment laden water will be either used for dust suppression purposes or transferred to the ACP for reuse.

The storage volume required at the downstream extent of the excavation was determined in accordance with procedures contained within the Blue Book for an 85th percentile, 5 day rain event. A copy of the calculation is provided in Appendix C:

- Eastern Diversion (and adjacent Stockpile) - 4100 m^3
- Western Diversion - 811 m^3

Review of the engineering drawings, and particularly the design cross sections, indicates there will be sufficient volume within the excavated channels to contain the above estimated runoff volumes. This will be confirmed by survey as soon as practicable upon excavation of the channel.

Entrained water will not be allowed to pond for any significant period of time to avoid impacts on completed stabilisation works and to ensure sufficient capture capacity for any subsequent rain events.

If determined necessary during excavation and construction of the channels, this temporary sump and pump arrangement may be duplicated at intervals along the excavated channels.

Control of flooding and associated impacts on construction areas was considered in the overall design of construction works (e.g. siting and design of stockpiles, siting of construction compounds and hard stand areas, no flow areas at each end of excavated channels prior to stabilisation, design and height of block banks).

While the probability of a flood occurring during construction is relatively low, some damage may occur to the bulk earthworks and any early rehabilitation works. Depending on the size of the flood event the majority of flood flows will be contained within the existing natural creek channel. However, in the event that a flood does occur during construction, impacts to the excavated channels or rehabilitated early areas will be remediated as soon as practicable.

7.2.7. Block Banks

Construction of the block banks and direction of flow into the diversion channels will not occur until relevant technical specialists have inspected and confirmed that the excavation, shaping and initial rehabilitation works are completed and considered likely to be stable under low flow conditions.

Following this inspection, the excavation of the upstream and downstream ends of the diversion channels will be completed, along with the relevant shaping and initial rehabilitation works. Low flows will then be directed down the completed creek diversions using minor temporary bunding to allow the construction of the initial block banks.

To minimise the potential impacts on creek flows and prevent scour / erosion, the block banks will be constructed as follows:

- Works will be planned to be completed in as short a time frame as possible, and consideration given to the weather forecast for the planned works period.
- Erosion controls will be implemented at all times downstream of the block bank locations (i.e., securely anchored hay bale filters – refer to standard drawings provided in Appendix B).
- Where possible, minor flows will be diverted around the active work area and into the completed diversion channel using temporary minor bunding.
- Finished batters will be topsoiled, grass-seeded and covered with jute mesh as soon as practical, to establish adequate grass coverage.
- Rock scour protection will be installed as soon as practicable (as specified on the Engineering Design Drawings).

7.2.8. Site Inspections and Maintenance

Construction areas and works will be regularly inspected and checked (using a standardised check sheet) by the Site Superintended and other relevant ACOL staff, where required. Inspections will be carried out:

- Daily.
- Immediately following rainfall events greater than 5mm in any one 24 hour period.

During site inspections the following will be checked and noted:

- The condition and performance of all erosion and sediment control measures employed, including clean water diversions.
- Low points where ponding could or does occur.
- Blockages in drains are cleared.
- Areas of erosion are repaired (e.g. lined with a suitable material) and/or velocity controls are provided, such as the installation of rock check dams (see Appendix B).
- Any maintenance requirements for erosion and sediment controls (where required).
- The location and type of any additional control requirements.
- Previously identified maintenance or additional control requirements have been implemented.
- Free board and available holding capacity of sediment retention ponds.
- Volume of water and sediment removed from sediment retention ponds, where applicable.
- A copy of the inspection sheet will be provided to the Environment and Community Relations Manager for their records.

All sedimentation systems will be maintained in good working order, with particular attention given to:

- Recent works to ensure that they have not resulted in diversion of sediment laden water away from them.
- Degradable products to ensure they are replaced as required.
- Sediment removal, to ensure the design capacity or less remains in the settling zone of the sediment basin.
- Stabilised areas will be inspected and monitored to ensure that the erosion hazard has been effectively reduced. Any repairs will be initiated as appropriate.

7.3. Water

7.3.1. Surface Water Quality

The key risk to surface water quality relates to management of soil and water within and around the construction areas, as previously described (Section 7.2), as well as the storage and handling of fuel, oil other potential water contaminants. In addition to previously described controls the following measures will be implemented:

- Construction compound and vehicle hard stand areas will be located above the 1 in 5 year ARI flood level.
- Bunded storage of fuel and oils for plant and equipment will be provided within the construction compound.
- No storage, transfer or handling of fuel or chemicals will occur outside of designated bunded areas.

Water quality monitoring is conducted under ACOL's existing *Site Water Management Plan*. Existing water quality monitoring locations are located immediately upstream (SM4), between the eastern and western diversion (SM5) and downstream (SM6) of the diversion channel construction areas. During construction, weekly surface water monitoring will be undertaken at these locations for the following parameters:

- pH.
- Electrical conductivity.
- Non-filterable residue.
- Oil and grease.
- Total dissolved solids.

Results will be compared to the trigger levels contained within the *Site Water Management Plan* and a brief report provided to the Environment and Community Relations Manager.

Where monitoring indicates construction activities are impacting surface water quality in the natural sections of Bowmans Creek:

- The Environment and Community Relations Manager will be notified immediately.
- Relevant government authorities will be notified.
- Works will cease until:
    - The source of water quality degradation can be identified and the erosion control works reviewed (or as otherwise required) to remediate the problem.
    - Approval is granted by the Environment and Community Relations Manager.

7.3.2. Groundwater Quality

The key risk to groundwater quality relates to storage, handling and use of fuel, oil and other potential groundwater contaminants. The following measures will be implemented to ensure groundwater quality is adequately protected during the construction and rehabilitation of the diversion channels:

- Construction compound and vehicle hard stand areas will be located above the 1 in 5 year ARI flood level.
- Bunded storage of fuel and oils for plant and equipment will be provided within the construction compound.
- No storage, transfer or handling of fuel or chemicals will occur outside of designated bunded areas.

Groundwater quality will be monitored in accordance with ACOL's existing *Site Water Management Plan.*

The diversion design incorporates an impermeable membrane (GCL) in the base of the reconstructed creek channels to minimise post-construction groundwater – surface water interaction. This is required to minimise the potential for loss of creek flow due to mine subsidence following longwall mining. While surface flows will be preserved, alluvial groundwater levels will be lowered due to increased hydraulic permeability in the underlying strata as a result of mine subsidence. (Note management of groundwater, post-construction, is outside the scope of this CMOP).

7.4. Flora and Fauna

All vegetation clearing activities will be undertaken in accordance with ACOL's existing *Flora and Fauna Management Plan* (ACOL 2006b). In addition, the following controls will be implemented during construction:

- Barrier fencing will be erected to demarcate construction exclusion zones and prevent inadvertent impacts to vegetation being retained.
- Hollow bearing trees located close to construction and stockpile areas will be clearly marked and protected.
- Trees required to be cleared will be inspected for arboreal fauna prior to clearing.

- Cleared trees will be stockpiled for reuse as habitat features (terrestrial and aquatic) in the final landscape.

The construction of the diversion channels presents an opportunity to develop improved ecological function compared to that existing along the current creek alignment. This will be achieved through landscaping, planting with native species to create a riparian zone and adjacent woodland, fencing to exclude stock from the creek and implementation of aquatic habitat features. The increased extent of native vegetation to be established will also increase and improve the availability of wildlife habitat and enhance connectivity with nearby woodland areas.

7.5. Weeds

Very high weed densities are present on the flood terrace within which the diversions will be constructed, particularly within the areas of improved pasture.

Works will be carried out in accordance with ACOL's existing *Weed Management Plan* (ACOL 2006d). Management actions specific to the construction of the creek diversions will include:

- Slashing pasture areas prior to clearing and topsoil scalping to minimise the extent of weed seed input to work areas.
- Treatment of stockpiled soils to minimise the opportunity for weed colonisation in rehabilitated areas, where required.
- Treatment of areas to be rehabilitated with glyphosate (e.g., Roundup Bioactive) prior to undertaking restoration treatments, where required.
- Regular weed management of rehabilitated areas until a dense native plant cover is in place, sufficient to provide natural regeneration of native species and minimise habitat / colonisation opportunities for weeds.

Regular monitoring of regeneration sites will identify potential problem areas before weeds take hold. If large areas are identified as being destabilised by weeds, the following weed removal methods will be implemented:

- Intensive herbicide application.
- Hand or mechanical removal.

Weed competition with tube stock for resources can be a major problem. This will be combated with the use of long-stem tube stock in later stages of the landscape restoration and vegetation works following completion of construction activities. Long-stem tube stock of fast growing colonising species will be farmed especially for contingency planting. These areas will be planted in high densities to improve competitive advantage against weeds. Once established they will outcompete weeds.

7.6. Aboriginal Heritage

An Aboriginal heritage assessment process was undertaken for the construction area in accordance with the DECCW guidelines, which involved consultation with Aboriginal stakeholders (individuals and groups).

- All works will be carried out only in accordance with the approved Aboriginal Heritage Impact Permit for the site and with ACOL's existing *Archaeology and Cultural Heritage Management Plan* (ACOL 2006).

There will be no construction within 70m of the Waterhole Site grinding grooves and appropriate controls will be implemented to protect this site from inadvertent construction activity impacts, including:

- Inclusion of a cultural awareness component in the general induction of contractors working on the project.
- All workers involved in construction will be given an induction that includes awareness of the location of aboriginal heritage sites in the area and appropriate procedures.
- Exclusion fencing of known Aboriginal sites to form a boundary between contractors and the outer perimeter of the site in areas not to be impacted by the construction works.
- Inclusion of a Work Method Statement that outlines the responsibilities of contractors in order to ensure that the site is not impacted and which outlines the repercussions of not adhering to the WMS (e.g. fines administered by DECCW).

Should any Aboriginal artefacts be detected during construction, work in that location will cease immediately and the finds will be reported to the Environment and Community Relations Manager, at which time the existing *Archaeology and Cultural Heritage Management Plan* (ACOL 2006)protocols will be implemented.

Work will not recommence in the area until instructed to do so by the Environment and Community Relations Manager.

7.7. Noise

The proposed works are located at least 2km form the nearest privately-owned residence. All construction activities will be confined to daytime hours only and managed in accordance with ACOL's existing *Noise Management Plan* (ACOL 2006). In addition the following noise management and mitigation measures will be implemented:

- Operation of plant and haulage of materials only to occur within designated hours of operation (see Section 3.2).
- Site equipment is to be selected or modified to minimise potential noise generation and will be maintained in good working order.
- Concurrent operation of multiple items of plant will be minimised to the extent practicable.
- Vehicles / plant will be turned off when not in operation.
- Due attention will be paid to adverse weather conditions (see NMP for further details) and modifications made to the works program where necessary.

7.8. Air Quality

Construction activities will be carried out in accordance with ACOL's existing *Air Quality Management Plan* (ACOL 2006f). In addition the following noise management and mitigation measures will be implemented:

- Haul roads will be graded or surfaced with appropriate material to ensure loose dust-generating surface material is kept to the lowest level practicable, where required.
- Water carts will be used within stockpile areas and on haul roads to keep trafficable areas in a damp condition.
- All exposed stockpiles will be kept damp by the use of fixed or mobile water sprays under dry and windy conditions.
- Speed limits on unsealed access tracks and haul roads will be restricted to a maximum of 40km/hr.
- Speed limits will be further reduced to minimise dust emissions, where required.

7.9. Traffic

Appropriate signage will be installed on the New England Highway and at relevant public access points for the duration of construction activities.

Access and egress to the site from the New England Highway will be managed in accordance with an RTA approved Construction Traffic Management Plan.

7.10. Waste Control

The generation of waste is expected to be minimal. Waste and green waste generated as a result of the construction activities will be reused and recycled wherever possible, or removal offsite to an appropriate licensed waste facility by licensed contractors.

Vegetation waste generated during construction will be used in rehabilitating the construction area. Excess spoil waste will be stored in the designated stockpile areas as previously described (Section 3.9) and used to fill subsidence troughs within the floodplain.

Statutory Declaration

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STATUTORY DECLARATION

New South Wales

STATUTORY DECLARATION

OATHS ACT, 1900

EIGHTH SCHEDULE

I,...**Brian Wesley**......................, of ...**8 Gould Close, Singleton 2330**..........

in the State of New South Wales, solemnly and sincerely declare as follows:

1. I am the duly appointed...**General Manager**.......... *(management position)*

   for ..**Ashton Coal Operations Pty Limited**............................*(mine name)*

2. I am authorised to make this Declaration on behalf of the Lease Holder,
   White Mining (NSW) Pty Limited (ABN 19 089 414 595),
   White Mining Limited (ACN 009 713 893),................*(name of leaseholder)*,
   ICRA ASHTON PTY LTD (ACN 097 499 780)
   A.C.N.....................................

3. All works and activities described in the Mining Operations Plan to which this declaration is attached comply with the conditions of the title of the mining lease (or mining leases) shown in the Mining Operations Plan, and with the conditions of Development Consent and all other relevant Government Agency approvals and licences granted in respect of them.

4. I confirm that all of the works and activities referred to in the previous paragraph lie wholly within the area shown in the Mining Operations Plan and that the tenements (mining leases, colliery holdings, land ownership) details of those tenements are correct.

And I make this solemn Declaration, conscientiously believing the same to be true and by virtue of the provisions of the *Oaths Act, 1900.*

Subscribed and Declared at **Camberwell (Ashton Coal Operations Pty Limited)**....

in the State of New South Wales this ....**11**............ day of...**February**................in

the year .**2011**...

(sgd) ...Brian Wesley...........

before me (sgd) ....Justice of the Peace

152838

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REFERENCES

ACOL (2006) Ashton Coal Mine Archaeology and Cultural Heritage Management Plan

ACOL (2006a) Ashton Coal Mine Erosion and Sediment Control Management Plan

ACOL (2006a) Ashton Coal Mine Flora and Fauna Management Plan

ACOL (2006c) Ashton Coal Mine Landscape and Revegetation Management Plan

ACOL (2006d) Ashton Coal Mine Weed Management Plan

ACOL (2006e) Ashton Coal Mine Noise Management Plan

ACOL (2006f) Ashton Coal Mine Air Quality Management Plan

ACOL (2010) Bowmans Creek Diversion Rehabilitation Strategy

AECOM (2009a) Bowmans Creek Diversion Landscape Restoration Report in EA Appendix 10

AECOM (2009b) Bowmans Creek Diversion Landscape Design Drawings in EA Volume 2, Plan Set 3

DECCW - Department of Environment and Climate Change and Water (2008) Managing Urban Stormwater Soils and Construction Volume 2E Mines and Quarries

Evans & Peck (2009) Bowmans Creek Diversion Environmental Assessment

Hansen Bailey (March 2008) Ashton Coal Mine Mining Operations Plan 2007-2012

Hyder (2010) Bowmans Creek Diversion Engineering Design Drawings C000 to C047 in EA Volume 2, Plan Set 2, as amended (Hyder, 2011).

Landcom (2004) Managing Urban Stormwater: Soils and Construction Volume 1 “Blue Book”

White Mining Limited, (2003) Soil Stripping Management Plan, Ashton Coal Project

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Figures

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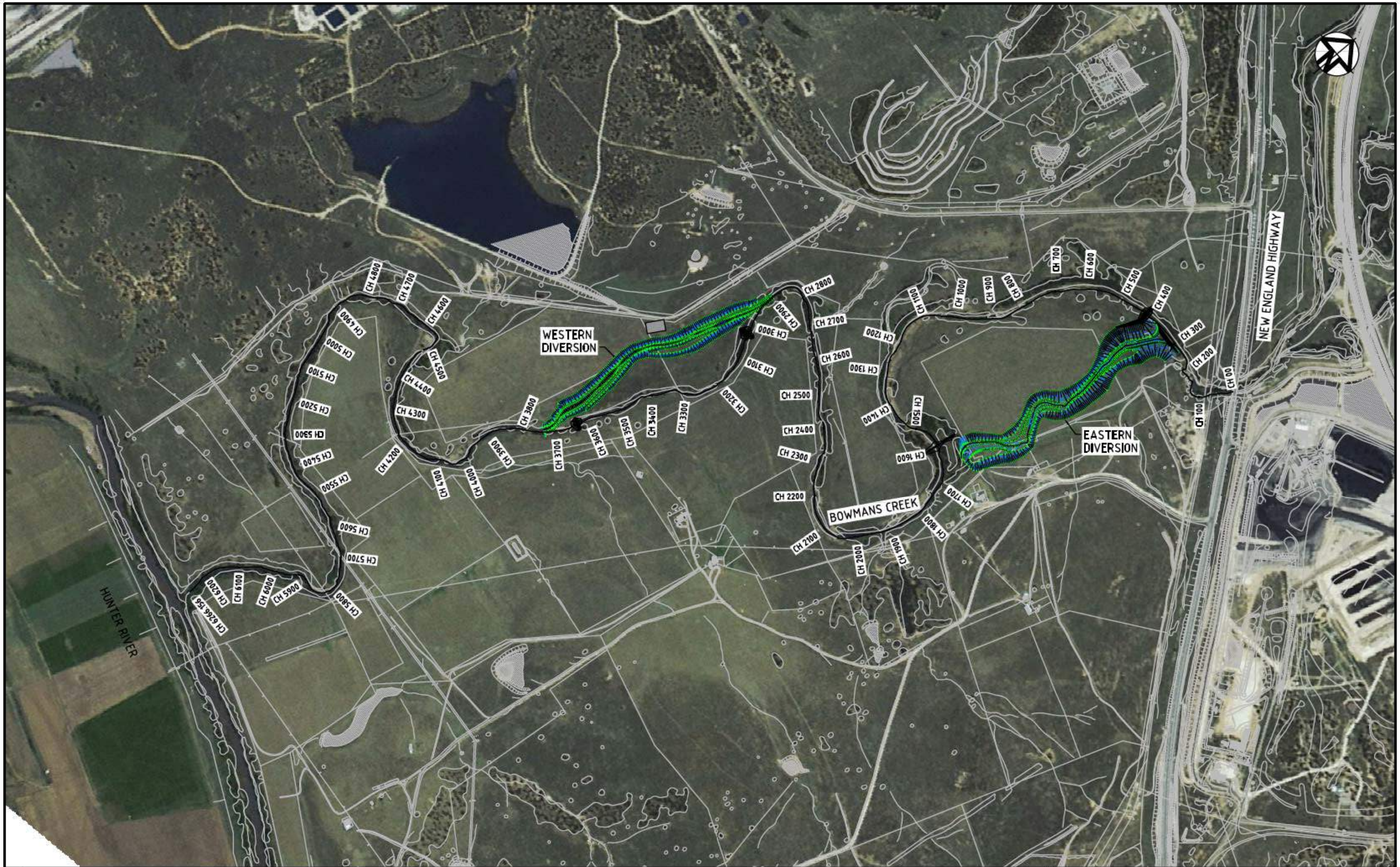

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P1	ISSUE FOR REVIEW	03/12/10

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Client: ASHTON COAL

Status: FOR CONSTRUCTION

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Original Size	A1	Designed	
Height Datum	AHD	Checked	
Grid		Approved	
Filename	C001-AA002659-HSD-00-OVERALL_PLAN.dwg		

Project: BOWMANS CREEK CAMBERWELL

Title: OVERALL SITE PLAN

Hyder

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Drawing No.	Project No.	Issue
C001	AA002659	A

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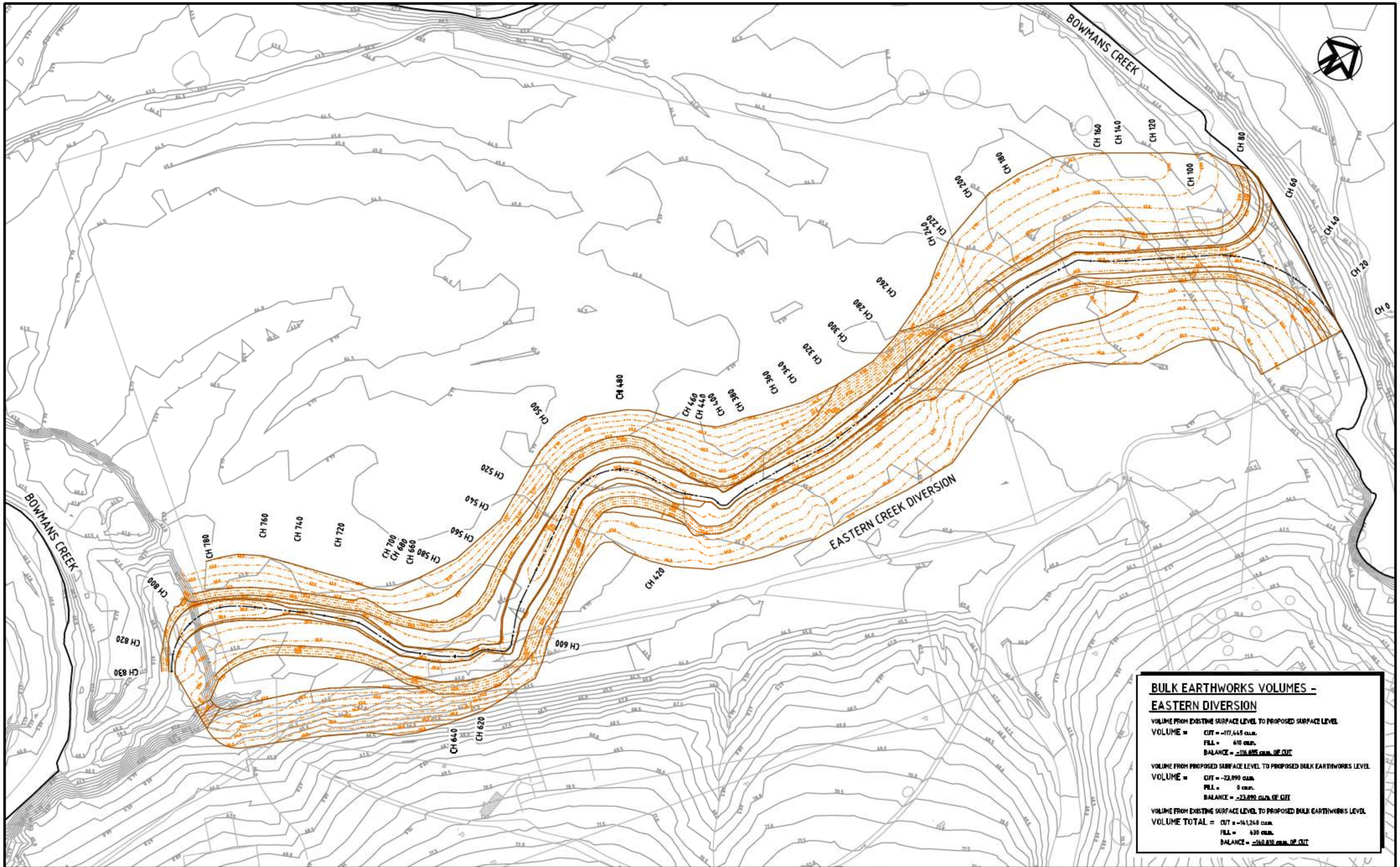

BULK EARTHWORKS VOLUMES – EASTERN DIVERSION

VOLUME FROM EXISTING SURFACE LEVEL TO PROPOSED SURFACE LEVEL

VOLUME = CUT = –117,445 cu.m.
FILL = 610 cu.m.
BALANCE = –116,835 cu.m. OF CUT

VOLUME FROM PROPOSED SURFACE LEVEL TO PROPOSED BULK EARTHWORKS LEVEL

VOLUME = CUT = –23,890 cu.m.
FILL = 0 cu.m.
BALANCE = –23,890 cu.m. OF CUT

VOLUME FROM EXISTING SURFACE LEVEL TO PROPOSED BULK EARTHWORKS LEVEL

VOLUME TOTAL = CUT = –141,240 cu.m.
FILL = 430 cu.m.
BALANCE = –140,810 cu.m. OF CUT

Issue	Description	Date
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P1	ISSUE FOR REVIEW	03/12/10

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Client: ASHTON COAL

Status: FOR CONSTRUCTION

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Original Size	A1	Designed	
Height Datum	AHD	Checked	
Grid		Approved	

File: C004-AA002659-NSD-00-EASTERN_DIVERSION_BULK_PLAN.dwg

Project: BOWMANS CREEK CAMBERWELL

Title: EASTERN DIVERSION BULK EARTHWORKS PLAN

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C004	–	AA002659	–	A

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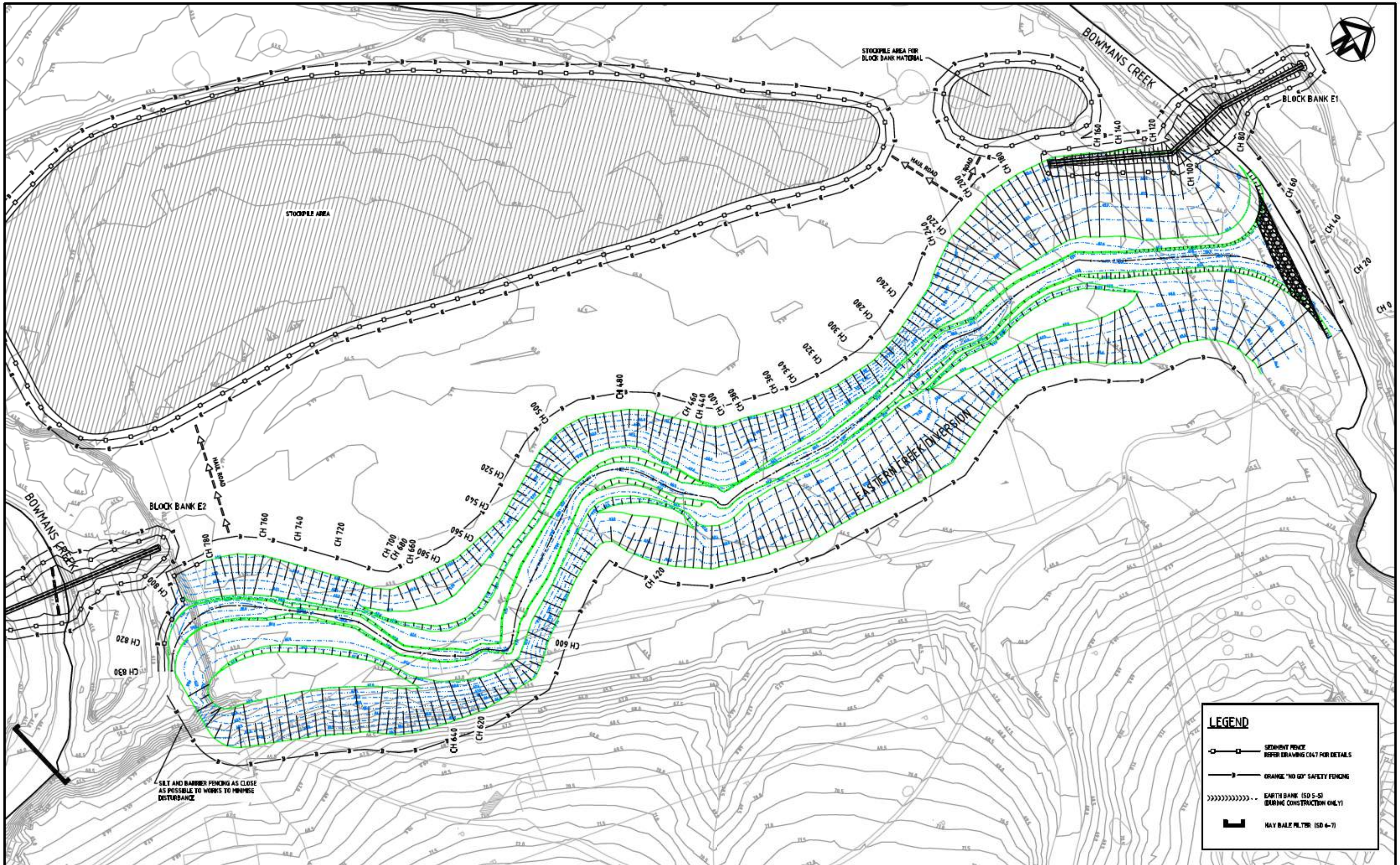

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P1	ISSUE FOR REVIEW	03/12/10

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Client: ASHTON COAL

Status: FOR CONSTRUCTION

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Height Datum	AHD	Checked	
Grid		Approved	

Project: BOWMANS CREEK CAMBERWELL

Title: EASTERN DIVERSION SEDIMENTATION AND EROSION CONTROL PLAN

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Drawing No.	Project No.	Issue
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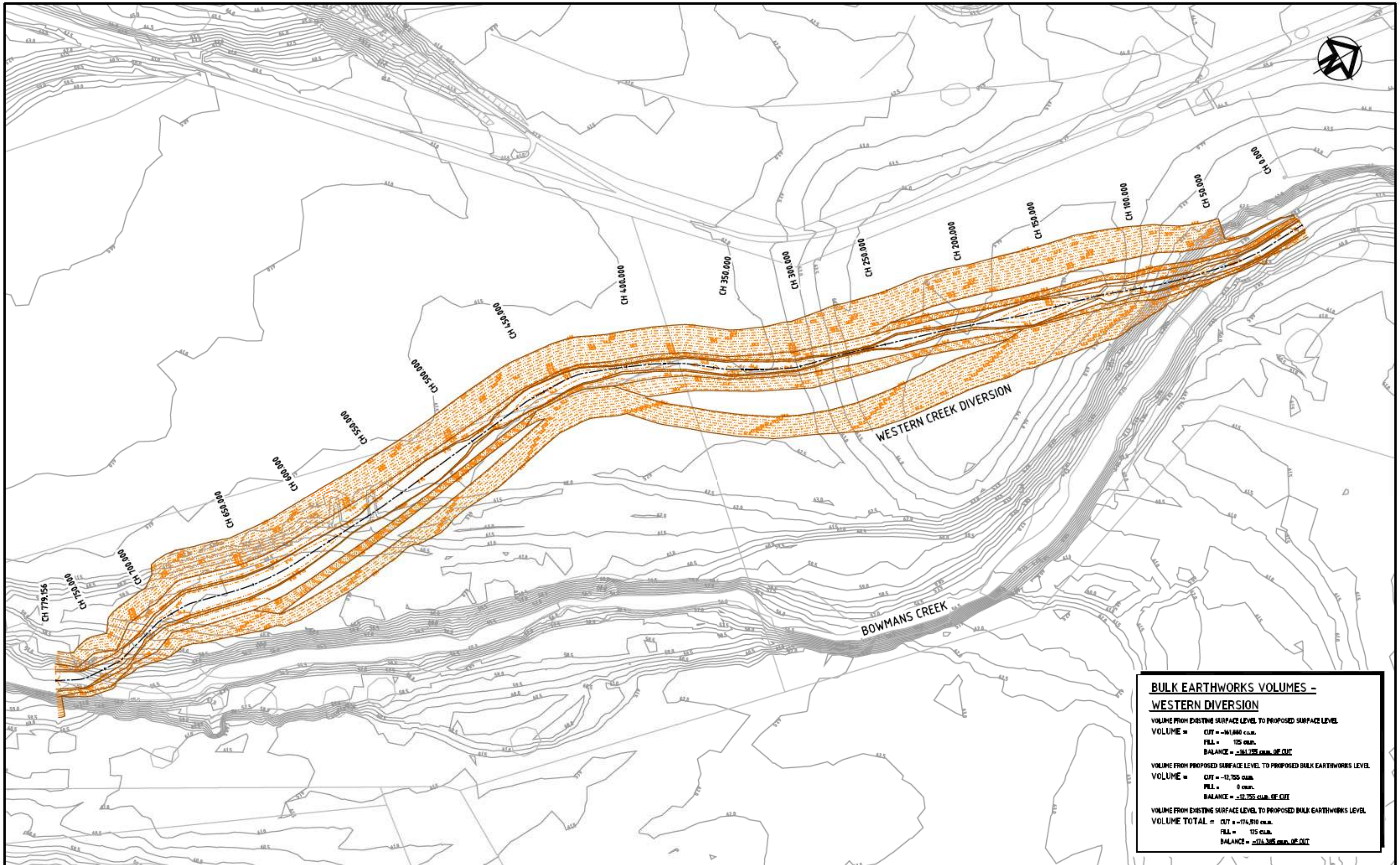

BULK EARTHWORKS VOLUMES - WESTERN DIVERSION

VOLUME FROM EXISTING SURFACE LEVEL TO PROPOSED SURFACE LEVEL
VOLUME = CUT = -161,880 cu.m.
FILL = 125 cu.m.
BALANCE = -161,755 cu.m. OF CUT

VOLUME FROM PROPOSED SURFACE LEVEL TO PROPOSED BULK EARTHWORKS LEVEL
VOLUME = CUT = -12,755 cu.m.
FILL = 0 cu.m.
BALANCE = -12,755 cu.m. OF CUT

VOLUME FROM EXISTING SURFACE LEVEL TO PROPOSED BULK EARTHWORKS LEVEL
VOLUME TOTAL = CUT = -174,510 cu.m.
FILL = 125 cu.m.
BALANCE = -174,385 cu.m. OF CUT

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Issue	Description	Date
P1	ISSUE FOR REVIEW	03/12/10

Client: ASHTON COAL

Status: FOR REVIEW

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Original Size	A1	Designed	
Height Datum	AHD	Checked	
Grid		Approved	

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Project: BOWMANS CREEK CAMBERWELL

Title: WESTERN DIVERSION BULK EARTHWORKS PLAN

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P1	ISSUE FOR REVIEW	03/12/10

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Status: FOR CONSTRUCTION

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Project: BOWMANS CREEK CAMBERWELL

Title: WESTERN DIVERSION SEDIMENTATION AND EROSION CONTROL PLAN

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Drawing No.	Project No.	Issue
C046	AA002659	A

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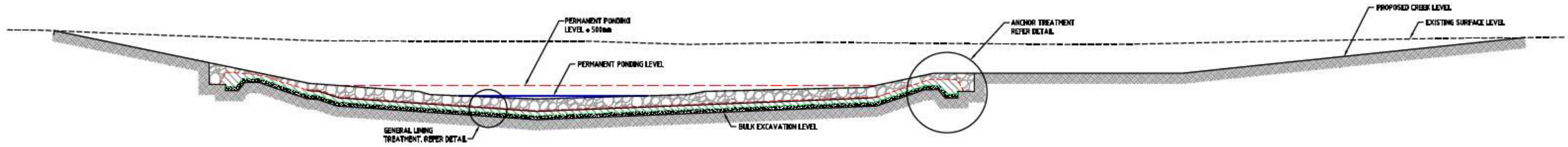

EASTERN DIVERSION TYPICAL BULK EARTHWORKS SECTION

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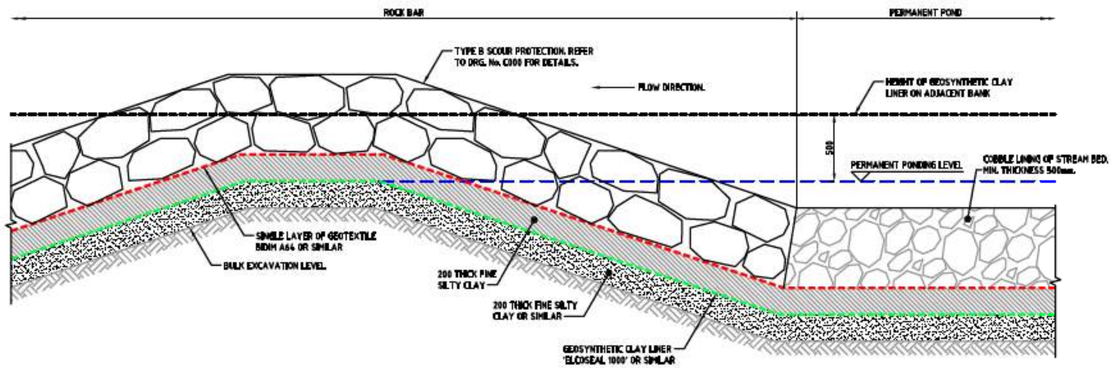

PONDING WEIR TREATMENT DETAIL WITH ROCK BAR

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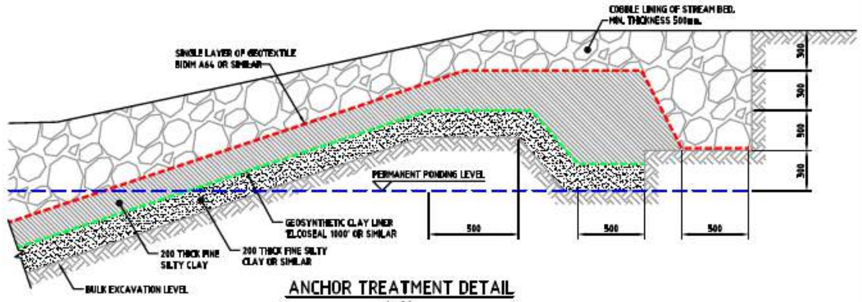

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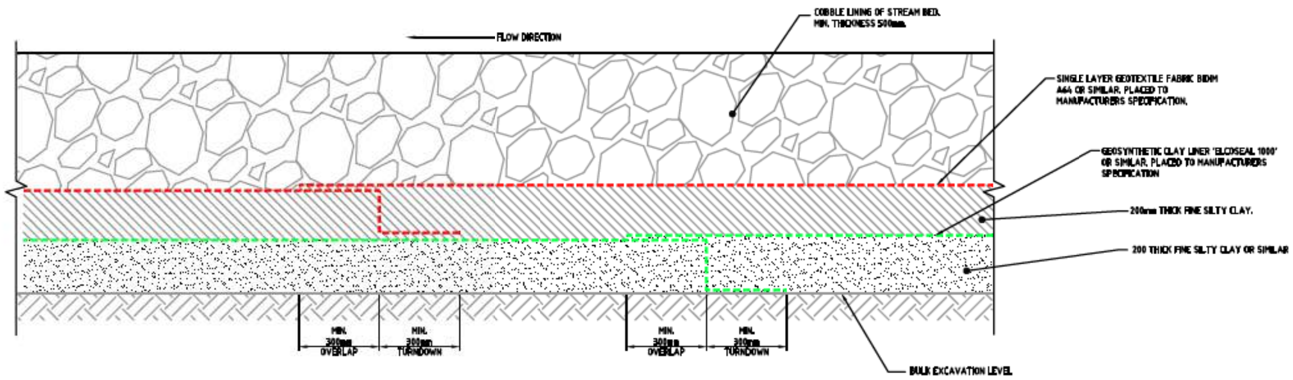

GENERAL LINING TREATMENT AND LAP DETAIL

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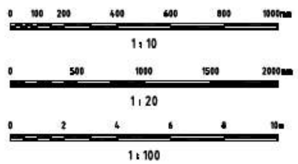
P1	ISSUE FOR REVIEW	03/12/10



Client: ASHTON COAL

Status: FOR CONSTRUCTION

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Height Datum	AHD	Checked	
Grid		Approved	

Filename: C002-AA002659-NSD-00-LINER_INSTILLATION_DETAILS.dwg

Project: BOWMANS CREEK CAMBERWELL

Title: GEO-SYNTHETIC LINER INSTALLATION DETAILS

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Drawing No.		Project No.		Issue
C002	–	AA002659	–	A

Date Plotted: 27 Jan 2011 – 05:47PM File Name: P:\AA002659\E-CAD\C-Civil\D-Final\C002-AA002659-NSD-00-LINER_INSTILLATION_DETAILS.dwg V1

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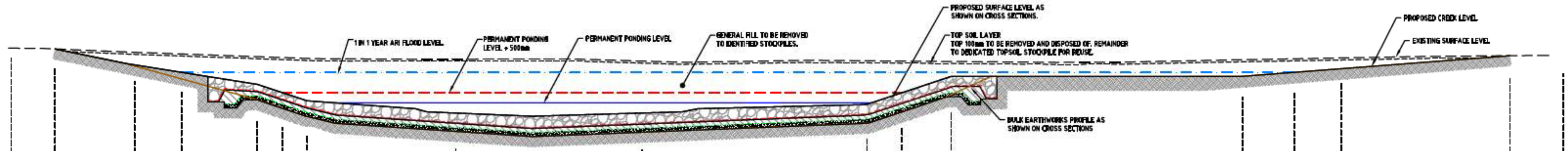

CREEK ZONE	FLOOD TERRACE	UPPER SIDE SLOPES	LOWER SIDE SLOPES		WATER COURSE LOW ACTIVE FLOODPLAIN	SHALLOW POOL AQUATIC/EPHEMERAL COMMUNITY	DEEP POOL	SHALLOW POOL	WATER COURSE LOW ACTIVE FLOODPLAIN	INSET BENCHES	LOWER SIDE SLOPES		UPPER SIDE SLOPES	FLOOD TERRACE
ZONE PROTECTION			JUTE MAT	"GRASS ROOTS" TURF REINFORCEMENT MAT		GEOSYNTHETIC CLAY LINER WITH GEOFABRIC OVER				"GRASS ROOTS" TURF REINFORCEMENT MAT		JUTE MAT		

CREEK ZONE DEFINITIONS

ZONE	DEFINITION	TREATMENT
DEEP POOL	PERMANENT WATER PONDING.	• WITHIN WATER COURSE INFILL ZONE. • BULK EXCAVATION LEVEL = 1m BELOW PROPOSED SURFACE LEVEL. • WATER COURSE INFILL ZONE CONSISTS OF 200mm SILTY CLAY, GEO-SYNTHETIC CLAY LINER, 200mm SILTY CLAY GEO-TEXTILE FABRIC AND 600mm OF PLACED COBBLE MATERIAL. • PLACED COBBLE TO BE AS PER SPECIFICATION (REFER TO DRG. No. C000).
SHALLOW POOL	EPHEMERAL WATER PONDING.	• WITHIN WATER COURSE INFILL ZONE. • BULK EXCAVATION LEVEL = 1m BELOW PROPOSED SURFACE LEVEL. • WATER COURSE INFILL ZONE CONSISTS OF 200mm SILTY CLAY, GEO-SYNTHETIC CLAY LINER, 200mm SILTY CLAY GEO-TEXTILE FABRIC AND 600mm OF PLACED COBBLE MATERIAL. • PLACED COBBLE TO BE AS PER SPECIFICATION (REFER TO DRG. No. C000).
LOW ACTIVE FLOOD PLAIN	REGULARLY INUNDATED BUT NOT SUBJECT TO PONDING.	• WITHIN WATER COURSE INFILL ZONE. • BULK EXCAVATION LEVEL = 1m BELOW PROPOSED SURFACE LEVEL. • WATER COURSE INFILL ZONE CONSISTS OF 200mm SILTY CLAY, GEO-SYNTHETIC CLAY LINER, 200mm SILTY CLAY GEO-TEXTILE FABRIC AND 600mm OF PLACED COBBLE MATERIAL. • PLACED COBBLE TO BE AS PER SPECIFICATION (REFER TO DRG. No. C000).
INSET BENCHES	BENCH ADJACENT TO WATER COURSE	• IF EXISTING COBBLES ENCOUNTERED, LEAVE IN-SITU. IF NOT, PLANT AND JUTE MESH. • OUTSIDE OF WATERCOURSE INFILL ZONE. • MATERIAL SHOULD COMPRISE OF VARIOUS ALLUVIAL MATERIALS. SOIL TESTING TO BE UNDERTAKEN IN ACCORDANCE WITH LANDSCAPER/RIPARIAN ECOLOGISTS DETAILS AND AMELIORATE AS REQUIRED TO ENSURE APPROPRIATE LEVEL OF PLANT RESPONSE. • AREA TO BE COVERED WITH A "GRASS ROOTS" TURF REINFORCEMENT PROTECTIVE MATTING.
LOWER SIDE SLOPES	BANK AREA BELOW 5 YEAR FLOOD LEVEL	• AREA TO BE MASS PLANTED WITH CELL-GROWN SEEDLINGS IN ACCORDANCE WITH LANDSCAPER/RIPARIAN ECOLOGISTS DETAILS. • AREAS OF BANK BELOW 1 YEAR RECURRENCE INTERVAL (REFER CROSS SECTIONS), TO BE COVERED WITH "GRASS ROOTS" TURF REINFORCEMENT MAT. AREAS ABOVE TO BE COVERED WITH A MEDIUM DUTY BIODEGRADABLE PROTECTIVE MATTING SUCH AS JUTE MAT.
UPPER SIDE SLOPES AND FLOOD TERRACE	BANK AREA ABOVE 5 YEAR FLOOD LEVEL AND TRANSITION TO EXISTING LANDFORM	• AREA TO BE DIRECTLY SEEDED WITH NATIVE GRASSES AND WITH A LIMITED STRUCTURAL PLANTING OF CELL-GROWTH SEEDLINGS IN ACCORDANCE WITH LANDSCAPER/RIPARIAN ECOLOGISTS DETAILS.
GENERAL	TOPSOIL	• TOPSOIL TO BE STRIPPED PRIOR TO DEEP EXCAVATION. • THE TOP 100mm WILL BE REMOVED TO A SUITABLE STOCKPILE LOCATION TO REMOVE THE MAJORITY OF THE SOIL WEED SEED BANK. • THE REMAINING TOPSOIL WILL BE SUBJECT TO SOIL TESTING AND AMELIORATION AS REQUIRED BY THE LANDSCAPER/RIPARIAN ECOLOGIST PRIOR TO REUSE ON EXCAVATED BANKS.

Issue	Description	Date
A	ISSUE FOR CONSTRUCTION	27/01/11
P1	ISSUE FOR REVIEW	03/12/10

Client: ASHTON COAL

Status: FOR CONSTRUCTION

Scales: AS SHOWN | Original Size: A1 | Height Datum: AHD | Grid

Current Issue Signatures: Drawn / Designed / Checked / Approved

Filename: C057-AA002659-HSD-00-CREEK_ZONE_DEFINITIONS.dwg

Project: BOWMANS CREEK CAMBERWELL

Title: CREEK ZONE DEFINITIONS

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Drawing No. C057 — Project No. AA002659 — Issue A

Date Plotted 27 Jan 2011 - 03:54PM File Name: P:\AA002659\E-CAD\C-Civil\D-Final\C057-AA002659-HSD-00-CREEK_ZONE_DEFINITIONS.dwg

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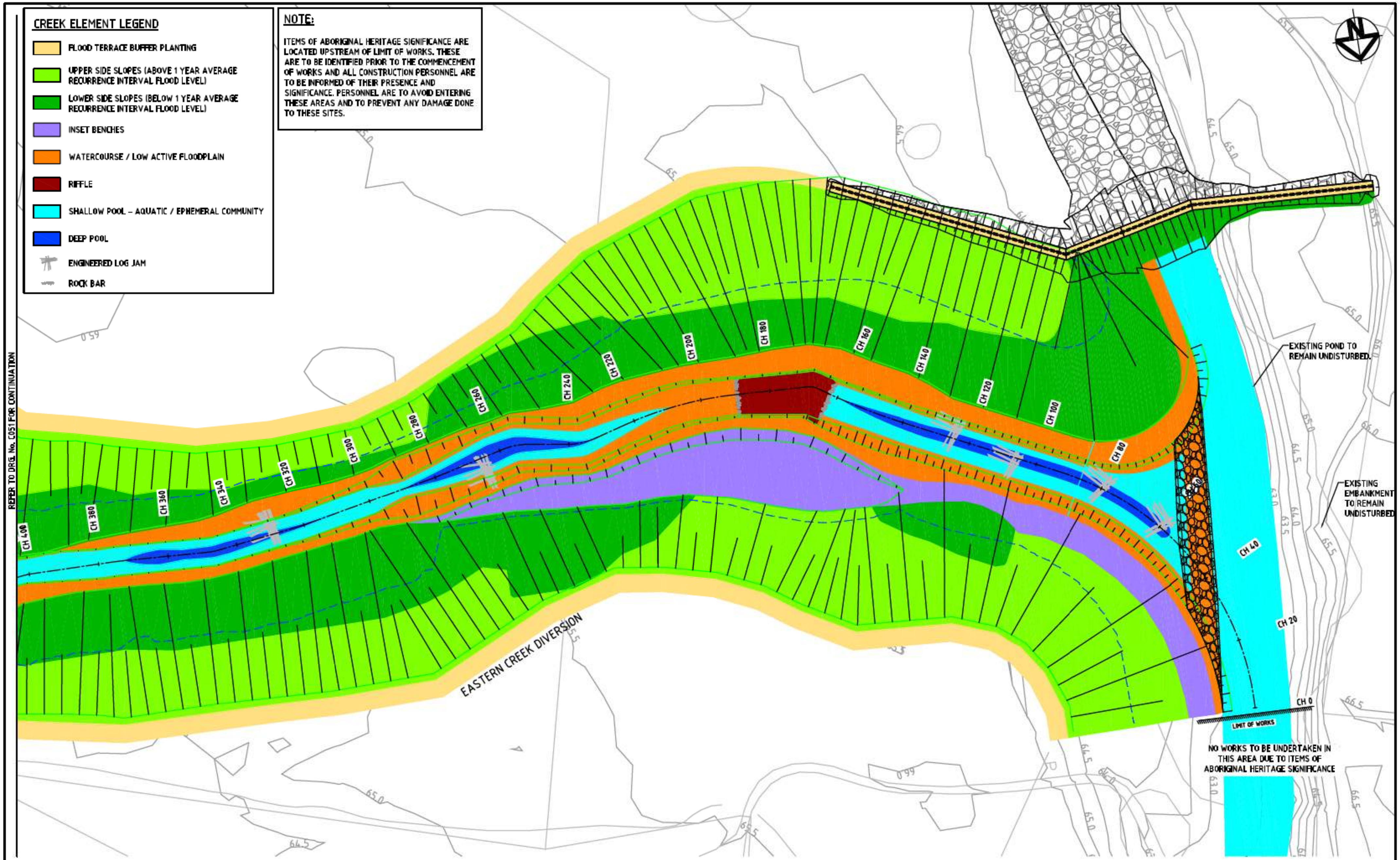
CREEK ELEMENT LEGEND

- FLOOD TERRACE BUFFER PLANTING
- UPPER SIDE SLOPES (ABOVE 1 YEAR AVERAGE RECURRENCE INTERVAL FLOOD LEVEL)
- LOWER SIDE SLOPES (BELOW 1 YEAR AVERAGE RECURRENCE INTERVAL FLOOD LEVEL)
- INSET BENCHES
- WATERCOURSE / LOW ACTIVE FLOODPLAIN
- RIFFLE
- SHALLOW POOL – AQUATIC / EPHEMERAL COMMUNITY
- DEEP POOL
- ENGINEERED LOG JAM
- ROCK BAR

NOTE:

ITEMS OF ABORIGINAL HERITAGE SIGNIFICANCE ARE LOCATED UPSTREAM OF LIMIT OF WORKS. THESE ARE TO BE IDENTIFIED PRIOR TO THE COMMENCEMENT OF WORKS AND ALL CONSTRUCTION PERSONNEL ARE TO BE INFORMED OF THEIR PRESENCE AND SIGNIFICANCE. PERSONNEL ARE TO AVOID ENTERING THESE AREAS AND TO PREVENT ANY DAMAGE DONE TO THESE SITES.



REFER TO DRG. No. C051 FOR CONTINUATION

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Issue	Description	Date
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P1	ISSUE FOR REVIEW	03/12/10

Client: ASHTON COAL

Status: FOR CONSTRUCTION

Scales	1:500	Current Issue Signatures	
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Original Size	A1	Designed	
Height Datum	AHD	Checked	
Grid		Approved	

Project: BOWMANS CREEK CAMBERWELL

Title: EASTERN DIVERSION CREEK ELEMENT PLAN – SHEET 1

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Drawing No. C050 – Project No. AA002659 – Issue A

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Date Plotted: 27 Jan 2011 - 03:53PM

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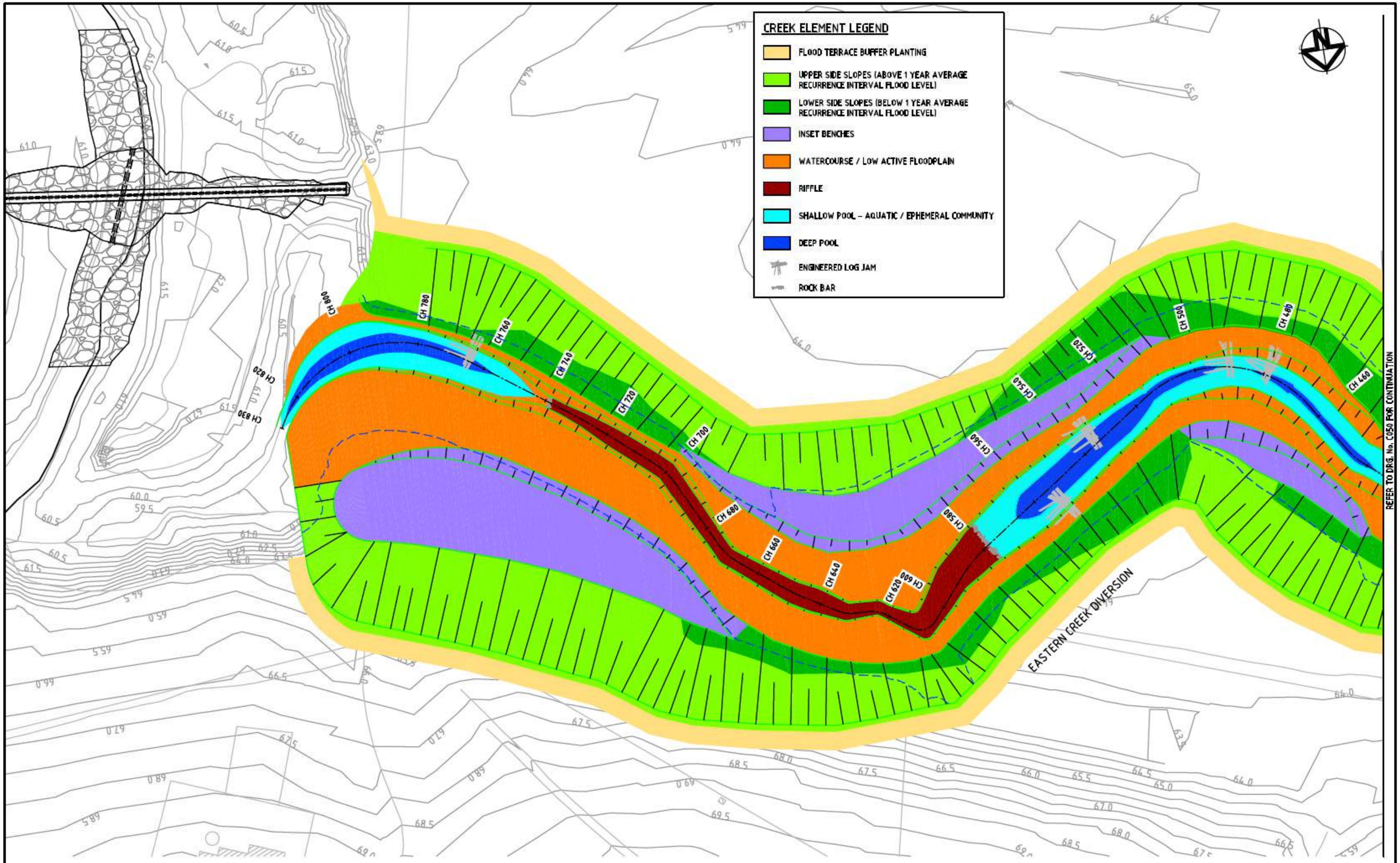

Issue	Description	Date
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P1	ISSUE FOR REVIEW	03/12/10

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Client: ASHTON COAL

Status: FOR CONSTRUCTION

Scales	1:500	Current Issue Signatures	
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Original Size	A1	Designed	
Height Datum	AHD	Checked	
Grid		Approved	

Project: BOWMANS CREEK CAMBERWELL

Title: EASTERN DIVERSION CREEK ELEMENT PLAN – SHEET 2

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C051	AA002659	A

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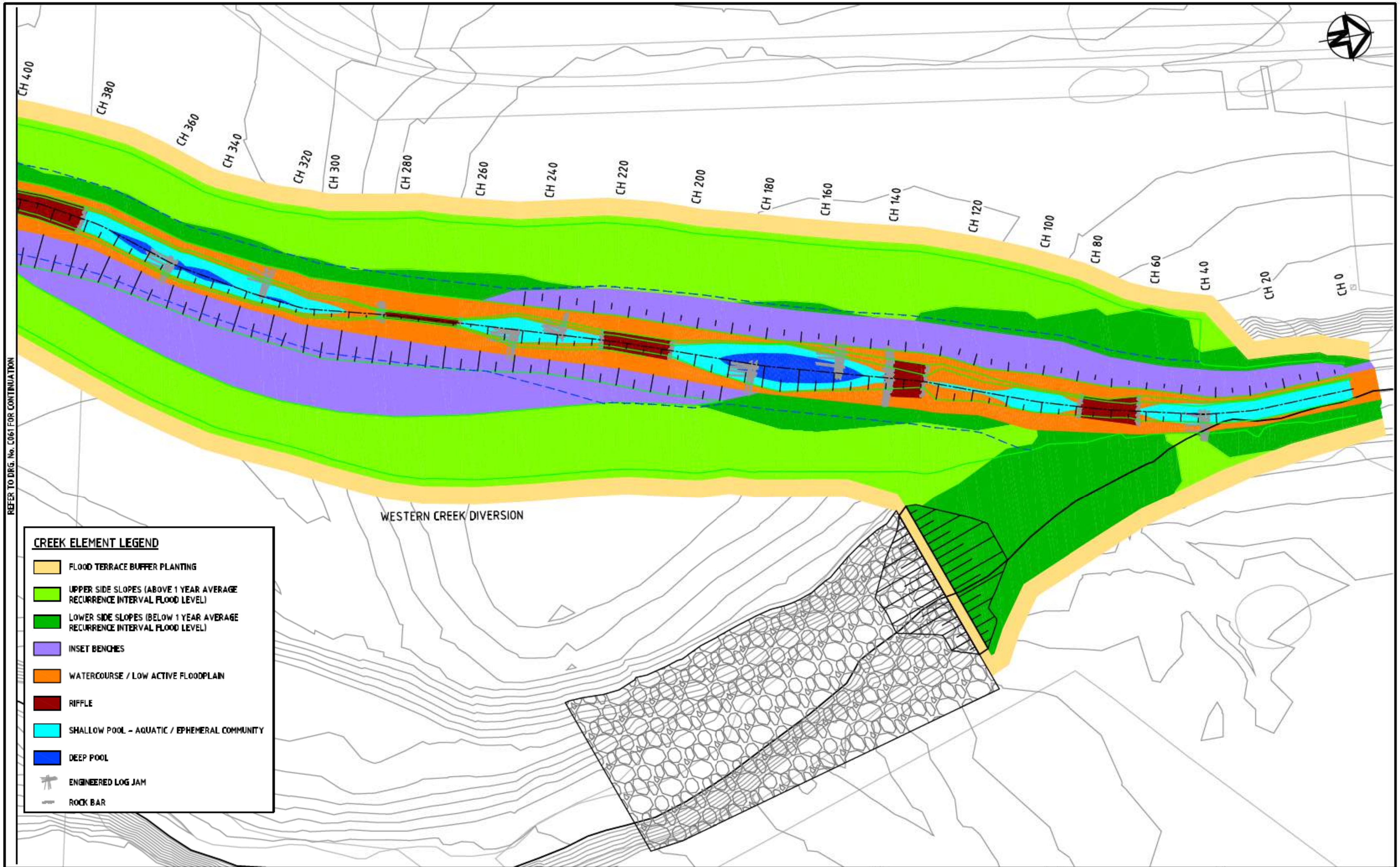

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A	ISSUE FOR CONSTRUCTION	27/01/11
P1	ISSUE FOR REVIEW	03/12/10

Client: ASHTON COAL

Status: FOR CONSTRUCTION

Scales	1:500	Current Issue Signatures	
		Drawn	
Original Size	A1	Designed	
Height Datum	AHD	Checked	
Grid		Approved	

Project: BOWMANS CREEK CAMBERWELL

Title: WESTERN DIVERSION DETAIL PLAN - SHEET 1

HYDER CONSULTING PTY LTD
ABN 76 104 485 289
Level 5, 141 Walker St
North Sydney NSW 2060
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Tel: +61 (0)2 8907 9000
Fax: +61 (0)2 8907 9001
www.hyderconsulting.com

Drawing No. C060 — Project No. AA002659 — Issue A

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Issue	Description	Date
A	ISSUE FOR CONSTRUCTION	27/01/11
P1	ISSUE FOR REVIEW	03/12/10

Client: ASHTON COAL

Status: FOR CONSTRUCTION

Scales	1:500	Current Issue Signatures	
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Project: BOWMANS CREEK CAMBERWELL

Title: WESTERN DIVERSION DETAIL PLAN - SHEET 2

HYDER CONSULTING PTY LTD
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Drawing No.	Project No.	Issue
C061	AA002659	A

AA002659-NSD-00-WESTERN_DIVERSION_DETAIL_PLAN_SHEET-2.dwg

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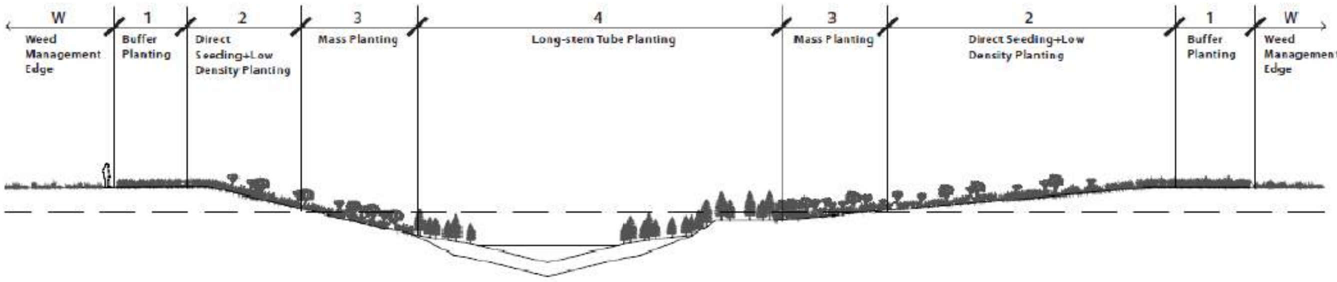
FIGURE 12



Phase 1 - Site Stabilisation - Year 1-3

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Plans

Plan 2/3	Pre MOP environment & land preparation
Plan 4/5	Proposed construction & rehabilitation
Plan 6	Final rehabilitation
Plan 7	Sections

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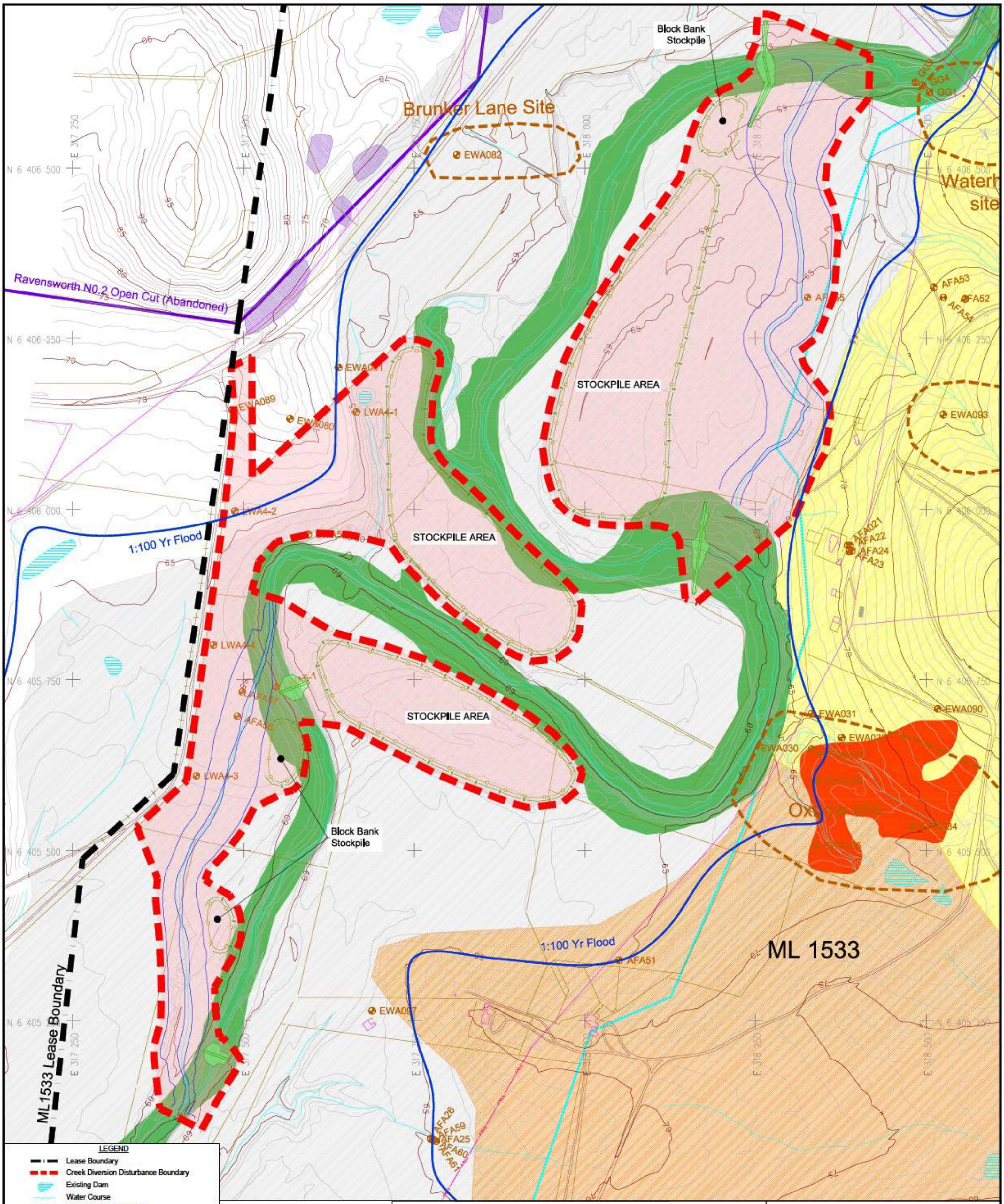

MINE OPERATIONS PLAN 2 & 3

Pre MOP Environment & Land Preparation

Name of mine	ASHTON UNDERGROUND COLLIERY
Mining Leases	ML1533, ML1623, ML1529
MOP Commencement Date	10-02-2011
Name of Leaseholder	White Mining (NSW) P/L, Austral-Asia Coal Hldng P/L, ICRA Ashton P/L
Name of mine operator	ASHTON COAL OPERATIONS PTY LTD
Reporting Officer	Brian Wesley
Title	General Manager
Signature	....
Date	10-02-2011

I, ..., holder of Mine Manager's Certificate of Competency No. ...., certify that the information on this plan is a true indication of the proposed development.

Date:.......................................

I, ...**Jeffrey Peck**........., a Registered Mining Surveyor under the Surveying Act 2002, certify that to the best of my knowledge and belief this plan conforms to the accuracy standards required by the NSW Department of Primary Industries.

Date:.......................................

AshtonCoal
PO Box 699 Singleton NSW 2330
Phone 61+ 02 6576 1111 Fax 61+ 02 6576 1122

Drawing No.	Revision No.	Date	Scale:	Drawn	Sheet Size
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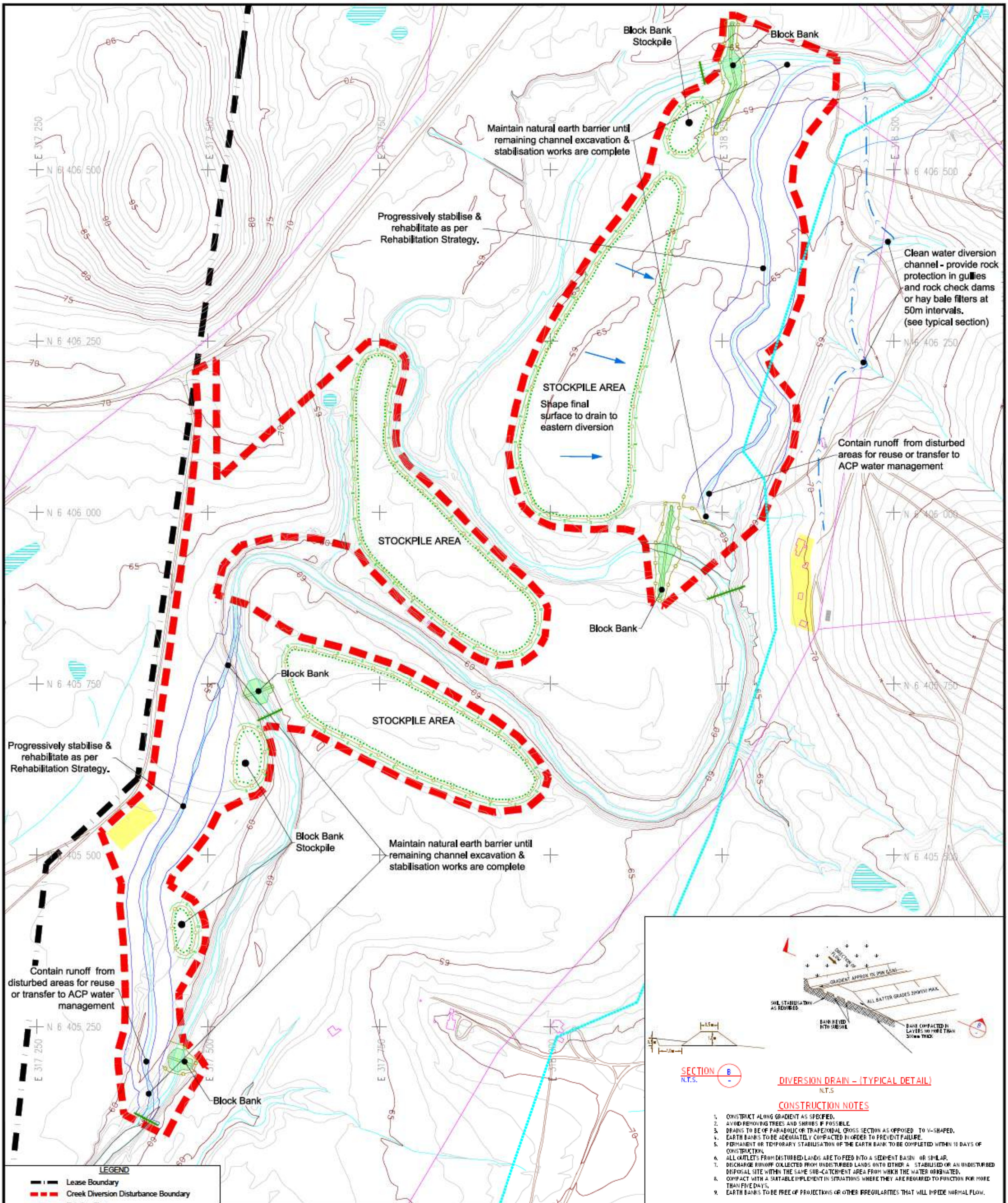

LEGEND

- Lease Boundary
- Creek Diversion Disturbance Boundary
- Existing Dam
- Power Lines
- Water Course
- Farm Infrastructure
- 1m Surface Contour
- Hunter River Pipeline
- Barrier Fence
- Sedimentation Control Fence
- Sedimentation Control - Hay Bale Barricade
- Clean Water Channel (temporary)
- Stockpile Bund
- Site Infrastructure

NOTES:
Stockpile & erosion controls to be managed in accordance with the Construction Mining Operations Plan.

All measurements are in metres

MINE OPERATIONS PLAN 4 & 5

Proposed Construction & Rehabilitation

Name of mine	ASHTON UNDERGROUND COLLIERY
Mining Leases	ML1533, ML1623, ML1529
MOP Commencement Date	10-02-2011
Name of Leaseholder	White Mining (NSW) P/L, Austral-Asia Coal Hldng P/L, ICRA Ashton P/L
Name of mine operator	ASHTON COAL OPERATIONS PTY LTD
Reporting Officer	Brian Wesley
Title	General Manager
Signature	....
Date	10-02-2011

AshtonCoal
PO Box 699 Singleton NSW 2330
Phone 61+ 02 6576 1111 Fax 61+ 02 6576 1122

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....

Date:..

I, Jeffrey Peck, a Registered Mining Surveyor under the Surveying Act 2002, certify that to the best of my knowledge and belief this plan conforms to the accuracy standards required by the NSW Department of Primary Industries.

....

Date:..

Drawing No.	Revision No.	Date	Scale:	Drawn	Sheet Size
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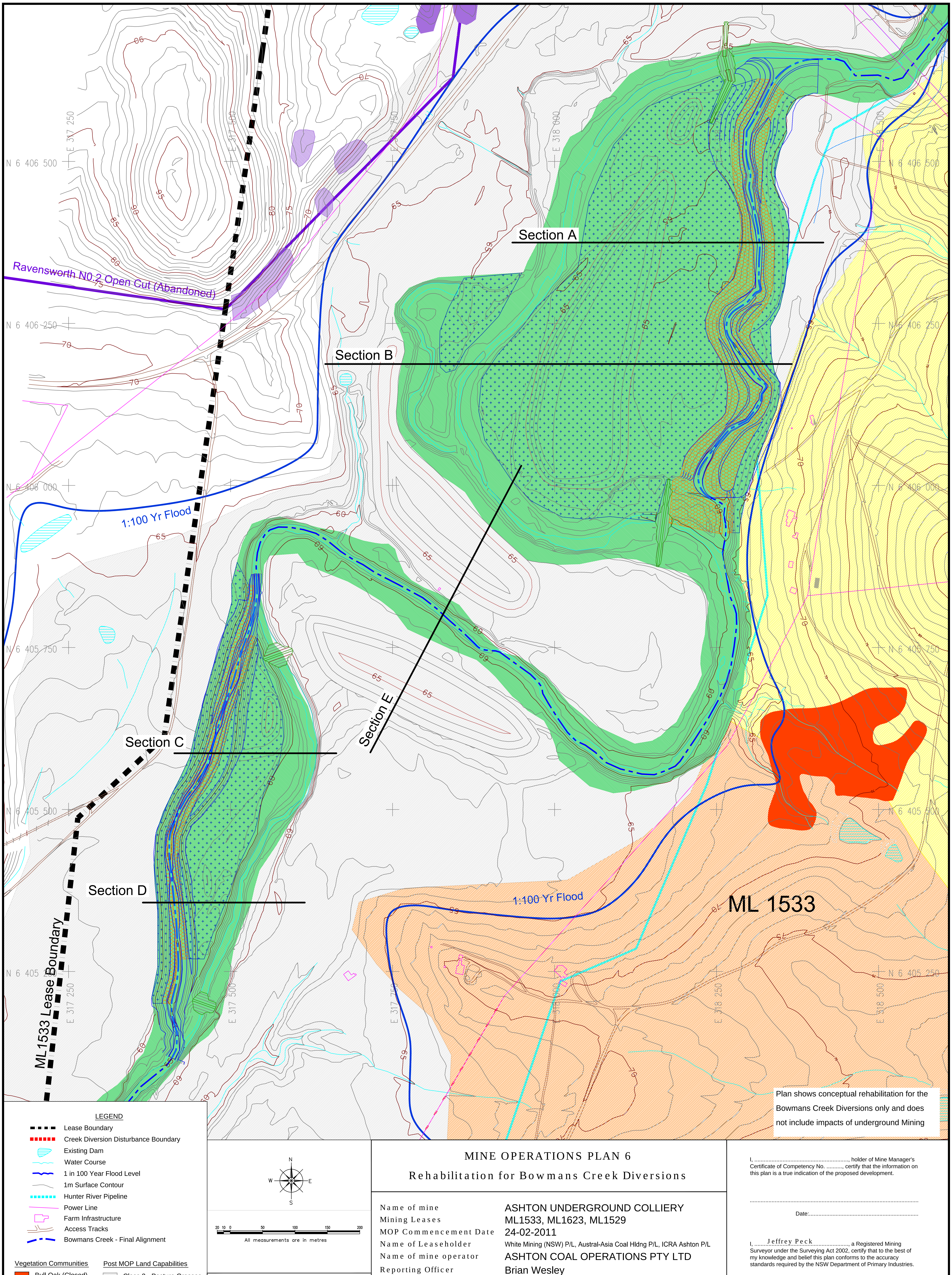

AshtonCoal

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Phone 61+ 02 6576 1111 Fax 61+ 02 6576 1122

MINE OPERATIONS PLAN 6

Rehabilitation for Bowmans Creek Diversions

Name of mine	ASHTON UNDERGROUND COLLIERY
Mining Leases	ML1533, ML1623, ML1529
MOP Commencement Date	24-02-2011
Name of Leaseholder	White Mining (NSW) P/L, Austral-Asia Coal Hldng P/L, ICRA Ashton P/L
Name of mine operator	ASHTON COAL OPERATIONS PTY LTD
Reporting Officer	Brian Wesley
Title	General Manager
Signature	....
Date	24-02-2011

I, ..., holder of Mine Manager's Certificate of Competency No. ...., certify that the information on this plan is a true indication of the proposed development.

....

Date:..

I, Jeffrey Peck..., a Registered Mining Surveyor under the Surveying Act 2002, certify that to the best of my knowledge and belief this plan conforms to the accuracy standards required by the NSW Department of Primary Industries.

....

Date:..

Drawing No.	Revision No.	Date	Scale:	Drawn	Sheet Size
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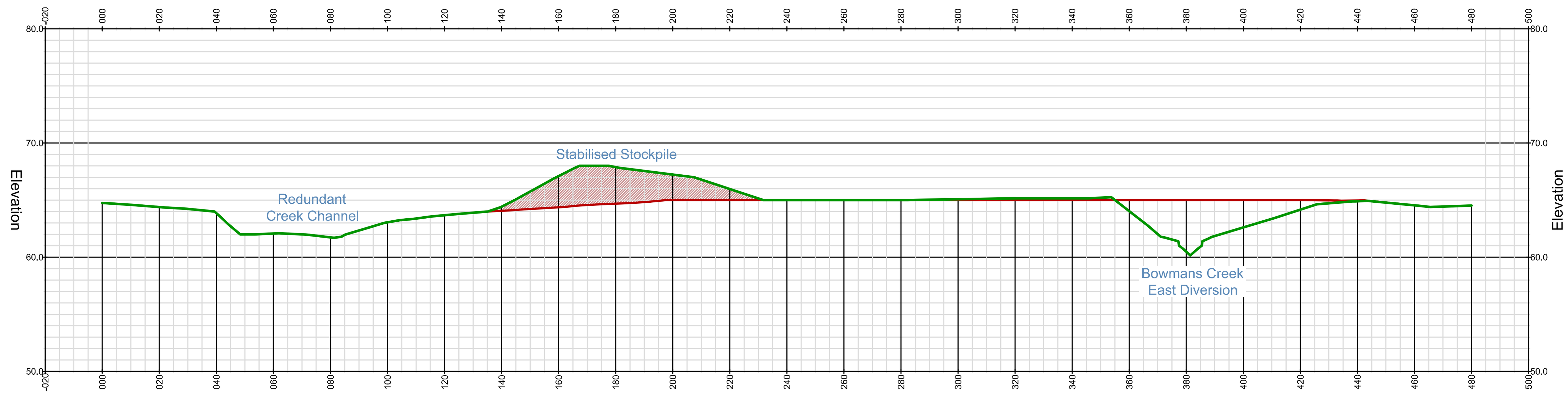
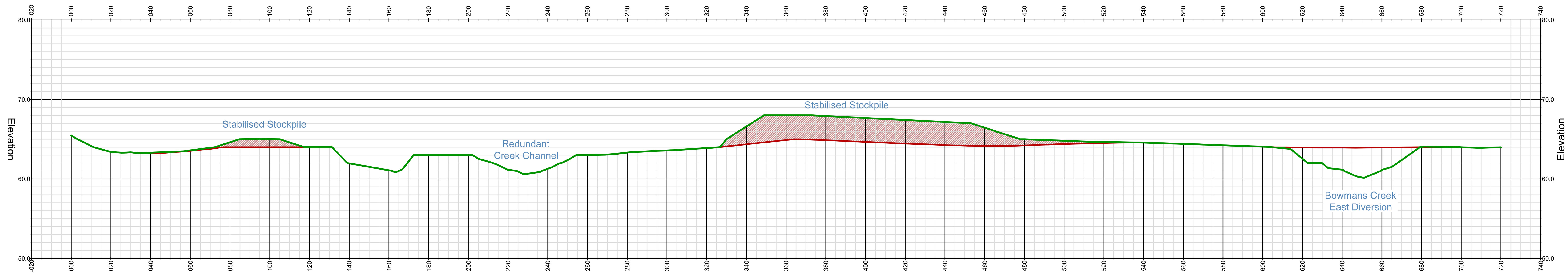
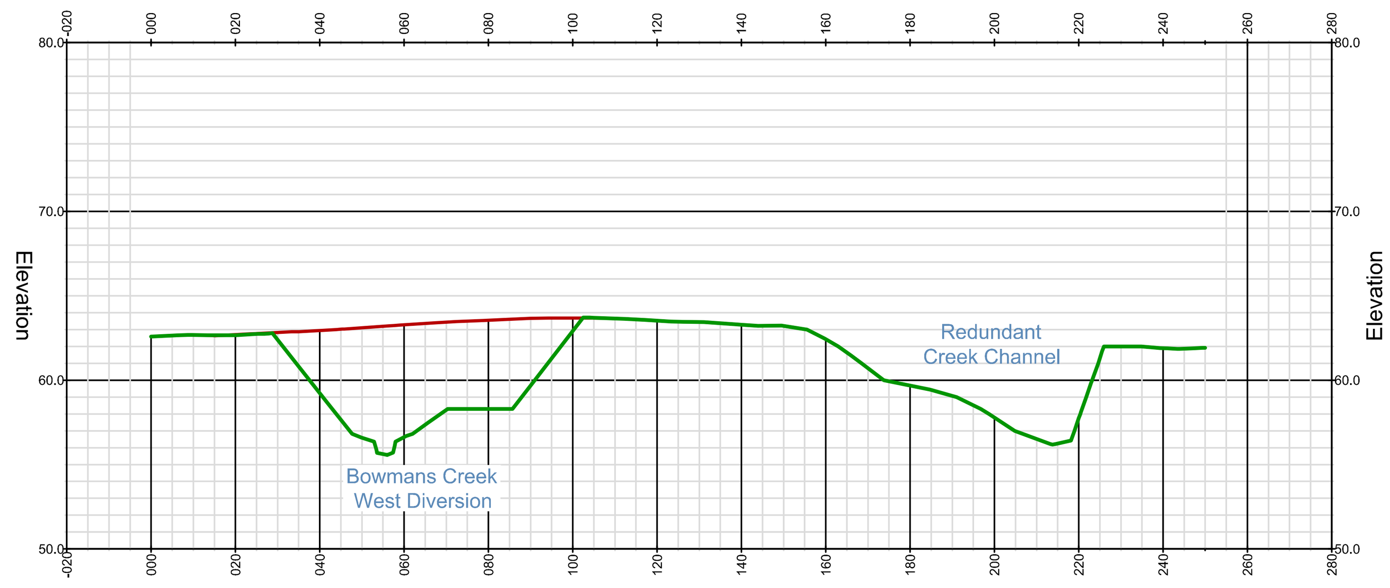
Section A - East Diversion



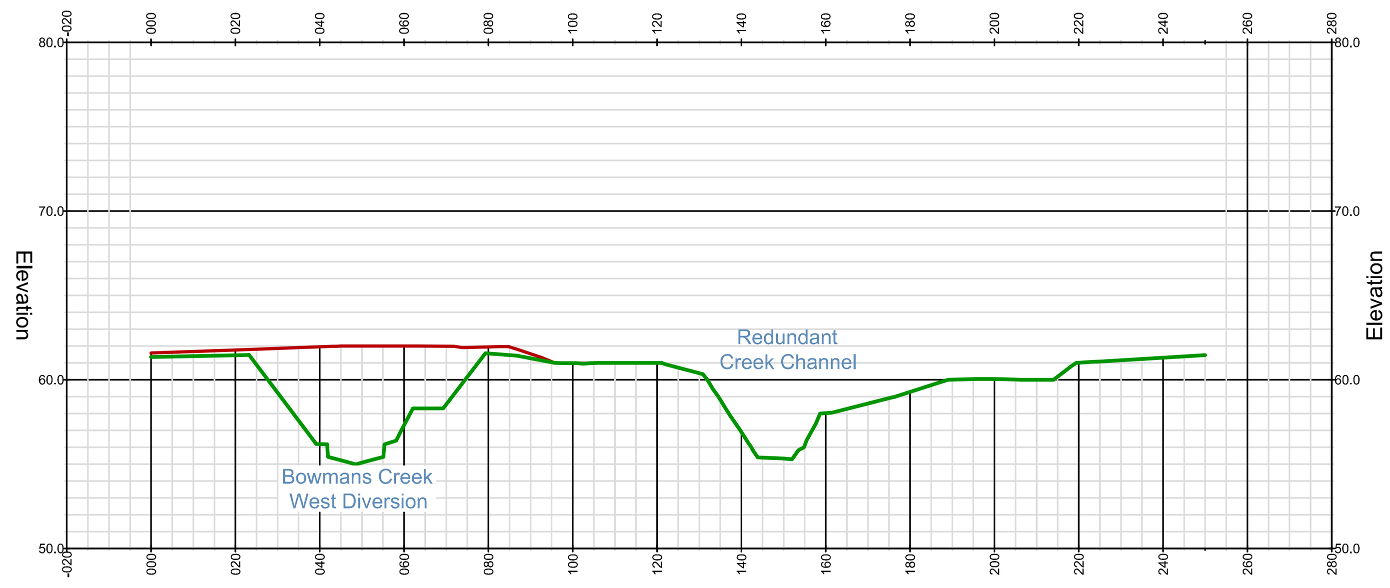
Section B - East Diversion



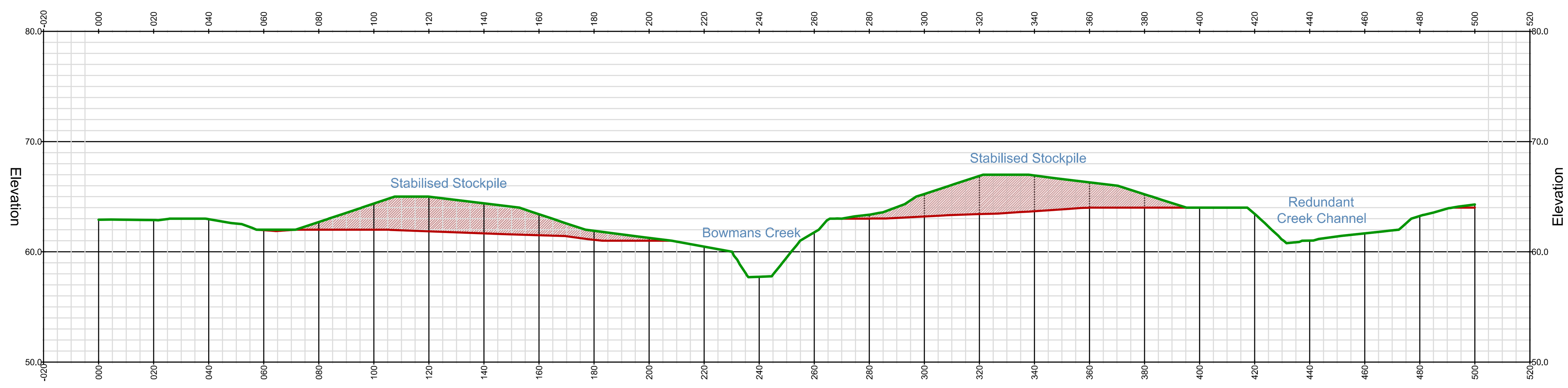
Section C - West Diversion



Section D - West Diversion



Section E - Bowmans Creek



Vertical Exaggeration 4 to 1

Legend

- Final Surface
- Pre-disturbance Surface
- Stabilised Stockpile

AshtonCoal
PO Box 699 Singleton NSW 2330
Phone 61+ 02 6576 1111 Fax 61+ 02 6576 1122

MINE OPERATIONS PLAN 7

Sections

Name of mine	ASHTON UNDERGROUND COLLIERY
Mining Leases	ML1533, ML1623, ML1529
MOP Commencement Date	24-02-2011
Name of Leaseholder	White Mining (NSW) P/L, Austral-Asia Coal Hldng P/L, ICRA Ashton P/L
Name of mine operator	ASHTON COAL OPERATIONS PTY LTD
Reporting Officer	Brian Wesley
Title	General Manager
Signature	....
Date	24-02-2011

I, ..., holder of Mine Manager's Certificate of Competency No. ...., certify that the information on this plan is a true indication of the proposed development.

....

Date:..

I, ...Jeffrey Peck......................................, a Registered Mining Surveyor under the Surveying Act 2002, certify that to the best of my knowledge and belief this plan conforms to the accuracy standards required by the NSW Department of Primary Industries.

....

Date:..

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Appendix A – Statement of Commitments

A copy of ACOL's commitments for the diversion of Bowmans Creek are provided below – as relevant to the construction works.

General
The diversion channels will be constructed in accordance with detailed civil and landscape design plans generally consistent with EA Plan Sets 2 and 3.
A geosynthetic clay liner will be placed under the low flow section of the diversion channels to minimise loss of baseflow from the constructed channels and to preserve surface flows in the diverted creek.
All workers involved in the construction of the diversion channels and block banks will receive site specific induction that includes requirements for good environmental management, including management of noise and dust; erosion and sediment; Aboriginal heritage; hazardous materials; and waste.
Surface Water
Water level monitoring will be undertaken in two pools immediately above LW6B as part of the routine monthly monitoring program and used to guide construction of block banks to their final level. While mining is occurring in LW6B, water levels will be monitored weekly.
Geomorphology
The bed and bank of the diverted creek will be surveyed: • Six months, one year and two years after completing construction of the diversion channels. • At five yearly intervals, or immediately after a flood with a peak flow greater than 150m3/s (about 5 years ARI), at existing cross sections in the retained sections of the existing creek. For purposes of this commitment, flow will be determined from the Office of Water gauging station. • At five yearly intervals, or immediately after a flood event with a peak flow greater than 150m3/s (about 5 years ARI), at ten new cross section locations and along the thalweg of each diversion channel. The cross section locations will be established to be representative of the various geomorphic forms within the diverted channels.
At the same time as cross sectional and longitudinal (thalweg) surveys, bed samples will be collected from four locations in each diversion channel (two pools and two riffles). Samples will also be collected from eight comparable representative sites in the remaining functional sections of the creek for statistical comparison. If there is a variation of more than 20% in the statistics of the data from the diversions compared to the existing channel, ACOL will commission an appropriately qualified geomorphologist to investigate the causes and recommend any remedial actions.
Construction of Diversion Channels
The diversion channels will be constructed during daylight hours: 7am-6pm Monday to Saturday. 8am-6pm Sundays and Public Holidays.
Erosion and sediment controls for the construction works will generally be consistent with: The existing ACP Erosion and Sediment Control Management Plan. Detailed diversion engineering design drawings (C045 – C047).

Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries (DECC 2008, or latest version).
Topsoil will be separately stockpiled within designated stockpile areas and used for rehabilitating disturbed areas, post construction, where required.
During and immediately after mining of the Pikes Gully seam, groundwater monitoring together with visual monitoring of stream flows and pools within Bowmans Creek (as diverted) will be undertaken. If there is any indication that significant drainage of the alluvium is occurring, or there is loss of stream flow, due to cracking, the full height block banks will be constructed immediately.
Noise and dust associated with construction activities will be minimised and managed consistent with existing ACP Noise and Dust Management Plans, including: • Monitoring against existing noise and dust impact assessment criteria at nearby sensitive receivers. • Minimising areas to be disturbed. • Using water trucks to suppress dust on all active haul roads and stockpile areas, where required. • Revegetating disturbed areas following completion of earthworks.
Appropriate signage will be installed on the New England Highway and at relevant public access points for the duration of construction activities.
A construction traffic management plan will be prepared and implemented to manage construction traffic interaction with the New England Highway, to the satisfaction of the RTA.
Detailed channel construction works will be carried out in consultation with appropriately qualified and experienced technical specialists.
Rehabilitation and Land Management
Landscape restoration will generally be consistent with the: The Rehabilitation Strategy described in the Response to Submissions Report. Conceptual landscape design drawings presented in the EA. Existing ACP Landscape and Revegetation Management Plan. Existing ACP weed management protocols.
Flood damage to the constructed channels will be remediated to restore hydraulic and geomorphic function.
Stock proof fencing (at least 5 m from the alignment of any riparian trees) will be installed along both sides of the functioning diverted creek for its full length between the New England Highway and the Hunter River.
Stock watering troughs will be installed at strategic locations on pasture areas adjacent to the creek in the post-mine landscape, where required.
Riparian and Aquatic Habitat
Habitat trees in close proximity to construction activities will be clearly marked and protected.
Fish passage will be maintained in the diverted creek sections under at least moderate flow conditions.
Resting pools will be included within the diverted creek sections.
Large woody debris will be used to restore aquatic habitat.
Loss of up to 1.8ha of riparian and aquatic habitat will be replaced with 15.7ha of combined aquatic and riparian habitat. An additional 58.7ha of mixed riparian woodland and grassy floodplain woodland will be established on the adjacent

floodplain to further improve terrestrial habitat.
The collection of River Red Gum seeds will be conducted under the appropriate licence or certificate, as required under the *Threatened Species Conservation Act 1995*.
Aboriginal Heritage
All workers involved in construction will be given a site induction that includes awareness of the location of aboriginal heritage sites in the area, prohibition on entering identified sites and procedures to be followed in the event of any Aboriginal artefacts be detected during construction work.
Should any Aboriginal artefacts be detected during construction, work in that location will cease immediately and the finds will be reported to the Environmental Manager, at which time the existing ACP Archaeology and Cultural Heritage Management Plan protocols will be implemented. Work will not recommence in the area until instructed to do so by the Environmental Manager.
There will be no construction within 70m of the Waterhole Site grinding grooves and appropriate controls will be implemented to protect this site form inadvertent construction activity impacts, including: Clear fencing of the site to form a boundary between contractors and the outer perimeter of the site. Inclusion of a work method statement (WMS) that outlines the responsibilities of contractors in order to ensure that the site is not impacted and which outlines the repercussions of not adhering to the WMS (e.g. fines administered by DECCW). Inclusion of a cultural awareness component in the general induction of contractors working on the project.
The management for sites and areas of potential Aboriginal heritage impacted by the proposed diversions will be developed in consultation with the registered Aboriginal Stakeholders, and approved through the Extraction Plan process.
The oral history of the area will be recorded through consultation with relevant Aboriginal stakeholders, local landowners and other sources as appropriate to inform mitigation measures during construction.
The existing ACP Archaeology and Cultural Heritage Management Plan will be reviewed and updated where required, in consultation with Aboriginal stakeholders, to include management of Aboriginal heritage within the Bowmans Creek diversion disturbance area.
Environmental Monitoring and Reporting
Environmental monitoring will be carried out generally as described in the EA for the creek diversion.
Completion criteria for the creek diversion, including a monitoring regime and reference sites will be formalised in a Rehabilitation Management Plan prepared in consultation with relevant government authorities.

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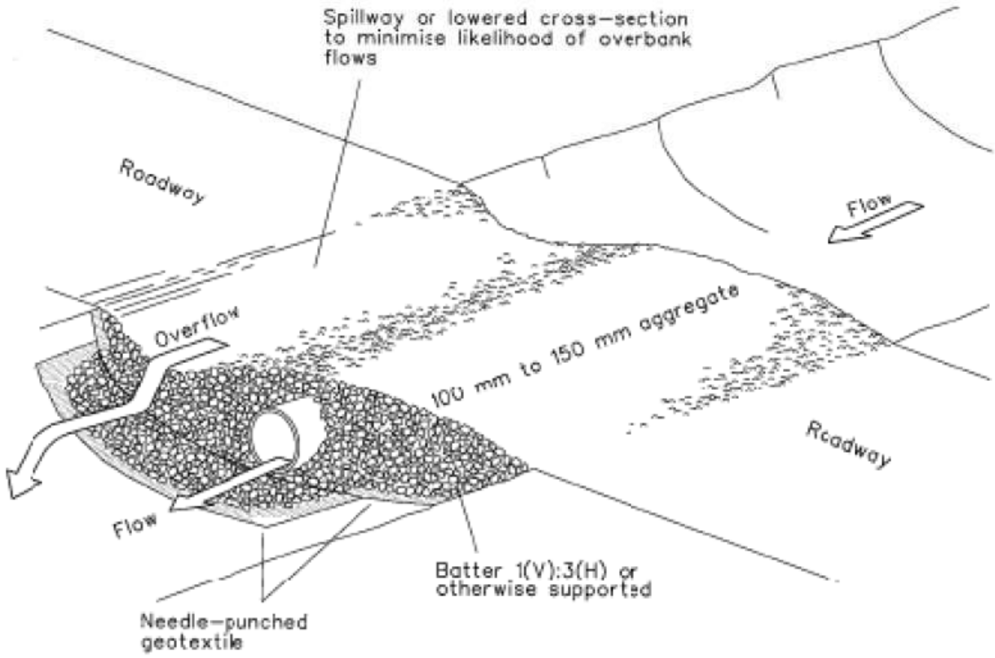
Appendix B – Erosion Control Measures (Typical)

The following standard drawings (Landcom 2004) apply to the erosion and sediment control works during construction.

- Temporary Waterway Crossing
- Rock Check Dams
- Sediment Fencing
- Hay Bales
- Diversion drain ("Earth Bank – High Flows")

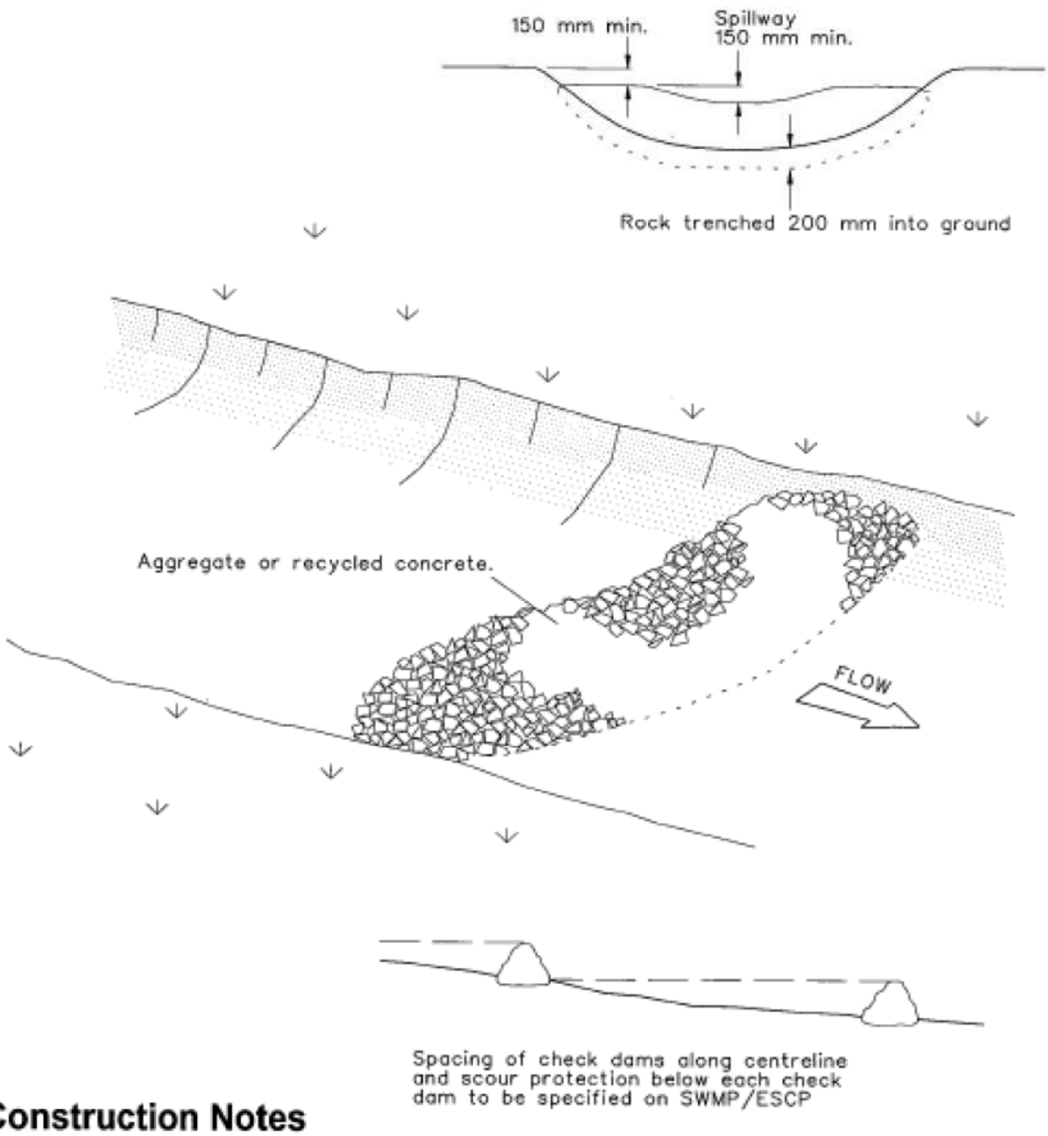
Copies of the above standard details from the Blue Book (Landcom 2004) follow.



Construction Notes

1. Prohibit all traffic until the access way is constructed.
2. Strip any topsoil and place a needle-punched textile over the base of the crossing.
3. Place clean, rigid, non polluting aggregate or gravel in the 100 mm to 150 mm size class over the fabric to a minimum depth of 200 mm.
4. Provide a 3-metre wide carriageway with sufficient length of culvert pipe to allow less than a 3(H): 1 (V) slope on side batters.
5. Install a lower section to act as an emergency spillway in greater than design storm events.
6. Ensure that culvert outlets extend beyond the toe of fill embankments.

TEMPORARY WATERWAY CROSSING **SD 5-1**



Construction Notes

1. Check dams can be built with various materials, including rocks, logs, sandbags and straw bales. The maintenance program should ensure their integrity is retained, especially where constructed with straw bales. In the case of bales, this might require their replacement each two to four months.

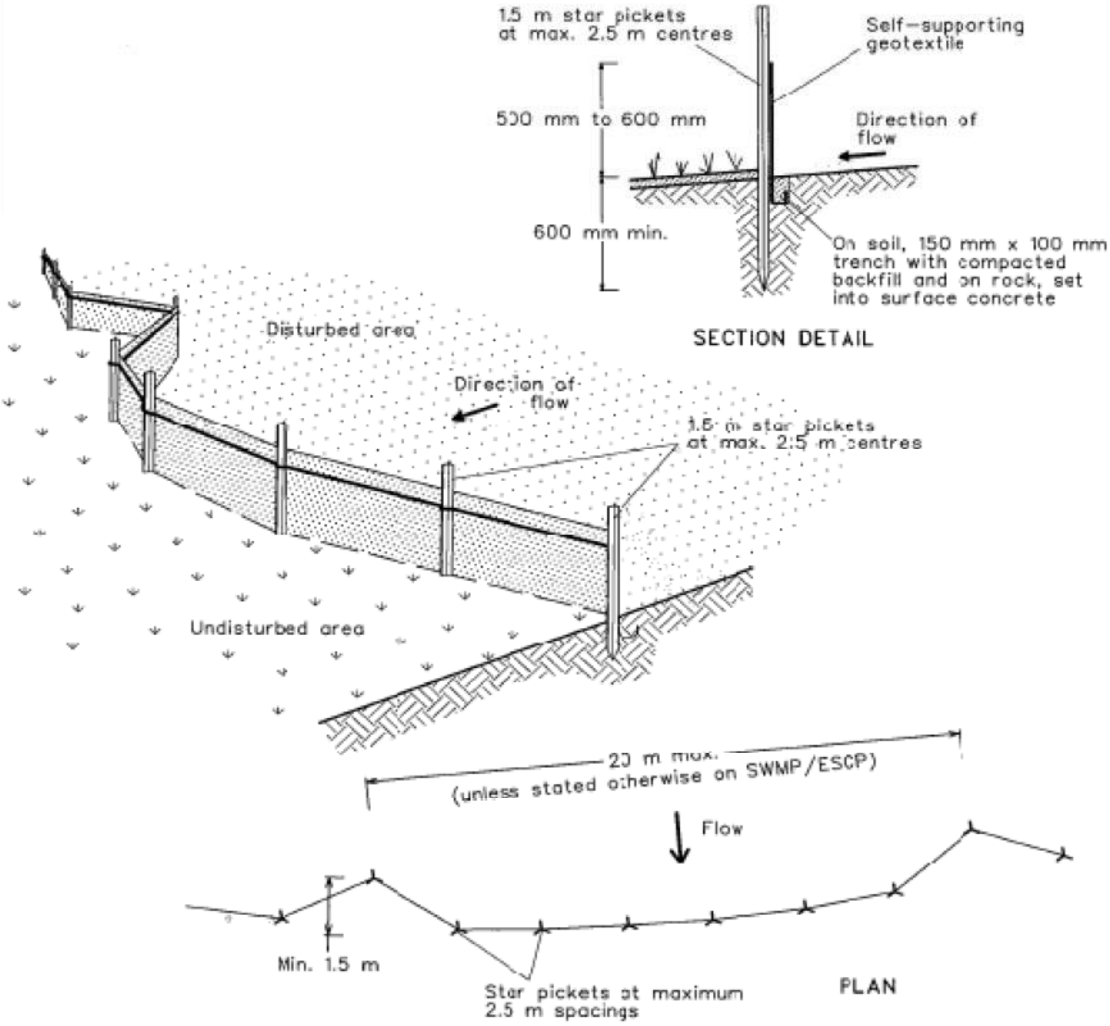
2. Trench the check dam 200 mm into the ground across its whole width. Where rock is used, fill the trenches to at least 100 mm above the ground surface to reduce the risk of undercutting.

3. Normally, their maximum height should not exceed 600 mm above the gully floor. The centre should act as a spillway, being at least 150 mm lower than the outer edges.

4. Space the dams so the toe of the upstream dam is level with the spillway of the next downstream dam.

ROCK CHECK DAM

SD 5-4

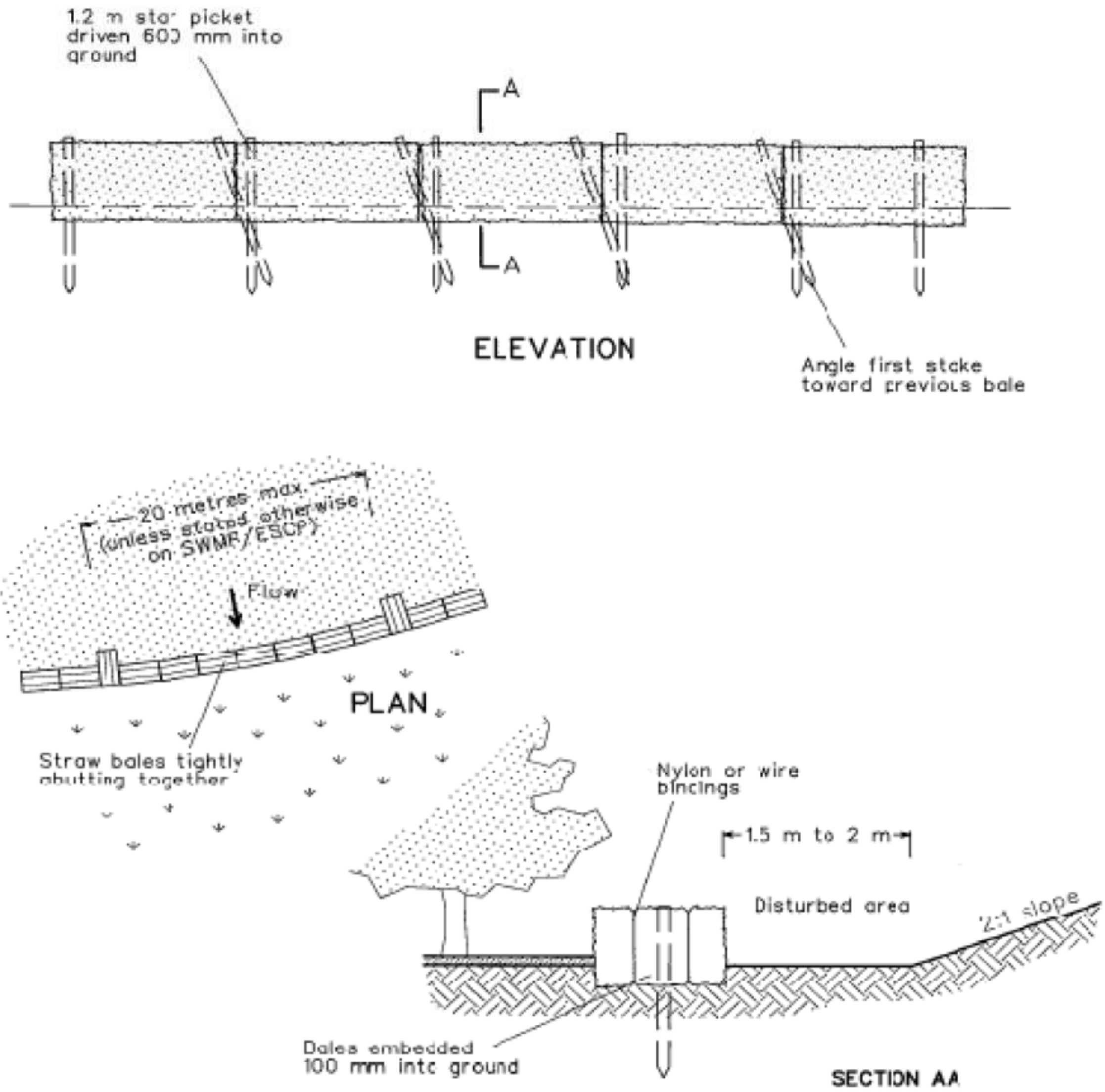


Construction Notes

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

SEDIMENT FENCE **SD 6-8** [2]

[2] Note: ACOL proposed to use alternate installation methodology (trenchless) as a minor variation to the above standard detail. Geotextile inserted to 200mm below ground level.

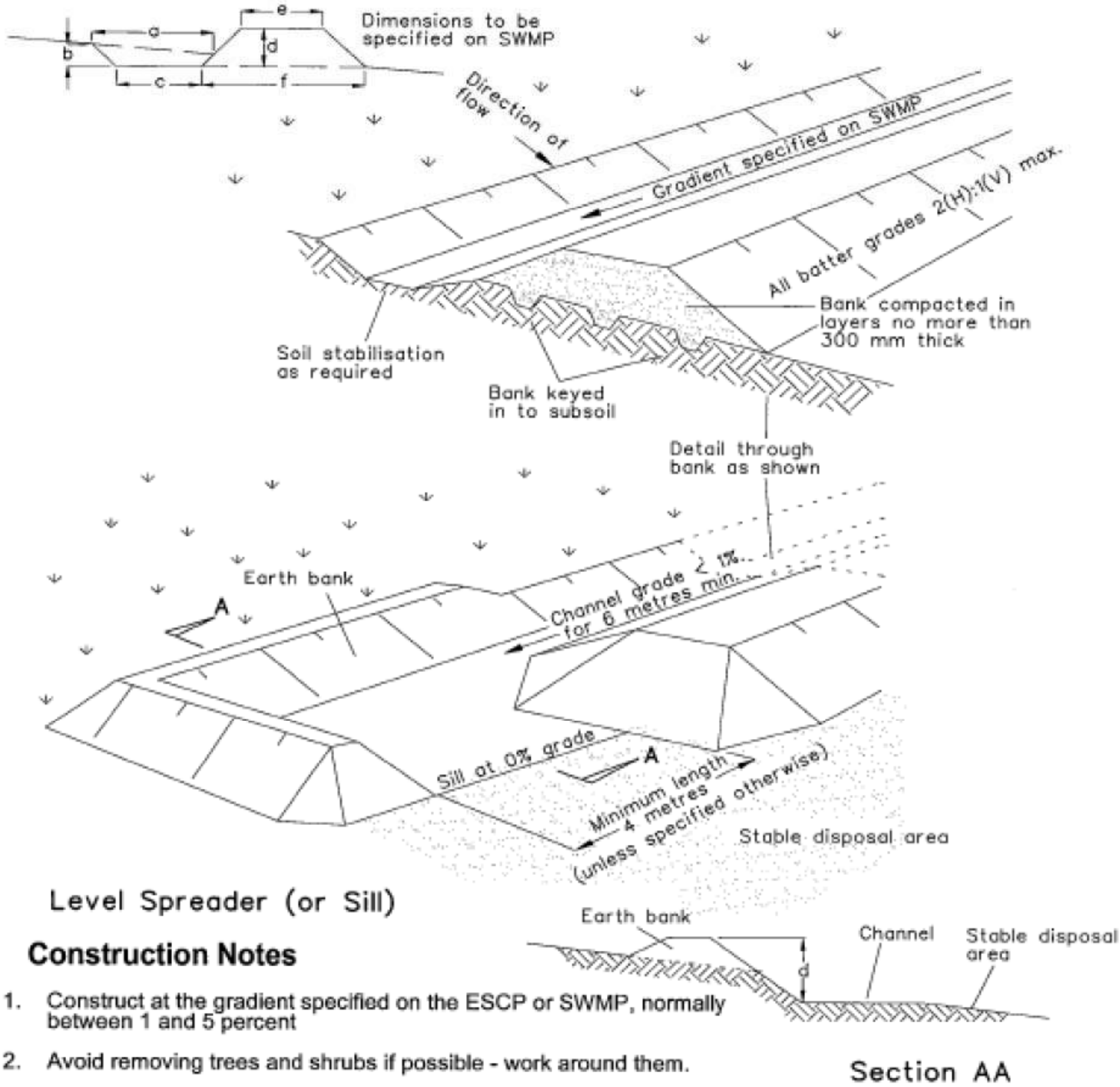


Construction Notes

1. Construct the straw bale filter as close as possible to being parallel to the contours of the site.
2. Place bales lengthwise in a row with ends tightly abutting. Use straw to fill any gaps between bales. Straws are to be placed parallel to ground.
3. Ensure that the maximum height of the filter is one bale.
4. Embed each bale in the ground 75 mm to 100 mm and anchor with two 1.2 metre star pickets or stakes. Angle the first star picket or stake in each bale towards the previously laid bale. Drive them 600 mm into the ground and, if possible, flush with the top of the bales. Where star pickets are used and they protrude above the bales, ensure they are fitted with safety caps.
5. Where a straw bale filter is constructed downslope from a disturbed batter, ensure the bales are placed 1 to 2 metres downslope from the toe.
6. Establish a maintenance program that ensures the integrity of the bales is retained - they could require replacement each two to four months.

STRAW BALE FILTER

SD 6-7



Construction Notes

1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible - work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V-shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

EARTH BANK (HIGH FLOWS) **SD 5-6**

Appendix C – Sediment "Basin" Sizing

Copies of the calculations to determine sediment basin treatment volume requirements for the Bowmans Creek Diversion are provided below. Assessment based on procedures contained within the Blue Book (Landcom 2004).

Note: These "Standard Calculation" spreadsheets relate only to low erosion hazard lands as identified in figure 4.6 where the designer chooses to not use the RUSLE to size sediment basins. The more "Detailed Calculation" spreadsheets should be used on high erosion hazard lands as identified by figure 4.6 or where the designer chooses to run the RUSLE in calculations.

1. Site Data Sheet

Site name: **Ashton Coal**

Site location: **Camberwell NSW**

Precinct:

Description of site: **Construction of Bowmans Creek Diversion**

Site area	Site						Remarks
	East	West					
Total catchment area (ha)	22.136	4.4328					
Disturbed catchment area (ha)	13.73	4.4328					

Soil analysis

Soil landscape	Singleton						DIPNR mapping (if relevant)
Soil Texture Group	D/F	D/F					Sections 6.3.3(c), (d) and (e)

Rainfall data

Design rainfall depth (days)	5	5					See Sections 6.3.4 (d) and (e)
Design rainfall depth (percentile)	80	80					See Sections 6.3.4 (f) and (g)
x-day, y-percentile rainfall event	24.4	24.4					See Section 6.3.4 (h)
Rainfall intensity: 2-year, 6-hour storm	7.55	7.55					See IFD chart for the site
Rainfall erosivity (R-factor)	1410	1410					Automatic calculation from above data

Comments:

Site runoff to be contained within excavation area will be pumped back to Ashton Coal's surface operations via existing pipeline. Storage volume determined using this spreadsheet to be maintained within the excavation area for capture of runoff.

2. Volume of Sediment Basins, *Type D* and *Type F* Soils

Basin volume = settling zone volume + sediment storage zone volume

Settling Zone Volume

The settling zone volume for *Type F* and *Type D* soils is calculated to provide capacity to contain all runoff expected from up to the y-percentile rainfall event. The volume of the basin's settling zone (V) can be determined as a function of the basin's surface area and depth to allow for particles to settle and can be determined by the following equation:

$$V = 10 \times C_v \times A \times R_{y\text{-}\%ile,\ x\text{-}day}\ (m^3)$$

where:

10 = a unit conversion factor

C_v = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period

R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events. (See Sections 6.3.4(d), (e), (f), (g) and (h)).

A = total catchment area (ha)

Sediment Storage Zone Volume

In the standard calculation, the sediment storage zone is 50 percent of the setting zone. However, designers can work to capture the 2-month soil loss as calculated by the RUSLE (Section 6.3.4(i)(ii)), in which case the "Detailed Calculation" spreadsheets should be used.

Total Basin Volume

Site	C_v	R x-day y-%ile	Total catchment area (ha)	Settling zone volume (m^3)	Sediment storage volume (m^3)	Total basin volume (m^3)
East	0.50	24.4	22.1358	2700.5676	1350	4050.8514
West	0.50	24.4	4.4328	540.8016	270	811.2024

Appendix D – Rehabilitation Strategy

Note: the final approved underground mine layout is shown in Figure 1 in the following document. All other figures showshow an early pre-approved version of the underground mine layout.

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Bowmans Creek Diversion

Rehabilitation Strategy

May 2010

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Annexure

1 INTRODUCTION

On 9th December 2009 an Environmental Assessment (EA) was submitted to the Department of Planning by Ashton Coal Operations Limited (ACOL) in support of an application for modification (MOD 6) of the existing development consent (DA 309-11-2001-i) for the Ashton Coal Project (ACP) located near Camberwell in the Singleton local government area of New South Wales. ACOL seeks to modify the 2002 development consent to provide for:

1. Underground mining operations which may result in a direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurring due to subsidence cracking;
2. The relocation of sections of Bowmans Creek as shown on **Figure 1** to mitigate subsidence impacts resulting from 1. above; and
3. Extraction of coal from the Upper Liddell Seam, Upper Lower Liddell Seam and the Lower Barrett Seam in the western most area of the approved underground mine (proposed Longwall 8 on **Figure 1**).

The ACP underground mine is a descending longwall operation targeting four coal seams in an area that is bounded to the north by the New England Highway and to the south by the Hunter River. Underground mining at the ACP commenced in December 2005 and it is expected that mining of the Lower Barrett seam will be completed by 2024.

In the light of extensive groundwater monitoring and better understanding of subsidence, ACOL has prepared a revised mine plan for the more efficient extraction of the coal resource in the vicinity of the Bowmans Creek alluvium which addresses the key issues of concern at the time that the original consent was granted. ACOL now considers that options are available that would allow diversion of the creek and the implementation of alternative mining plans which would result in acceptable environmental impacts whilst providing reserve optimisation, business sustainability and employment security. The potential impacts and the proposed mitigation measures are summarised in **Table 1** (which contains relevant extracts from the Executive Summary in the EA).

Table 1: Summary of Potential Impacts and Mitigation Measures

Aspect	Impact	Mitigation and Offset
Aquatic	Loss of **198m** in stream length, or 3.2% between existing and diversions.	– Increase width of diversions, such that there is an increase in pool area. – Incorporation of additional aquatic habitat (large woody debris) in the diversions. – Incorporation of fish friendly riffle and rock bar structures. – Provision of backwater resting pools to assist fish migration.
	6.7ha of existing riparian habitat area to be isolated by the block banks and diversions.	Diversions to incorporate **6.4ha** riparian habitat Excised sections of creek will progressively evolve to flood plain woodland and add to the diversity of habitat.
	Loss of floodplain grassland for construction of channels and other areas incorporated into fenced riparian zones.	The existing ACOL *Land Management Plan* proposes to fence and manage approximately 62ha of the Bowmans Creek riparian corridor (this includes 31ha of creek line and banks). This project will improve existing fencing and increase the fenced area by **41.6ha** (making a total riparian corridor of **103.6ha**) to exclude livestock, and permit the natural regeneration of floodplain and riparian vegetation.
Fauna	Loss of three (3) trees containing hollows.	Provision of replacement hollows or nesting boxes at a ratio of **3:1** within the riparian corridor.
Flora	Removal of **1.8ha** of existing riparian woodland at the connection points of the diversions.	The diversions will be planted with **7.3ha** of terrestrial riparian woodland of similar or better composition.
	Disturbance of **28.5ha** of pasture grasses from the diversions, stockpiles, haulage and site compounds.	**9.9ha** of this area will be returned to pasture for livestock grazing, while the remainder (**18.6ha**) will be planted as riparian woodland and/or actively managed.

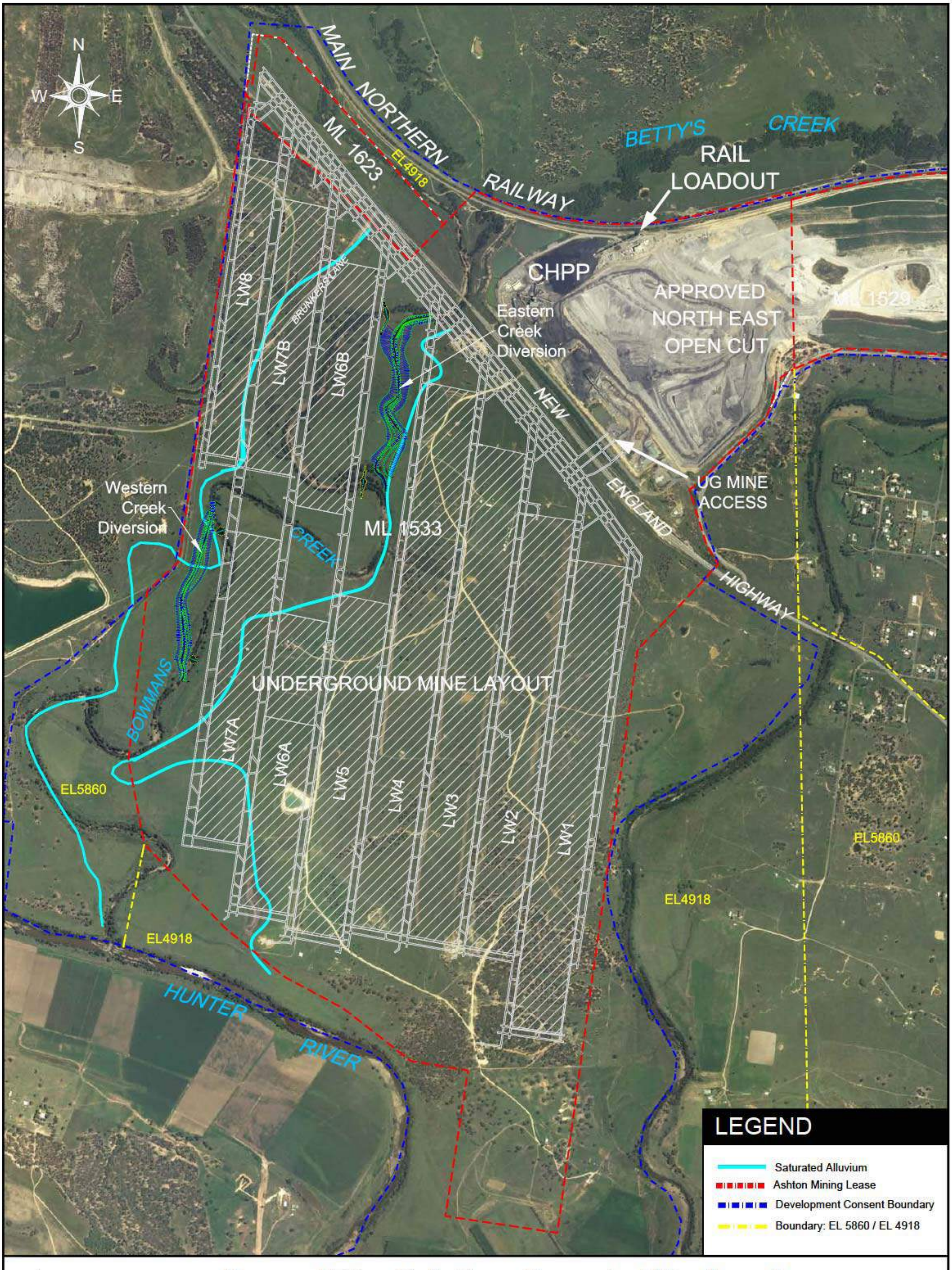
Table 1: Summary of Potential Impacts and Mitigation Measures

Aspect	Impact	Mitigation and Offset
Agriculture	Temporary loss of **9.9ha** of pasture for grazing of livestock from stockpiles, haulage roads and site compounds.	These areas will be progressively revegetated. Stockpiles will be used over time as a source material to remedy subsidence troughs and correct drainage. These areas will be returned to pasture grasses.
	Permanent loss of **72.6ha** of pasture for grazing of livestock from the improvement of fencing on the riparian corridor to exclude livestock, which includes the two diversions and northern-most stockpile.	In the case of the diversions these areas will be replanted with woodland, while the fenced riparian corridor will naturally revegetate and be managed for weed and erosion control measures.
Surface Water Flow	Baseflow reduction progressively increasing to a total of 47.5 ML/year by the end of mining and about 20 ML/year after 100 years recovery.	Impermeable barrier under the diverted sections to minimise loss. Residual loss will be off set against existing licences.
Surface Water Quality	Potential for degradation of surface water quality.	Salt load to the Hunter reduced by 36t/year. Exclusion of stock from riparian zone will reduce sediment load resulting from stock trampling. Diversion channels will be provided with erosion protection matting and dense planting in zone immediately adjacent to the channel below the 1 year flood level Temporary low block banks (overtopped in 6 month flow) to reduce the risk of flood damage in early stages of rehabilitation in diversion channels.
Subsidence	Subsidence induced strains, tilting and cracking of excised section of creek and alluvials.	Construction of diversion channels to minimise impacts to the creek. Partial extraction under the functional sections of creek
	Ponding of runoff or floodwater in subsidence troughs	Create free draining landscape by construction of drainage or filling of subsidence troughs.

In its submission to the Department of Planning, Industry and Investment NSW (I&I) sought further detail in relation to the rehabilitation of the proposed creek diversions and associated soil emplacements. In particular, I&I requested measurable completion criteria for the phases of the rehabilitation program and contingency strategies that could be implemented in the event that key elements of the rehabilitation fail to meet the requirements of the design.

This document provides a consolidated account of the overall design and rehabilitation strategy including the staging of construction and rehabilitation works, the safeguards and contingency measures embedded in the proposal, draft high level completion criteria and the proposed procedures for defining agreed final completion criteria with the relevant agencies. Much of the material contained in this document has been extracted from the EA and presented in a manner that focuses on the rehabilitation strategy, anticipated outcomes and monitoring activities.

Cross reference to the original EA documentation is provided where necessary. For clarity, references to tables and figures in this document are in **bold**, while cross references to the EA are generally in *italics*.



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Proposed Pikes Gully Seam Conceptual Mine Layout
- Bowmans Creek Diversion

Figure 1

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2 REHABILITATION PLANNING

2.1 Introduction

Ashton Coal Operations Ltd (ACOL) acknowledges that rehabilitation of mined land is an integral part of the mining process. It is also acknowledges that the best long term environmental, social and economic outcomes for the Bowmans Creek Diversion project will be achieved through integrating rehabilitation objectives into project design and planning. Further, that on-ground rehabilitation works must commence as soon as practicable following mine disturbance and be progressively carried out throughout the life of the project. This will enable ACOL to meet its rehabilitation and mine closure objectives, following the completion of underground mining related to the Bowmans Creek project (Longwalls/Miniwalls 5-8).

The approach adopted in developing the concept for the construction and rehabilitation associated with the diversion of Bowmans Creek and the subsequent rehabilitation of the diversion channels and subsidence impacts on the alluvial floodplain is based on the hierarchy of processes identified by Tongway (CSIRO Sustainable Ecosystems) in relation to the rehabilitation of mined landscapes (see **Figure 2**).

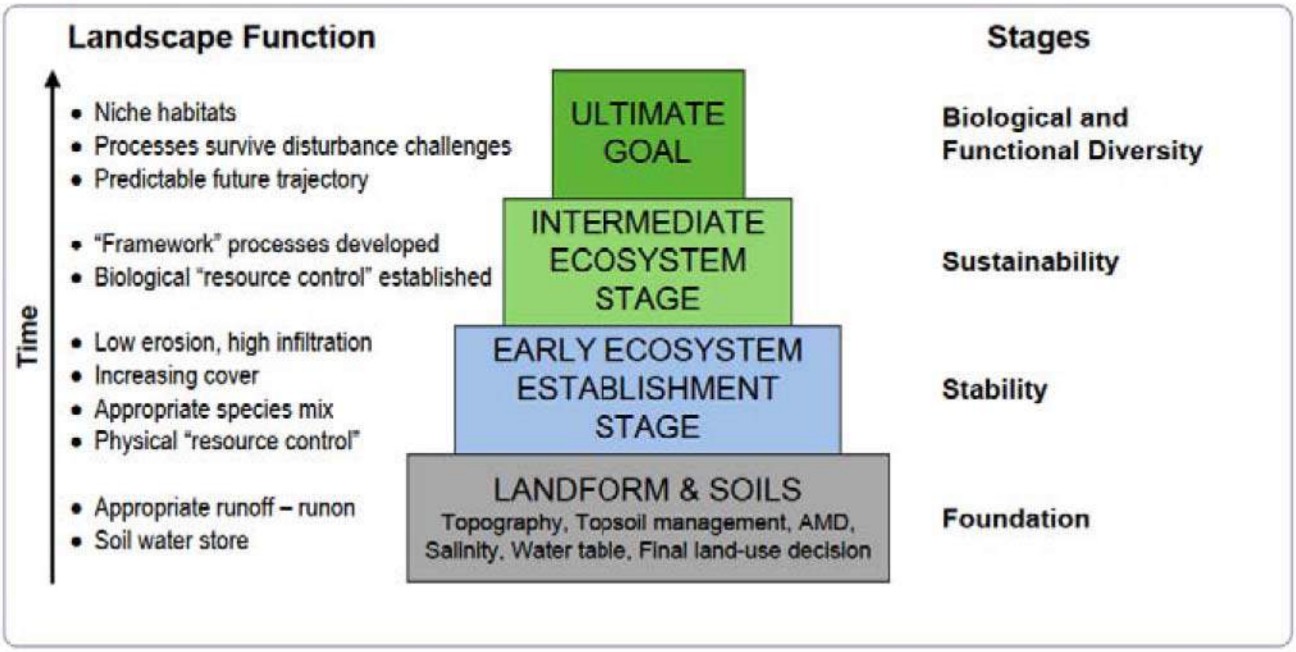


Figure 2:
Hierarchy of Processes on Rehabilitation Sites Over Time
(after Tongway, Undated)

The concepts illustrated in **Figure 2** have been adapted to the requirements of the Bowmans Creek Diversion project by recognising the following hierarchy:

- **Foundation** Appropriate physical form of the diversion channels to provide the required hydraulic and geomorphic characteristics together with aquatic habitat opportunities;
- **Stability** Initial stabilisation of the landscape with physical methods (rockwork, erosion control matting, etc) and selected vegetation;
- **Sustainability** Further planting to provide vegetation community structure;
- **Diversity** Augmentation of vegetation to provide functional diversity and resilience.

The development of the concept design and rehabilitation strategy for the Bowmans Creek Diversion project recognised the importance of a sound physical foundation, as illustrated in **Figure 2**. The approach taken was to copy the geomorphology and habitat of the existing creek. The first step was to characterise the geomorphology and physical habitat (hydraulics) of the existing creek. Characterisation of the geomorphology and physical habitat is reasonably straightforward because the fundamental processes are governed by basic physical laws of hydraulics and sediment movement that have been understood for centuries. Industry standard methods for analysing the creek's hydrology, hydraulics, and potential for sediment movement were utilised meaning that there is little complexity and uncertainty associated with recreating the geomorphology and habitat of Bowmans Creek.

The progressive development of the rehabilitation hierarchy for Bowmans Creek not only provides a robust basis for creation of a long term sustainable ecosystem, but also takes account of the progressive changes in the floodplain that will occur as a result of mining of successive coal seams and provides a basis for the staging of rehabilitation.

Completion of underground mining operations in the vicinity of Bowmans Creek will be undertaken in consultation with government authorities and key stakeholders and be consistent with ACOL's rehabilitation objectives and commitments. The overall rehabilitation objectives for the Bowmans Creek Diversion project are to:

- Rehabilitate the diverted sections of Bowmans Creek to a naturally vegetated state using appropriate endemic species to provide improved riparian and aquatic habitat compared to that which exists at present (as demonstrated by comparison to reference sites and baseline monitoring undertaken to date);
- Restore land affected by subsidence to a free draining landform suitable for agriculture and native vegetation establishment to complement the riparian vegetation and vegetated corridor linkages.

In addition to rehabilitating mine impacted areas, the project will also improve existing degraded sections of Bowmans Creek including the existing River Red Gum communities to provide significantly improved riparian and aquatic habitat compared to that which exists at present (as demonstrated by reference to monitoring undertaken to date).

The Bowmans Creek Diversion project will potentially disturb an area of 30.3 ha (1.8 ha of riparian woodland and 28.5 ha of pasture grass – see **Table 1**), comprising the two sections of creek diversion (total 1,734m in length), the areas of the Bowmans Creek alluvial floodplain affected by subsidence and areas to be used for temporary placement of alluvial spoil extracted during the construction of the diversion channels.

The vision for the final rehabilitation associated with the Bowmans Creek Diversion project is shown on **Figure 3** (which is a copy of *Figure 10.3* from the EA). Rehabilitation will be undertaken in a progressive manner as soon as practicable after construction of the diversion channels and as subsidence affects the areas of the Bowmans Creek floodplain. At completion of underground mining associated with Bowmans Creek Diversion project (Longwalls/Miniwalls 6-8), it is envisaged that Bowmans Creek and the associated riparian restoration areas will be used for conservation and potentially for the purposes of passive recreation and environmental education. Other areas of the alluvial floodplain that have been subject to subsidence will be restored to provide a free draining landscape capable of being used for grazing or cropping purposes.

The specific rehabilitation objectives for the Bowmans Creek Diversion project are:

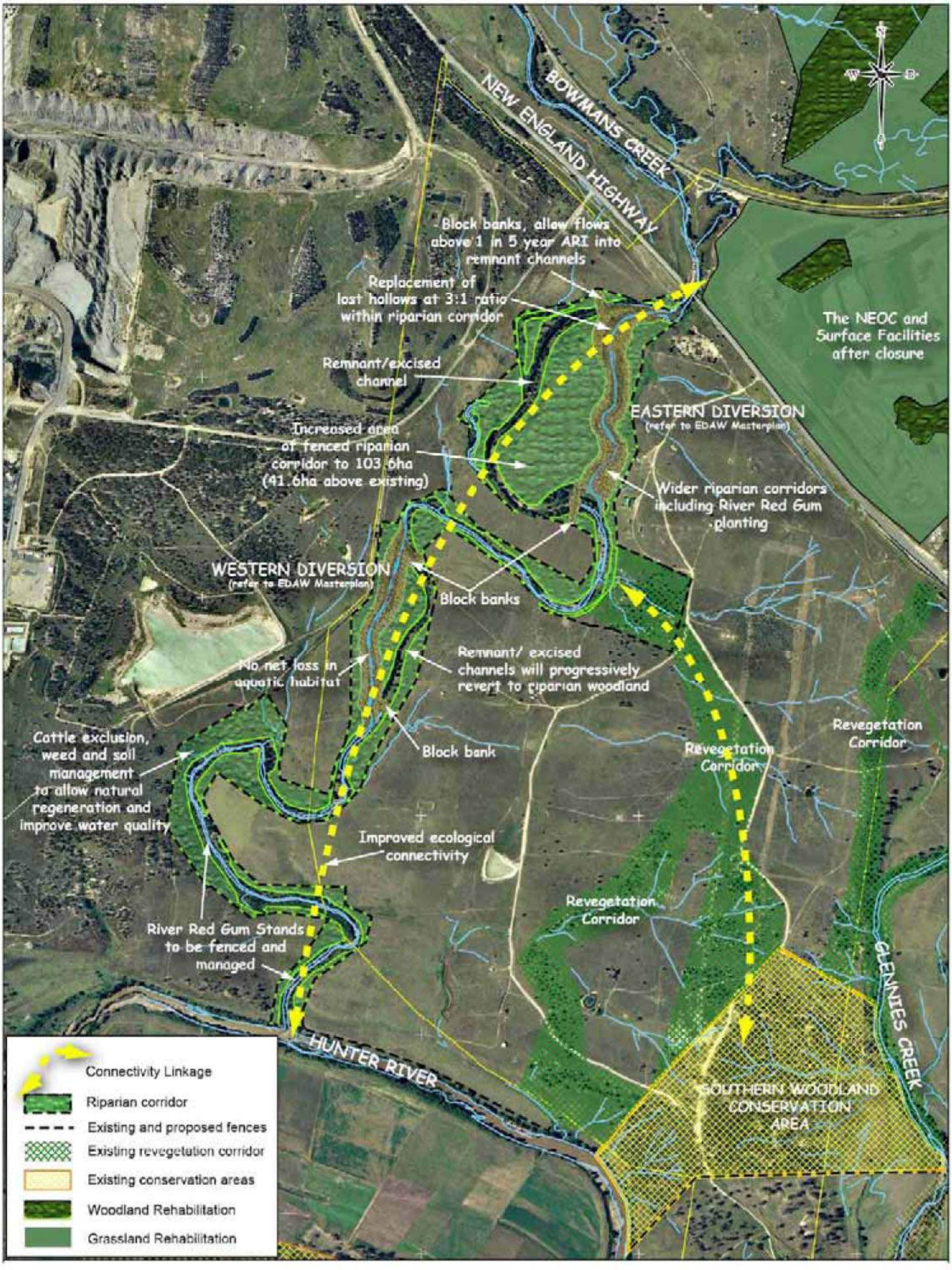
- Creating a natural looking, stable creek that mimics the geomorphic form of the existing channel of Bowmans Creek and provides increased areas of aquatic habitat as well as improved diversity and quality of aquatic habitat (pools and large woody debris) whilst maintaining the fish passage characteristics of the original creek;

- Creating a self sustaining and ecologically diverse riparian corridor along the length of Bowmans Creek between the Hunter River and the New England Highway including revegetating and enhancing remnant riparian vegetation on non-mine affected land with endemic native species including River Red Gums so as to increase the area and quality of native riparian woodlands, particularly along the section of Bowmans Creek located between the Hunter River and the Western Diversion;
- Creating revegetation links and habitat corridors between existing remnant vegetation (to the east of Bowmans Creek near the southern end of the Eastern Diversion) and the Southern Woodland Conservation Area that connects to the Hunter River and Glennies Creek (located on ACOL land – see **Figure 3**);
- Maintaining the diversity and genetic resource of flora currently existing within the locality;
- Maintaining and enhancing habitat for native fauna;
- Reinstating surface drainage to create a free draining landform by filling areas of subsidence on the alluvial floodplain and provision of minor drainage works on adjoining land;
- Preventing soil erosion and sedimentation as a result of construction works, placement of temporary stockpiles or as a result of changes in land slope as a result of subsidence;
- Fencing designated riparian and revegetation corridors so as to prevent impact from domestic stock;
- Providing access for monitoring and adaptive management, control of competitive native and exotic flora and fauna species and suppression of fires;
- Progressing towards meeting closure and post-mining land use objectives in a timely and cost effective manner.

These rehabilitation objectives provide an opportunity to enhance and improve the ecological value of the area Bowmans Creek riparian zone and floodplain by re-establishing native vegetation along the length of the creek between the Hunter River and the New England Highway as well as across an area between the existing creek and the Eastern Diversion that has previously been cleared for agriculture.

To achieve these objectives, ACOL will:

- Progressively revegetate the diversion channels in order to provide initial stabilisation against scour followed by further augmentation to provide community structure and subsequent enrichment of species diversity;
- Continue to manage weeds (willows, blackberry, etc) and undertake supplementary planting along retained sections of the creek in order to provide enhanced riparian community structure and species diversity in line with the standard of rehabilitation proposed for the diversion channels;
- Exclude domestic stock from the riparian zone along Bowmans Creek between the Hunter River and the New England Highway;
- Revegetate the temporary stockpiles of alluvial spoil to stabilise against erosion from rainfall and flowing water;
- Re-distribute the material from the temporary stockpiles as subsidence of the floodplain occurs in order to maintain a free draining landform. All filling of subsidence areas will be revegetated in a manner consistent with the final land use (riparian floodplain forest or agriculture);
- Continually refine a monitoring and maintenance program to guide rehabilitation success and provide continual improvement to meet the long-term post-closure land use objectives.



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Bowmans Creek Diversion Project

Figure 3
Post Mining Landscape, Connectivity and Offsets

2.2 Rehabilitation Principles

Mine rehabilitation generally comprises two stages: design and construction of a stable landform, and establishment of a sustainable post-mining land use which, in this case, involves the provision of four key elements:

- Channel geomorphology that mimics the existing channel;
- Provision for fish passage and a rich diversity of aquatic habitat;
- An ecologically diverse naturally vegetated riparian corridor;
- A free draining floodplain that is vegetated to a standard consistent with the final intended land use.

Successful rehabilitation of Bowmans Creek and its alluvial floodplain will be achieved through the application of the following guiding principles:

- Adoption of mine completion criteria based on creek and landform design, erosion control, drainage, soil processes, flora, fauna and ecosystem function as set out in **Section 6** of this report;
- Progressively implement the rehabilitation strategy in line with the sequence of underground mining and consequential subsidence of the floodplain;
- Selectively stockpile gravel/cobbles, topsoil and other alluvial fill extracted during construction of the diversion channels. These materials will be re-used in the construction of the diversion channel (gravel/cobbles for bed and bars, topsoil for upper batters) and filling of floodplain subsidence areas with mixed alluvial material followed by topsoil for enabling successful establishment of relevant plant species;
- Seed and manage temporary stockpiles with appropriate species to provide erosion control;
- Retain as much of the existing riparian vegetation as possible as well as habitat trees with hollows;
- Where possible, reuse removed trees for large woody debris within both the retained and new sections of the creek;
- Use other vegetation for respreading on the batters of the constructed channels and temporary stockpiles, in either a mulch or directly spread form;
- Re-fill and re-contour subsided areas of the floodplain to create a stable, adequately drained landscape that complies with rehabilitation and erosion control guidelines and post-mining land use objectives;
- Continue the existing pest and weed control program to eliminate existing weeds and prevent the introduction of pests and noxious weeds in rehabilitated areas;
- Use an adaptive management approach with continuous improvement;
- Provide necessary access for the suppression of fires, control of competitive native and exotic fauna and noxious weeds, and monitoring of rehabilitated areas.

2.3 Completion Criteria

In line with best practice rehabilitation, ACOL intends to develop agreed completion criteria in consultation with the relevant agencies based on the process suggested by Nichols (2005) and illustrated in **Figure 4**.

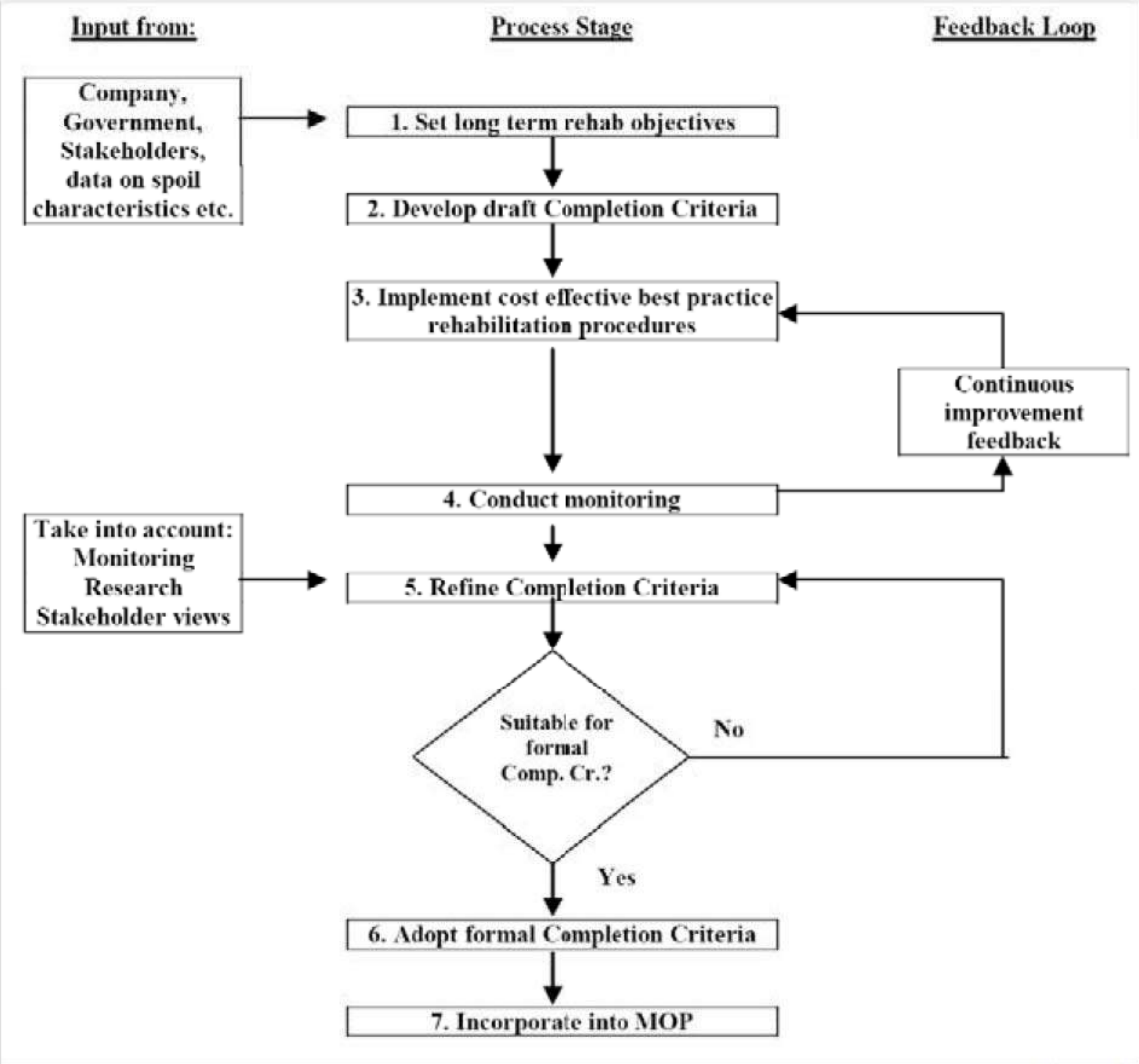


Figure 4:
Suggested Process for Developing Completion Criteria
(from Nichols, 2005)

The proposed long term rehabilitation objectives for Bowmans Creek and its associated alluvial floodplain are set out in **Section 2.1** above. The key indicators that ACOL proposes to take into account in developing completion criteria are set out in the following sections of this document. In line with the process suggested in **Figure 4**, ACOL proposes to develop detailed completion criteria based on:

- The use of reference (or "analogue") sites where available, or baseline monitoring results as applicable as benchmarks against which the relevant completion criteria will be measured;
- Monitoring the key indicators over time so as to track their trajectory towards the benchmarks defined by the reference sites or baseline data (see **Error! Reference source not found.**).

Details of the proposed reference sites, relevant baseline data and key indicators that reflect different facets of the various domains within the project area are provided in subsequent sections of this report.

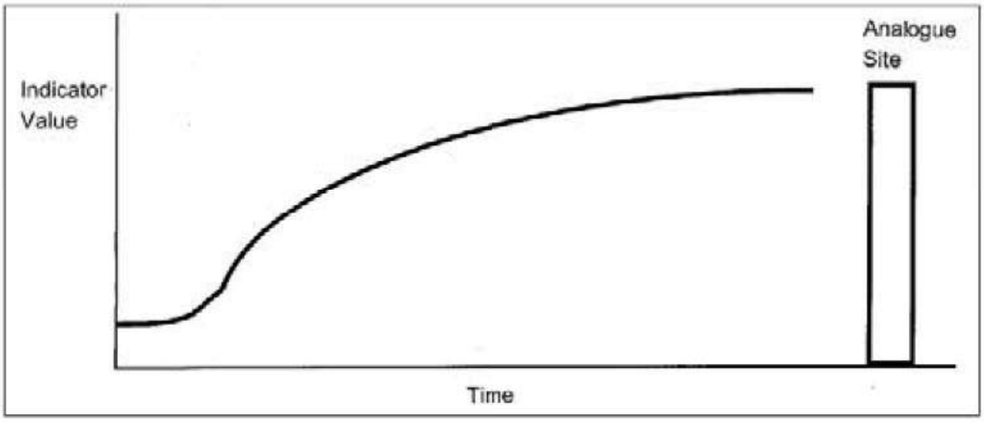


Figure 5:
Classic Successional Trajectory Following Disturbance
(after Nichol, 2005)

2.4 Project Staging

The Bowmans Creek Diversion project involves a series of stages that reflect the sequence of underground mining which, in turn, have been taken into account in the planning and scheduling of the rehabilitation program.

Figure 2.5 and *Figure 2.8* of the EA provide indicative schedules for mining of the four coal seams over 15 years and the construction and initial rehabilitation of the diversion channels. An overall indicative project schedule that illustrates the interdependence of mining (and the ensuing subsidence), channel construction, flow diversion and stages of rehabilitation (that reflect the hierarchy in **Figure 5**) is shown in **Figure 6**.

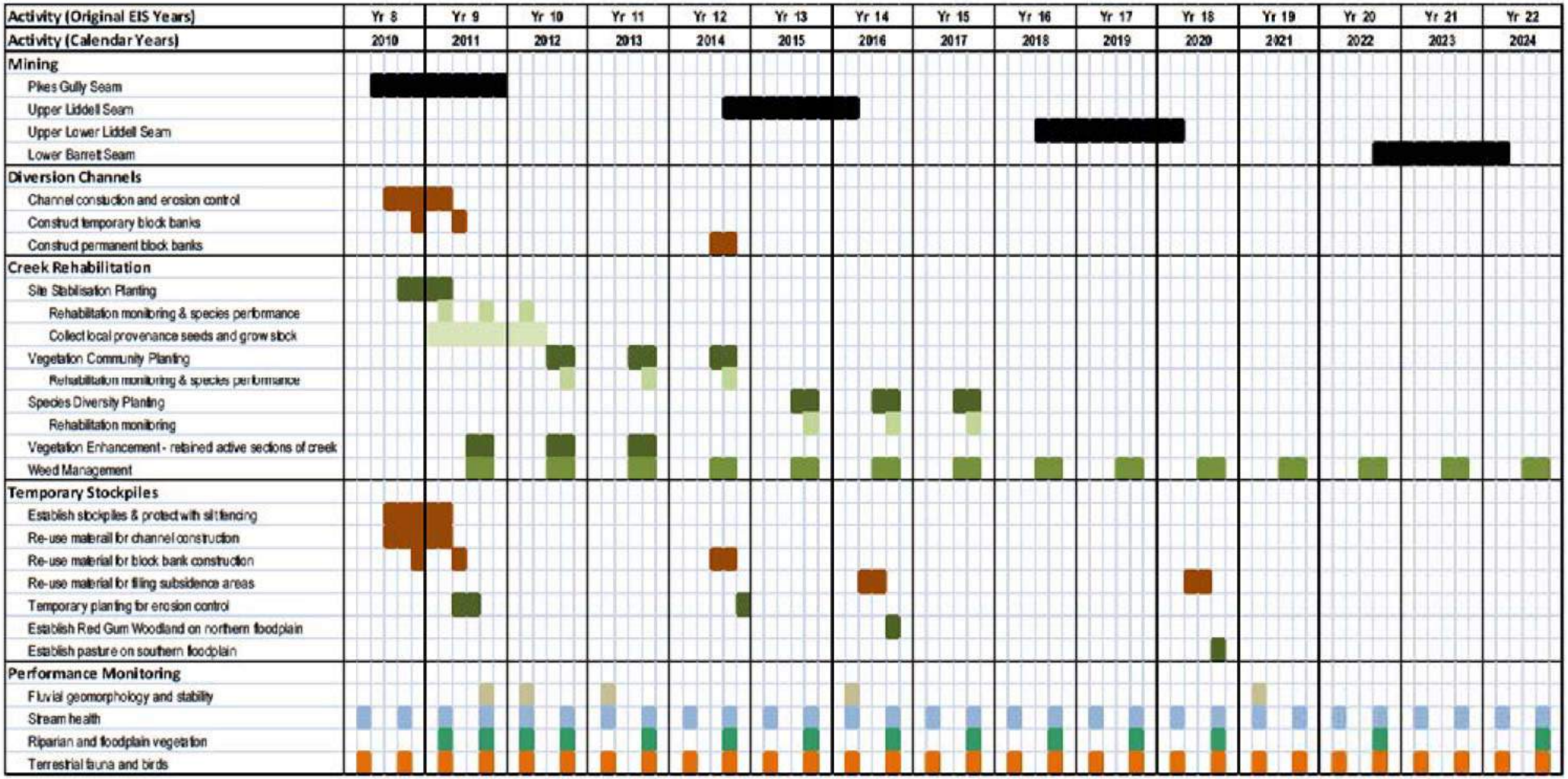


Figure 6:
Indicative Schedule for Mining, Rehabilitation and Monitoring

3 CHANNEL AND LANDFORM DESIGN

Details of the proposal to divert two sections of Bowmans Creek have been developed taking into consideration significant monitoring of the channel form, surface water quality and stream health that has been under taken since 2002. This monitoring has taken the form of;

- Routine water quality monitoring;
- Spring and autumn monitoring of stream health (see Marine Pollution Research 2005, 2007a, 2007b, 2008a, 2008b, 2009a);
- Geomorphic assessment including two sets of detailed topographic survey of the channel at 51 locations before and after the flood of June 2007 (approximately 35 year average recurrence interval) (see ERM 2006a, Maunsell Australia 2008).

As a result of the 2007 flood, 42 cross sections showed negligible change. Of the others:

- Four locations at which bed lowering occurred were in the reach of the creek immediately upstream of the Hunter River (as least 1.3 km downstream of the Western Diversion);
- One location at which bed lowering occurred was in the reach of the creek upstream of the proposed Eastern Diversion;
- Two were located in the section of channel to be retained between the two diversion channels;
- One, located in the channel adjacent to the Western Diversion, exhibited bed lowering of 0.17 m and the other, located in the creek adjacent to the Eastern Diversion showed an accretion of 1.38 m.

The effects of the 2007 flood on channel stability and scour have been taken into account in the development of an integrated set of engineering and rehabilitation works that are designed to retain the key geomorphic characteristics of the creek and provide an opportunity to significantly enhance the quality and diversity of riparian and aquatic habitat. The fact that the existing creek channel was relatively stable in a significant flood provides a high level of confidence that the diversion channels, which mimic the existing channel form, will remain stable in major floods.

The concept for the diversion of Bowmans Creek has been based on the following hierarchy of measures to ensure that the diversion channels are resilient and perform in the same manner as the existing creek in the long term:

- **Robust design** based on sound technical analysis of the hydraulic and geomorphic characteristics of the existing creek (as endorsed by Erskine, 2006) and best practice for stream rehabilitation (eg. Raine & Gardiner 1995, Rutherfurd et al 2000). In this instance, the survey cross sections from the existing creek were used as templates for the diversion channels with adjustment in bed elevation to conform to the required pool and riffle sequence. Stability analysis under different flow conditions (taking account of the observations from the 2007 flood) has been used to ensure that the channel has sufficient depth of cobble bed to accommodate natural changes as a result of floods while ensuring that bed load transport will continue in the same manner. In addition, rock bars and ramps have been added to the design to provide fixed control points for bed elevation and channel location.
- **Construction staging and methodology** that will involve close supervision by an experienced geomorphologist to ensure that all elements of the construction are carried out in accordance with designs and sound geomorphic principles. The construction program also provides for staging of construction of block banks to initially only divert moderate flows (up to 6 months average recurrence interval) into the diversion channels.
- **Staged rehabilitation** that commences with extensive use of erosion control matting to provide initial stability supplemented with extensive dense planting on the low active floodplain and inset benches.

3.1 Channel Design

The proposal involves the construction of two diversion channels on Bowmans Creek between the New England Highway and the Hunter River to mitigate the impact on Bowmans Creek that would result due to subsidence:

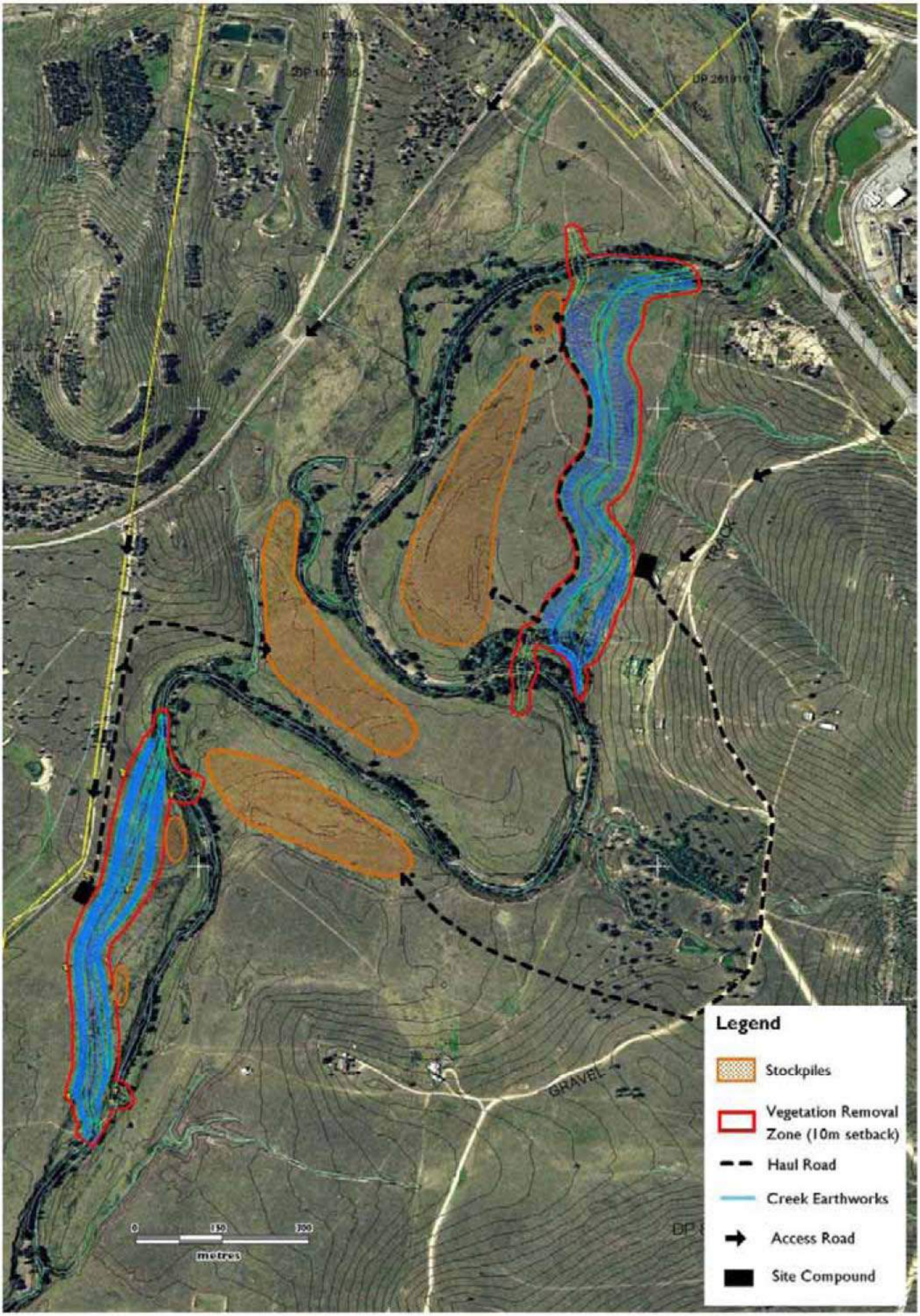
- Eastern Diversion which will start about 175m south of the New England Highway and extend for about 955m approximately along the eastern edge of the alluvial floodplain to join an existing oxbow channel (approximately 125m long) and then drain into the existing creek. This diversion will involve excavation of a meandering channel that mimics the geomorphic features of the adjacent reach of Bowmans Creek, including variable width (about 35m to 100m) and variable bed levels to create pools and riffles. Typical maximum excavation depth in this diversion varies from 4.0m to 5.5m. The volume of material to be excavated includes approximately 140,000m^3 of bulk earthworks to form the macro-channel and 20,000 m^3 of detailed earthworks to create the detailed topography of the stream bed zone (low flow channel, low active floodplain and inset benches); and
- Western Diversion which will start just downstream of the existing streamflow monitoring station (operated by the Office of Water). This diversion, which will extend for approximately 780m, will also mimic the geomorphic characteristics of the adjacent reach of Bowmans Creek which is typically about 7m deep. The top width of this diversion channel varies from 45m to 70m. The volume of material to be excavated is approximately 180,000m^3 bulk earthworks to form the macro-channel and 15,000 m^3 of detailed earthworks to create the detailed topography of the stream bed zone.

Figure 7 (copy of *Figure 2.6* from the EA) provides an overview of the proposed diversion channels and associated block banks (to redirect flow) together with the location of temporary stockpiles for excavated material that will subsequently be used to fill subsidence troughs in order to create a free draining landscape. The stockpiles are located:

- Mainly in areas that are not affected in a flood with an average recurrence interval (ARI) of 20 years.
- In areas that do not require haulage across the existing creek channel or the diversion channels either for initial placement of material or for subsequent re-use of stockpiled material for construction of block banks or filling of subsidence troughs.

Where the stockpiles have a minor encroachment onto areas affected by a 20 year ARI flood the encroachment is only into flood fringe areas that would be subject to low flow velocities.

On the basis of the cross-section data, and the field survey, the main cross-sectional dimensions of the two sections of existing creek corresponding to the two proposed diversion channels have been characterised in terms of mean and standard deviation (see *Tables 9.1 and 9.2* of the EA). These data form a basis for the design of the diversion channels. The data indicate that the two sections of the creek that will be excised are quite different in many geomorphic respects with the upper (Eastern) section of creek corridor being broader and less incised than the lower (Western) section.



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Bowmans Creek
Diversion Project

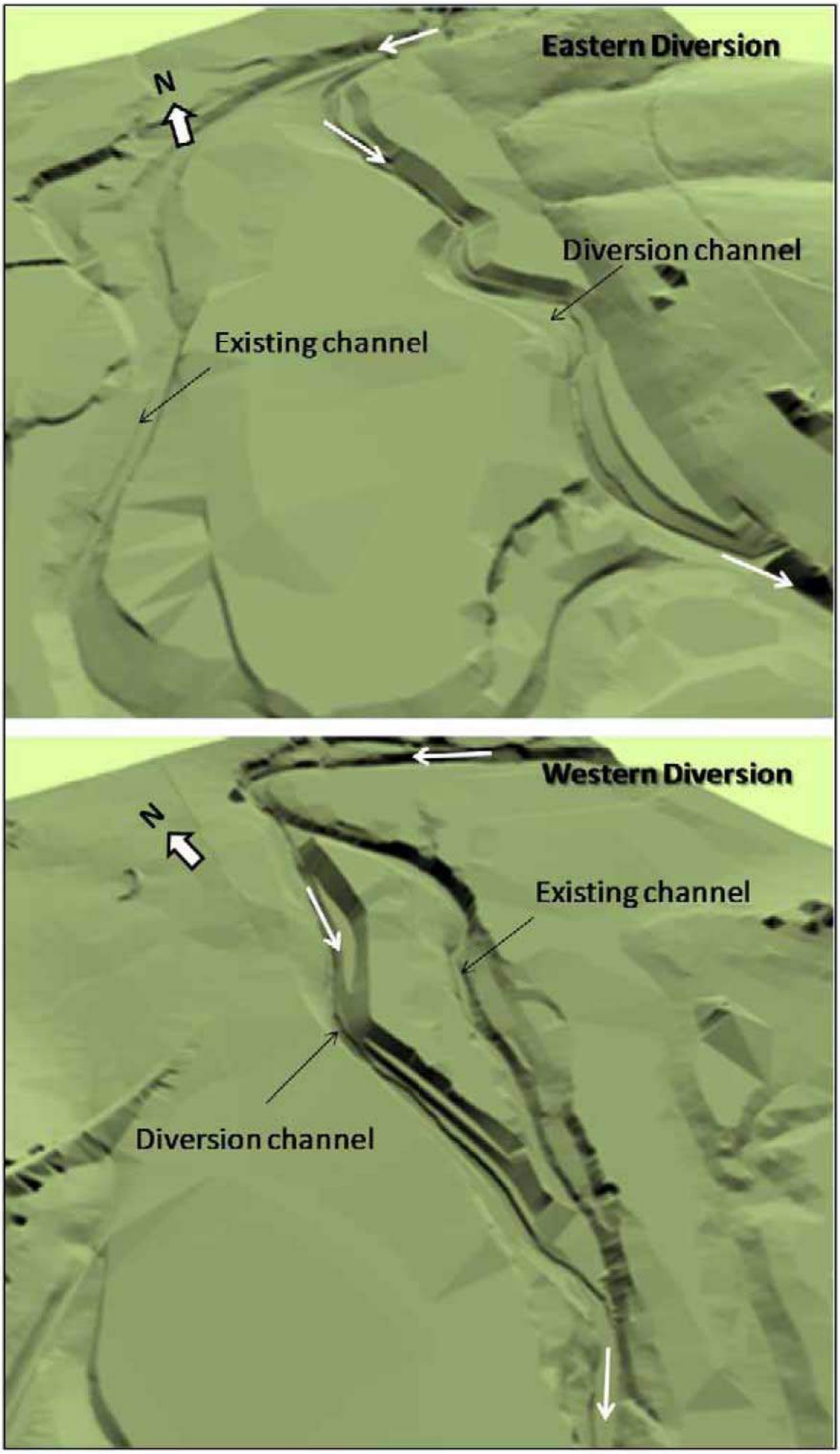
Figure 7
Site Works Overview

The design of the diversion channels (see *Plan Set 2* in Volume 3 of the EA) incorporates a high degree of geomorphic and landscape complexity which is intended to:

- Mimic the important geomorphic characteristics of each of the sections of the creek to be excised. This is illustrated in **Figure 8** (*Figure 2.7* in the EA) which shows perspective views of the existing and proposed channels;
- Provide comparable fish passage and comparable, or better, quality aquatic habitat than the existing creek including pools and riffles, supplemented with large woody debris (largely absent from the existing creek);
- Provide the basis for significantly improved riparian habitat quality compared to the excised creek sections; and
- Provide comparable hydraulic conveyance to the existing creek.
- The key criteria for developing the channel design relate to geomorphic and ecological considerations rather than the primarily functional hydraulic objectives of earlier proposals.
- **Table 2** summarises the key physical objectives, the numerical criteria or strategy adopted for the design of the diversion channels while **Table 3** provides the design objectives for aquatic habitat and the low active floodplain.

Table 2: Key Physical Design Objectives
(Source EA Table 2.4)

	Design Objective	Criteria/Strategy	Features of the Proposal
1	**Conveyance**		
1.1	Divert flows up to 5 year ARI	152 m^3/s	152 m^3/s
1.2	Minimise seepage losses in 80th – 100th percentile low flow range	Seal under low flow channel (80th percentile flow =2 ML/day (0.023 m^3/s)	Seal under channel to convey flow up to 10 m^3/s
2	**Channel Morphology and Stability**		
2.1	Channel shear stress	Comparable to existing	Comparable to existing
2.2	Low flow channel cross section and long profile	Mimic existing	Channel sections copied. Longitudinal profile with similar variation
2.3	Floods inundate low level floodplain	Inundation at least once per year	Low level floodplain inundated once per year
3	**Channel Alignment and Geometry**		
3.1	Maximise channel length with sinuosity within defined corridor	Existing E channel grade 0.17% Existing W channel grade 0.39%	E channel grade 0.24% W channel grade 0.40%
3.2	Batter slopes comparable to existing channel	1:3.5 - 1:11	Typical batter slopes 1:4 – 1:7
3.3	Maintain comparable lower active flood plain	Range 21 - 35+m	Channels sections copied
3.4	Maintain comparable width of incised creek corridor	Range 50 - 100m	Channels sections copied
3.5	Sinuosity	Mimic existing channel sinuosity as far as possible	Comparable channel alignment
4	**Flood Levels and Flood Storage**		
4.1	100 year ARI flood level at Highway	No increase	No increase
4.2	Flow velocity at Highway	Peak 100 year ARI velocity 4.3 m/s	Peak 100 year ARI velocity 4.5 m/s
4.3	Flood storage volume	No significant loss	Increased flood storage



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Bowmans Creek
Diversion Project

Figure 8
Landscape Perspective Showing
Diversion Channels

(Source: Fluvial Systems)

Table 3: Key Design Objectives for Aquatic Habitat and Low Active Floodplain
(Source EA Table 2.4)

	Design Objective	Criteria/Strategy	Features of the Proposal
1	**Fish Passage and Aquatic Habitat**		
1.1	Fish passage when creek flowing	Passage possible in moderate flow	Flow conditions similar
1.2	Provide appropriate pool and riffle sequence	Mimic existing channel	Pool and riffles mimic existing creek
1.3	Maximum bed slope of riffles	Approximately 5%	Approximately 5%
1.4	Maintain comparable pool area	0.9 ha	1.1 ha
2	**Riparian and Low Active Floodplain Ecology**		
2.1	Maintain area of lower active floodplain area inundated in 1 year ARI flood	6.7 ha	6.4 ha
2.2	Improve habitat value of lower active floodplain	Revegetate and exclude domestic stock	Establish plant communities characteristic of those present prior to European colonisation
2.3	Ecosystem resilience	Create robust, relatively self-sustaining ecosystem	

Flow will be directed into the diversion channels by means of block banks across the existing creek. These block banks will ultimately be constructed to a level approximately the same as the surrounding floodplain which corresponds to about the 5 ARI flood level. Floods in excess of 5 years ARI will spill over the block banks and floodplain and into the existing creek channel.

In order to prevent leakage from the diversion channels, a geosynthetic clay liner (GCL) will be installed. Importantly, the cross section shape and bed levels of the diversion channels have been designed to mimic the geomorphic and aquatic habitat characteristics of the existing creek. To achieve this, and to ensure that flow velocities and scour potential are managed, a stream bed zone has been specifically designed using suitably graded cobble material to replicate the existing natural stream bed conditions.

The Bowmans Creek diversion channels have been designed to replicate the flow conveyance characteristics of the existing channel as well as mimic its geomorphic characteristics and maximise the area of riparian and aquatic habitat. While the diversion channels have been located to provide acceptable hydraulic characteristics, the block banks have been placed as far downstream or upstream as possible in order to maximise retention of the existing creek habitat. As a result of these considerations, the proposed project includes retention of a total of 385m of existing pools that will become backwater resting pools while remaining connected to the creek system. Overall the total length of creek between the Hunter River and the New England Highway will be reduced by 3% (195m see *Table 3.3* and *Table 3.4* of the EA for details).

3.2 Floodplain Landform

Longwall mining of all four coal seams will lead to subsidence above the longwall panels. The proposed measures to mitigate the consequences of these changes include:

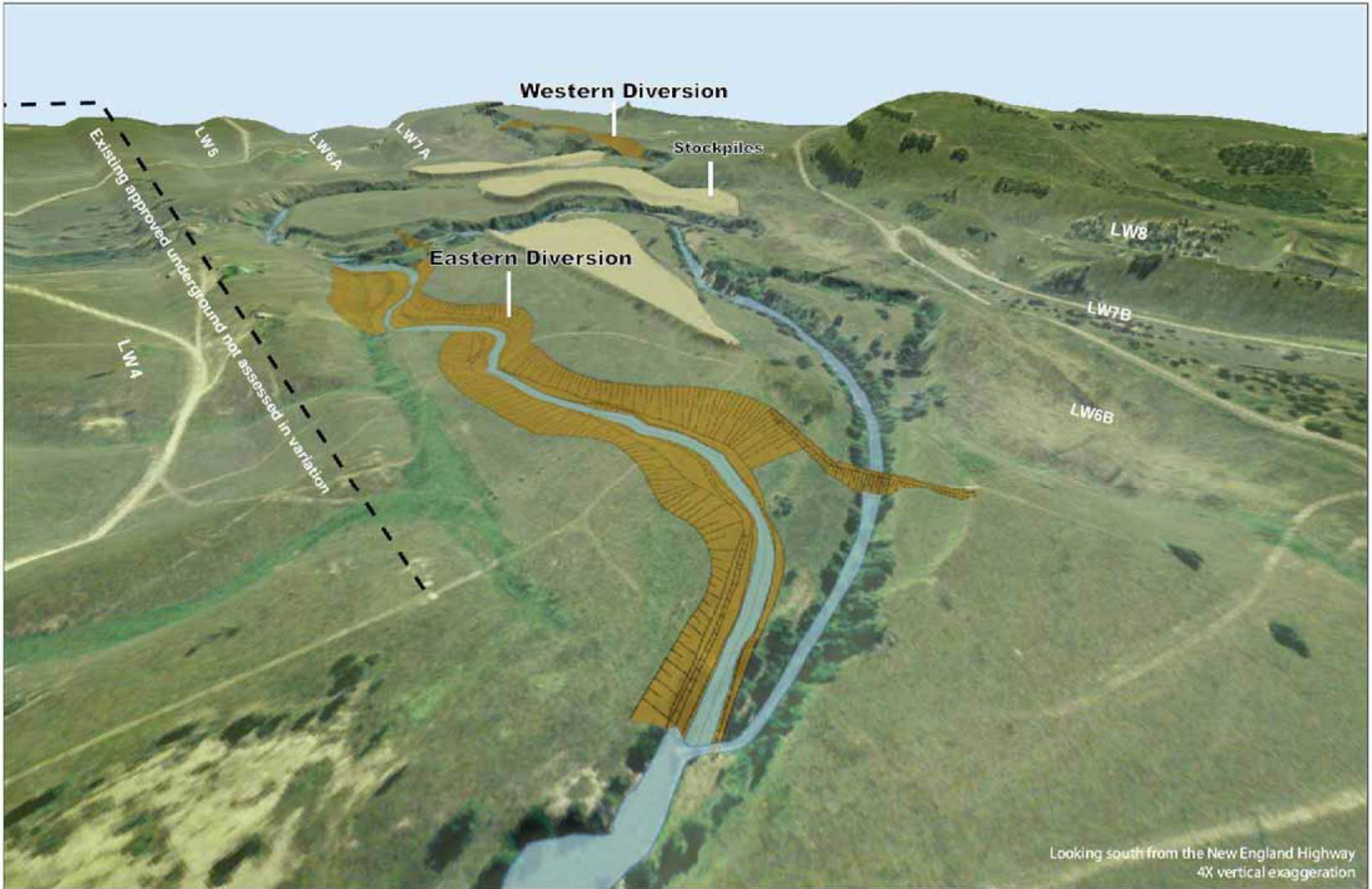
- Location of the diversion channels in areas which will be subject to minimal subsidence, if any (outside the alignment of the longwall panels);
- Use of "miniwalls" under those sections of the existing creek that will remain functional in order to minimise subsidence effects;
- Progressive filling and re-contouring of areas on the floodplain as necessary to maintain a free draining landscape;
- Drainage works on elevated land outside the floodplain as necessary to maintain a free draining landscape.

As part of the studies that support the project application, detailed analysis was undertaken, based on recent monitoring and research, to provide a high degree of certainty in the predictions of subsidence (see *Section 6* and *Appendix 4* of the EA). The subsidence predictions have been based on an assumed 'worst case' mine design in which longwalls in the lower seams are 'stacked' immediately below the one above.

Subsidence at the centre line of the longwalls is predicted to progressively increase from a maximum of 1.6m following mining of the upper seam (Pikes Gully) to a maximum of 8.3m following mining of the lowest seam (Lower Barrett). The predicted subsidence varies significantly from a maximum at the centreline of the longwall to a negligible amount (~20mm) about 50m outside the boundary of the longwall panels. The subsidence assessment included an analysis of the effects of the "miniwalls" that are proposed to run under those sections of the existing creek that will remain functional.

Figure 9 is a perspective view of the Bowmans Creek area following subsidence resulting from mining of all four coal seams. This view has been generated from the most recent data for the existing landform onto which the predicted subsidence, diversion channels, block banks and temporary stockpiles have been superimposed. It should be noted that the image shows the subsidence troughs and temporary stockpiles prior to re-working of the stockpile material to partially fill the subsidence troughs on the floodplain in order to create a free draining landform.

The data used to generate **Figure 9** has also been used to generate a series of cross sections and a longitudinal section through the final landform. These are contained in **Annexure A** to this report.



AshtonCoal

Prepared by Wells Environmental Services

Bowmans Creek Diversion Project

Figure 9

Perspective Landform Following Subsidence from Longwalls in the Immediate Vicinity of Bowmans Creek and its Alluvial Floodplain

4 CONSTRUCTION AND SPOIL MANAGEMENT

Commencing with the Eastern Diversion, construction and rehabilitation of the diversion channels will occur over a total of about six months and will follow the construction sequence outlined below and described in greater detail in *Section 12* of the EA. Construction will commence at the downstream end of each diversion channel and progress upstream so as to ensure that all joins in the geosynthetic clay liner have the exposed edge on the downstream side. Excess spoil from the diversion channels will be stockpiled as shown on **Figure 7** for subsequent re-use for filling subsidence troughs on the floodplain to create a free draining landscape.

4.1 Site Preparation and Clearing

The locations of the diversion channels and the temporary stockpiles have been selected so as to minimise the impact on the existing riparian and floodplain vegetation. Of the 30.3 ha that will be disturbed for channel construction, temporary stockpiles and haul roads, only 1.8 ha requires the removal of existing riparian vegetation. In addition, only three trees containing nesting hollows (out of 31 identified within the project area) will need to be removed for construction purposes.

Competent trees that would be suitable for construction of log jams in the diversion channels will be salvaged and retained for later use. All other vegetation will be retained for use in the rehabilitation of the channel batters.

In accordance with ACOL's existing *Erosion and Sediment Control Management Plan,* erosion and sedimentation controls and barrier fencing will be installed to demarcate exclusion zones for construction activities (diversion channels, block banks and stockpile areas as shown on *Drawings C045* and *C046* of the *Engineering Design Drawings* in Plans Set 2 of Volume 3 of the EA). In particular, sediment control fencing will be installed in all areas from which runoff could drain into the creek, particularly:

- Along the toe of the stockpile areas closest to the creek. (Note that all stockpiles are to be located a minimum of 40m from the bank of Bowmans Creek and are not to be located within 5m of minor watercourses).
- Around the area of the block banks. (Note that at the time of construction of the block banks, securely anchored straw bales will be placed immediately downstream to provide filtration for any flowing water that inadvertently encroaches into the works area. Minor bunding works within the bed of the creek will be used to divert the majority of flow around the immediate works area as work progresses across the bed of the creek).

In accordance with ACOL's existing *Soil Stripping Management Plan*, topsoil from each channel corridor and from the stockpile areas will be stripped and stockpiled separately and allowed to compost for later reuse on diversion channel batters and spoil stockpiles.

The main earthworks comprise the excavation of the diversion channels which will take place from downstream to upstream (leaving in place a narrow barrier of existing earth to exclude creek flow until the construction works and initial rehabilitation are complete). Because the excavation works will all be below natural ground level, any runoff from the works area or groundwater inflow from the base of the excavation will naturally remain within the excavation. A temporary pump will be set up at the downstream end of the excavation and connected to one of the existing water transfer pipelines that feed into the existing ACP water management system. All sediment laden water collected within the excavation will be treated in this manner.

4.2 Construction Staging

Following site establishment and installation of sediment control fencing, the construction of each of the diversion channels will be undertaken sequentially using the steps set out below (extracted from *Section 12.3* of the EA). Construction will commence at the downstream end of each diversion channel and progress upstream so as to ensure that all joins in the geosynthetic clay liner (GCL) within the channel have the exposed edge on the downstream side.

1. Undertake bulk earthworks using a combination of scrapers and bulldozers together with excavators and trucks. Scrapers and or excavators and trucks will be used to undertake the bulk excavation, while excavators and trucks will be used to selectively extract suitable material for reconstruction of the geomorphic characteristics of the channel, including cobbles and cobble/silt mix as well as fine sandy silt for bedding of the geosynthetic clay liner.
2. Detailed channel shaping that will involve excavation of the low flow channel and trimming of batters using excavators loading onto trucks;
3. In the course of excavation of the base of the channels, it is anticipated that groundwater will be encountered. Sediment laden water resulting from groundwater inflow to the excavation or rainfall runoff will be pumped to the Ashton Mine water storage dam located to the north of the New England Highway by means of an existing pipeline.;
4. Once the excavation is complete, laying of the GCL will be undertaken in accordance with the manufacturers' guidelines. Care will be taken with placement of the bedding material below and above the geosynthetic clay liner to ensure that the liner is not punctured and the imperviousness of the liner is not compromised. The edges of the liner will be firmly anchored in the manner shown on *Drawing C002 of the Engineering Design Drawings*;
5. Once the liner has been laid and a subsequent layer of fine material placed over the top, the stream bed zone will be covered with a geotextile fabric (Bidim A29 or similar);
6. Construction of rock bars upstream and downstream of riffle sections, placement of rock armouring on the outside of bends and construction of engineered log jams will be undertaken following the placement of the geotextile fabric. Details of the locations of these elements of the channel design are shown on the Landscape Masterplans (Drawings SK01 and SK03 in the *Landscape Plans* that form Plan Set 3 in Volume 3 of the EA);
7. The stream bed will be constructed using the stockpiled gravels, cobbles and large sized boulders to form the low flow channel and adjacent cobble terraces in accordance with the details shown on the *Landscape Plans* (Plan Set 3 in Volume 3 of the EA);
8. Detailed landscaping and revegetation work in accordance with the Landscape Plans. This will commence immediately after completion of the detailed shaping of a section of the diversion channel and progressively follow that work along the channel. Extensive use will be made of erosion control matting on the inset benches immediately adjacent to the low flow channel in order to mitigate the risk of erosion to these until they have been stabilised by vegetation;
9. The construction of the block banks and subsequent cut-in of the ends of the diversion channels will be undertaken following completion of revegetation.

An important aspect of the proposed construction of the diversion channels will be the detailed works to be undertaken in the base of the excavation in order to create the geomorphic and habitat features shown on the *Engineering Design Drawings* and *Landscape Plans* (in Volume 3 of the EA), including:

- Variable channel geometry including pools, riffles and cobble beaches in the low active floodplain within the envelope created by the placement of the GCL – primarily created by placement of cobbles;
- Construction of rock bars and a rock ramp (using large imported rock) to provide additional bed control (in addition to the existing rock outcrops in the retained sections of the creek);
- Construction of a total of 23 engineered log jams to provide additional diversity of aquatic habitat.

This work will be undertaken under close supervision of an experienced fluvial geomorphologist.

4.3 Block Banks

Construction of the block banks will be undertaken in the following sequence that is designed to minimise the risk of flood damage to the diversion channels while providing moderate flow fish passage through the diversion channels and retaining (for as long as possible) the existing aquatic habitat in the sections of creek that will eventually be bypassed:

Initially, temporary low level banks (about 1m high) will be constructed in the existing creek near the upstream end of each diversion channel to divert all flows up to about the 6 month ARI. Flows in excess of 6 months ARI will be able to spill over the block banks into the existing creek channel.

The permanent block banks that divert flows up to the 5 year ARI flood level will be constructed just prior to mining of the Upper Liddell seam (approximately 3 years after construction of the temporary banks - see **Figure 6**) unless groundwater monitoring and/or subsidence monitoring indicates that significant alluvial groundwater or surface water has drained as a result of cracking of the underlying Permian rocks, in which case the permanent block banks will be constructed earlier.

Downstream block banks will be constructed in the existing channel just upstream of the point where the diversion channel connects with the existing channel. The primary purpose of these banks is to prevent backwater flooding of the excised section of the creek once subsidence occurs. In order to allow drainage from the excised section of the creek, the downstream block banks will include a culvert with a one-way flap gate that will allow water to drain downstream, but prevent backwater flow into the excised portion of the creek. The downstream block banks will be constructed just prior to mining of the Upper Liddell seam (approximately 3 years after construction of the temporary banks).

Each permanent block bank will have a small concrete levelling inset into the top to provide a fixed level for overflow of flood water (see Engineering design Drawing C016). Apart from the concrete for the levelling wall and large rip-rap for scour protection on the block banks and immediate downstream channel, all materials for the construction of the block banks will be sourced from material excavated from the alluvial floodplain during excavation for the diversion channels.

4.4 Stockpile Management

The management of spoil excavated from the diversion channels has required consideration of different issues from those that typically occur during open-cut mining. In particular, because the excavation will be in alluvial material, in which the existing channels are formed, shortage of topsoil and maintenance of soil health will not require the degree of attention devoted to these issues in relation to the rehabilitation of overburden stockpiles. However, because of the risk that weed seeds might be present in the topsoil used for the channel batters, the vegetation and a shallow soil layer (up to 100 mm) will be pre-stripped and disposed of elsewhere on land owned by ACOL well away from the Bowmans Creek floodplain.

From observations of the existing creek bank, investigation drilling and an understanding of the geomorphic processes that created the alluvial fill material, it is anticipated that the alluvium will be heterogeneous with lenses and bands of finer silty/sand mix interspersed with cobbles. Accordingly, it is expected that all bulk materials required for construction of the diversion channels and block backs will be sourced by selective extraction during the excavation for the diversion channels. **Table 4** below summarises the volume of alluvial material that will be extracted to form the channels and the volumes of selected material required for construction, namely:

- Sandy silt for bedding and a protective layer each side of the GCL;
- Cobbles for lining the low flow channel and the inset benches;
- Topsoil for respreading on the channel batters and the temporary stockpiles.

Separate stockpiles for these materials will be constructed within the designated stockpile areas shown on **Figure 7**. Materials for construction of the block banks will be separately stockpiled close to the location of the block banks as shown on **Figure 7**.

Table 4: Estimated Earthworks Quantities
(Source EA Table 12.1 and Engineering Design Drawings)

Item	Eastern Diversion (m^3)	Western Diversion (m^3)	Stockpile Areas (m^3)	Total (m^3)
Extraction				
Topsoil stripping (assume 150 mm)	9,200	5,500	14,800	29,500
Bulk earthworks	131,000	175,000	-	306,000
Excavation for stream bed zone	20,000	15,000	-	35,000
Construction				
Sandy silt layer below and above GCL	6,000	3,000		9,000
Cobble backfilling to form channel and terraces	14,500	12,500		27,000
Topsoil on channel batters	7,500	4,500		12,000
Block banks – bulk earthworks	3,600	3,600		7,000
Topsoil on temporary stockpiles			14,800	14,800
Available for subsidence troughs (1.2 bulking factor)				360,000
"Spare" topsoil				2,700

All excess alluvial material that is not required for channel or block bank construction purposes will subsequently be extracted for filling of subsidence depressions on the floodplain in order to assist in the creation of a free draining landform. All areas to be filled will have the topsoil layer removed prior to placement of bulk fill and subsequently replaced after filling in order to create a soil profile with similar productivity potential to the existing soil.

Viable topsoil is recognised as one of the most important factors in successful rehabilitation. Topsoil stripping, stockpiling and re-spreading will be planned to make optimal use of the available resource and minimise the time that soil is held in a stockpile. Once an initial stockpile of topsoil has been established, topsoil removed progressively from the bulk earthworks area will be re-used immediately on the completed sections of channel batter. This process will ensure that maximum value is obtained from the existing soil organic matter.

Stockpiles of bulk alluvium that will be retained for re-spreading into subsidence troughs on the floodplain will be managed in the following manner:

- Stabilisation with permanent native vegetation and silt fencing to control erosion and weeds.
- Regular inspection, particularly after storm events, with eroded areas stabilised as required.
- Weed growth on stockpiles will be monitored and subsequently controlled with herbicides if necessary.

4.5 Contingency Management

Contingencies associated with the construction of the diversion channels have been carefully considered in the design process in order to provide a design that is highly conservative and inherently resilient to the effects of flood damage. Various contingencies that have been considered in the design, and the way that these contingencies are addressed, are set out below.

4.5.1 Flood Damage

It is expected that during the period of ongoing underground mining following the construction of the diversion channels (about 14 years), there is likely to be a sufficient number of significant flood events to adequately test the integrity of the channels. The hydrologic analysis includes an assessment of the timing of historic flood events that have exceeded flow corresponding to a 5 year ARI flood (about 150 m^3/s peak flow) (see *Figure 2.4* in *Appendix 7* of the EA). That analysis indicates that in any consecutive 14 year period in the historic record there were a minimum of three flood events that exceeded a peak flow of 150m^3/s, and a maximum of six. The peak 5 year ARI flood of 150 m^3/s is significant in this instance because:

- In floods larger than 150 m^3/s the floodwater will overtop the block banks and flow will be split between the excised section of creek and the new (diversion) section. (This behaviour is illustrated for 20 and 100 year ARI floods in *Drawing G009* and *Drawing G010* in *Appendix 6* of the EA.)
- The detailed flood modelling (see *Appendix 6* of the EA) indicates that under these flow conditions, the flow velocity in the diversion channels in a 5 year ARI flood will be very similar to that in a 100 year ARI flood (see *Drawing G007* and *Drawing G010* in *Appendix 6* of the EA).

Accordingly, the diversion channels will be subjected to severe "stress" conditions comparable to a 100 year ARI flood on several occasions during the period following construction, while the mine is operational. This will provide sufficient opportunities to identify and rectify any defects in the design or construction of the diversion channels.

4.5.2 Failure of the Geosynthetic Clay Liner

A geosynthetic clay liner (GCL) is a manufactured hydraulic barrier system comprising a layer of bentonite clay sandwiched between, and bonded to, layers of geosynthetic fabric. A geosynthetic clay liner has been chosen specifically because of its inherent advantages over other hydraulic barrier materials (compacted clay, HDPE, etc). The key advantages of GCLs are that they:

- Have very low permeability (<5 x 10-11 m/s);
- Provide a hydraulic barrier with uniform properties over a large area. (Compared to compacted clay liners which are subject to variation in the source material and construction quality;
- Have high tensile strength and flexibility and can conform to irregular surfaces;
- Are resistant to puncturing because of the geosynthetic fibre, and are self sealing if punctured.

Because the permeability of a GCL is more than an order of magnitude less than the requirements set out in the NSW "*Environmental Guidelines: Solid Waste Landfills*" (1 x 10-9 m/s), GCLs have been widely used as an alternative to compacted clay for leachate barrier systems in landfill cells and capping.

Although the GCL is inherently resistant to puncturing and is self sealing, the GCL will be isolated from the overlying channel cobble bed by a 200mm layer of fine silty-sand material and a layer of geotextile fabric (see *Figure 2.9* in the EA). The depth of the cobble bed has been determined from analysis of the hydraulic conditions that will occur in the channel and takes account of the impacts of the 2007 flood (about 35 year ARI) on the existing channel. Because of these aspects of the design, the risk of puncturing the GCL is considered remote. Nevertheless, in the course of the channel geometry survey and geomorphic monitoring, any significant change in flow regime will be observed and, further investigations and repairs will be undertaken if necessary.

Once placed, the GCL will be subject to minimal movement as a result of settlement following construction or mine induced subsidence (both channels have been located outside the subsidence zones). The inherent flexibility of the GCL layer combined with its self sealing properties will allow the GCL to accommodate any such movements.

As shown in the design drawings (*Drawing C002* of the *Engineering Design Drawings* in Volume 3 of the EA), the GCL will be securely anchored in a trench on either side of the channel. Similar anchoring will be provided at the start and end points of the GCL. The rock protection, to be provided in the bed of the channels at either end of the riffle zones will provide an additional level of protection against undermining of the liner. In addition, the laying procedure (see **Section 4.2**) will involve placement of successive strips of the GCL starting at the bottom end of each diversion channel with each successive stream strip overlapped over the top of the downstream strip. This method of construction will ensure that, should damage or undermining of one section of liner occur, the damage would not propagate downstream. In the remote event that any such damage occurred, it would be repaired immediately.

As noted in **Section 4.5.1** above, the diversion channels will be subjected to "stress" conditions comparable to a 100 year ARI flood on several occasions during the 14 year period following construction which will provide sufficient opportunities to identify and rectify any defects in placement of the GCL.

4.5.3 Tunnel Erosion

Tunnel erosion is not anticipated to be a problem. Tunnel erosion usually occurs in sodic and dispersive soils. The alluvial soils in which the diversion channels will be constructed are not sodic or dispersive, and therefore have negligible risk of tunnel erosion. This low risk is confirmed by the fact that, notwithstanding some almost sheer banks on the existing creek, there is no evidence of tunnel erosion.

Any erosion of the banks of the channels, whether caused by surface runoff or tunnelling processes, will identified during the routine monitoring and repaired as necessary.

4.5.4 Block Banks

The block banks will be broad based, low structures that have been designed to be overtopped by floodwater. Two features have been included in the design to ensure the long term competence of the structures:

- Rock armouring on the face that could be subject to shallow high velocity flow when the bank is overtopped (downstream face of the upstream block banks and both faces of the downstream block banks – see *Engineering Design Drawings* in Volume 3 of the EA). The specifications for the rock armouring have been determined on the basis of an analysis of the case flow velocity down the face of the bank and on the downstream channel.
- A concrete wall embedded in the crest of the block bank to eliminate the risk of flow through the rock armouring leading to core material being washed out.

Notwithstanding these design features, as noted in **Section 4.5.1** above, it is expected that the block banks will be subjected to at least three floods during the 14 year period following construction. Following any flood, the block banks will be inspected and the nature of the damage assessed. Repairs will be undertaken as necessary.

5 REVEGETATION

5.1 Revegetation Strategy and Techniques

Details of the revegetation and habitat enhancement proposed for Bowmans Creek have been developed taking into consideration significant monitoring of the flora and fauna that has been under taken since 2005 (see HLA-Envirosciences 2001, ERM 2005, 2006a, 2006b, 2006c, 2008a, 2009a, 2009b, 2009c, DnA & Carbon Based Environmental 2009a, 2009b, 2009c)

As described in *Section 12.5* and the *Landscape Restoration Report* (Appendix 10) of the EA, and in line with the hierarchy described in **Figure 2**, the rehabilitation of the Bowmans Creek diversion channels is an integral part of the project and has been developed to complement the physical foundations inherent in the design and construction of the diversion channels which include:

- Mimicking the existing channels so as to provide comparable hydraulic conditions;
- Cobble lining of the low flow channel and low active floodplain to provide bed stability comparable to the existing creek;
- Extensive use of erosion control matting to provide additional stabilisation during the plant establishment phase;
- Staged diversion of flow into the diversion channels so as to reduce the risk of damage during the early phases of rehabilitation. Temporary block banks will initially allow flow in excess of a 6 month ARI flood to spill into the existing channel. Permanent block banks (at a level that would allow flow into the existing channel in flows in excess of 5 years ARI) will be constructed about three years after completion of construction of the diversion channels.

The overall objective of the rehabilitation strategy is to re-establish plant communities that are characteristic of those that were present prior to European colonisation including River Red Gums. Aims of the rehabilitation strategy are to create plant communities that establish rapidly, are species rich and have dense plant cover, so as to achieve:

- Quick ground-holding characteristics sufficient to withstand flooding early within the plant establishment period;
- Resistance to on-going weed colonisation, maximising the potential for natural colonisation / regeneration of the planted species, particularly the native grasses;
- A diverse suite of endemic species that maximise the potential for colonising of new niches as they become available within the developing community; and
- High plant cover rates to ensure the communities will have natural resistance to weed colonisation, good ground-holding characteristics sufficient for a range of periodic flood events, and sufficient species diversity to develop into an appropriate climax community.

A key aim of the rehabilitation strategy is to provide a flexible, cost effective and adaptive approach to the restoration process, which takes advantage of the opportunities offered by the relatively long life of the project, i.e. a period of some 14 years. Advantages of this approach are as follows:

- Facilitates early focus on ground stabilisation and associated simplified maintenance approach, i.e. weed management is less constrained by the number and range of species planted and subsequent very high need in the early stages of the project for skilled, highly labour intensive weed management, which given the area to be covered for this project would be very difficult to adequately resource. The proposed approach of having a limited number of robust native grass species providing the main initial ground holding and weed suppressing function, simplifies maintenance and provides better protection, increased soil moisture holding capability and a more biologically active soil layer for subsequent plantings over that available in a single occurrence conventional mass planting process;

- Facilitates early commencement of the works in keeping with ACOL's program, as seed is only required for a handful of species, and cell-grown seedlings can initially be procured in readily low, achievable quantities;
- Provides appropriate lead time to procure a diverse suite of species in high numbers;
- Facilitates the opportunity for collection of provenance propagation materials by ACOL, e.g. for *Eucalyptus camaldulensis*, and may facilitate the same for other species in the normal course of nurseries providing plant material for the project, given the opportunity for substantial plant order lead times;
- Facilitates a gradual building up of species diversity, by-passing problems often associated with procurement of particular species, e.g. limited viable seed drop in some seasons;
- Early structural planting provides a framework for the later introduction of 'softer' species that are difficult to introduce in the early phases of a project due to their particular requirements, e.g. areas with dappled light, elevated soil moisture, wind and sun protection, locally increased humidity, etc.

The restoration will take a measured approach to flood risk and cost by providing for:

- A 'flood resistant' surface on areas below the level of the 1 year ARI flood, comprising erosion / weed control matting to all areas of exposed soil and relatively dense planting; and
- A staged restoration program above the level of the 1 year ARI flood, commencing with the direct seeding of a dense native grass cover and limited structural planting, which will be augmented over an 8 year period into a fully structured, species rich plant community.

Revegetation will be undertaken in accordance with the relevant Ashton Coal project approved management plans (*Landscape and Revegetation Management Plan*; *Weed Management Plan*) as well as the site specific requirements set out in:

- The *Landscape Restoration Report* (Appendix 10 in Volume 2 of the EA) and the
- *Landscape Design Drawings* (Plan Set 3 in Volume 3 of the EA).

The landscape restoration method presented in detail in the *Landscape Restoration Report* (Appendix 10 of the EA) proposes that the works be undertaken gradually and in a staged and adaptive manner, commencing with site stabilisation using a combination of direct seeding of native grasses and planting, followed by a gradual building up of community structure and species richness, until a robust, and relatively low maintenance, self-perpetuating corridor community is created.

An appropriate level of resources will be committed in the initial plant establishment period, in particular during the first 12 to 18 months after implementation to ensure that, subject to climate conditions, this process succeeds. Weed control will be regularly undertaken during this phase, so as to facilitate the colonising of the great majority of available niches by native species. Once this outcome has been achieved, it can be expected that the required maintenance effort will significantly drop-off, until it reaches a relatively low, long-term maintenance level.

As part of this process, an adaptive management approach will be adopted, with outcomes being monitored and evaluated against restoration goals and objectives, and management actions adjusted as required to best achieve a trajectory towards meeting the ecosystem characteristics on relevant baseline or reference sites.

Impact and reference sites will be established that include the following characteristics:

- Underground mining sites;
- Riparian sites removed from mining;
- Sites adjacent to mining activity;
- Reference control sites removed from mining; and
- Road corridor sites.

The objective of the reference sites is, firstly to use these sites as indicators of no change under normal no mining impact conditions, therefore isolating mining impacts and recording changes in populations that can be clearly associated with activity on the site. Secondly, as benchmarks against which the regeneration success can be measured. The surveys proposed for mining areas will also be replicated outside areas of mine impact. Site selection will focus on comparative site (controls) and benchmark sites with the final location being randomly selected for statistical robustness.

5.2 Proposed Vegetation Communities

A flora and fauna assessment that included the Bowmans Creek Diversion project area was undertaken in 2001. The assessment included a summary of eight previous flora and fauna assessments commencing from 1984, and undertaken either specifically for the site, or within close proximity to the site, in addition to species identified within the NSW National Parks and Wildlife Service Wildlife Atlas. The report provides a species list incorporating findings from six of the previous flora and fauna assessments, the NPWS Wildlife Atlas and the 2001 study (copy provided as Appendix 2 to the *Landscape Restoration Report* in Appendix 10 of the EA). No threatened species (flora or fauna) were observed on the site.

Additionally, seven specimens of River Red Gum (*Eucalyptus camaldulensis*) were identified in the narrow riparian corridor of the southern meander of Bowmans Creek near the confluence with the Hunter River. Within the Hunter Catchment, this population is unique in NSW, being the only one to occur within a coastal catchment, and is restricted to 19 stands, covering approximately 100 hectares. The River Red Gum population within the Hunter Catchment is listed as an endangered population under the *Threatened Species Conservation Act, 1995* (TSCA). The Hunter-Central Rivers Catchment Management Authority (Hunter-Central Rivers CMA, 2007) states that:

- the regional TSCA listed population of River Red Gums is in danger of extinction from the introduction of 'non-natural hybrid River Red Gums for revegetation projects' which could result in the extinction of the local gene pool for this species; and
- the community is under extreme threat, is not reserved, and that urgent protection and management agreements are required with private landholders.

The Hunter-Central Rivers Catchment Management Authority has produced vegetation mapping of the Central Hunter Valley which identifies existing plant communities. The plant communities listed below were identified within the CMA reporting, and selected by the landscape consultants as being likely to be associated with Bowmans Creek and its adjoining flood terrace environs (see *Landscape Design Drawings* - Plan Set 3 in Volume 3 of the EA).

5.2.1 Hunter Valley River Oak Forest

This community is proposed for the low active floodplain and adjoining inset benches. The low active floodplain will comprise a cobble / sand / silt material mix placed over a synthetic clay liner, while the inset benches will comprise in-situ alluvial material.

This community typically forms a mid-high to tall forest with a mid-dense canopy almost exclusively dominated by River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*). Other less frequent canopy species may include Rough-barked Apple (*Angophora floribunda*), Forest Red Gum (*Eucalyptus tereticornis*), Swamp Oak (*Casuarina glauca*). Rainforest-affiliated low trees and shrubs sometimes form an understorey stratum, which may include such species as Native Peach (*Trema tomentosa* var. *viridis*), Ironwood (*Backhousia myrtifolia*) and Muttonwood (*Rapanea variabilis*) (Hunter-Central Rivers CMA, 2007).

5.2.2 Hunter Valley Red Gum Woodland

This community is proposed for the side slopes and adjoining flood terrace. The side slopes are likely to comprise of lenses of various in-situ alluvial materials including cobbles, sand, silt and clay.

The community typically forms a mid-high to very tall or open woodland, and occurs on floodplains and floodplain rises along the Hunter River and several major tributaries. Sites on major floodplains between Singleton and several kilometres south of Scone are dominated by River Red Gum (*Eucalyptus camaldulensis*), often as a sole dominant canopy species. Forest Red Gum (*Eucalyptus tereticornis*), Yellow Box (*Eucalyptus melliodora*) and Rough-barked Apple (*Angophora floribunda*) can co-dominate in places although they usually form a minor part of the canopy. River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) once formed a gallery forest, within the typically surrounding Red Gum Forest, along most creeks and rivers (Hunter-Central Rivers CMA, 2007).

5.3 Proposed Plant Species

A list of the proposed plant species to be used to create the various vegetation communities in different elements of the landscape, and for each if the proposed phases of the rehabilitation program (see **Section 5.9**), are set out in **Table 5**.

5.4 Seed Collection and Management

Seed Availability

Seed sourced within the bio-region level and below would be suitable; with the closer the seed stock to the site, the better the restoration outcomes are predicted to be. There is a large area of source stock within local National Parks. Alternatively seed stock will be sourced from local native seed stock suppliers. ACOL will consult with the Hunter–Central Rivers CMA or local agronomists to determine the most appropriate seed source.

Storage and Preparation

The Australian Tree Seed Centre Operations Manual or the Florabank Guidelines will be followed as the guide for storage and preparation. Seed cleaning can be done using sieves, blowing machines or by hand. Relatively unskilled staff can play an important role in this aspect of the work. The cleaned dried seed is sealed into moisture-proof containers. The conditions for storage are related to the expected duration, for example: Short term – room temperature or 4°C, Medium term – less than 0°C, 3-7% moisture content, and Long term – less than -18°C, 3-7% moisture content.

River Red Gum Seed Resource

Where available, provenance River Red Gum seed will be utilised for this project. Research has shown that in some cases seed release, viability and germination rates in River Red Gum do not appear to limit recruitment (Jensen et al 2008). In water-stressed trees, however, seed release was found to be up to nine-fold less. An estimation of seed resource followed by tests of viability may be required to establish River Red Gum seedling stock. Assessment of the effectiveness of the long term self germination success may also be required. It has been shown that germination requires water from floods or local rainfall (Jensen et al 2008). The importance of local rainfall as a complementary water source was also demonstrated (Jensen et al 2008).

Table 5: Proposed Plant Species for Staged Revegetation

Phase 1: Site Stabilisation	Phase 2: Community Structure	Phase 3: Species Diversity
Aquatic / Ephemeral Community		
Phragmites australis (Common Reed) *Persicaria decipiens* (Slender Knotweed), *Persicaria lapathifolia* (Pale Knotweed), *Polygonum arenastrum* (Common Wireweed)	*Cyperus polystachyos* (Bunchy Flat-sedge) *Cyperus sesquiflorus* (Mullumbimby Couch) *Carex appressa* (Bunchy Flat-sedge) *Juncus subsecundus* (Clustered Rush) *Juncus usitatus* (Common Rush)	*Fimbristylis dichotoma* (Common Fringe-rush) *Schoenoplectus validus* (River Club-rush) *Schoenus apogon* (River Club-rush))
Hunter Valley River Oak Forest (low active floodplain and adjoining inset benches)		
Long-stem tube planting of *Casuarina cunninghamiana* (River Oak), with lesser occurrences of *Eucalyptus tereticornis* (River Red Gum). Augmented periodically with low-density planting of key structural elements as either long stem or cell-grown seedlings, as available. Inset bench protected with erosion control matting. Cell-grown seedings will be planted regularly, but in relatively low numbers to minimize losses to flood, and will include the following: **Trees:** *Casuarina cunninghamiana* (River Oak) *Eucalyptus tereticornis* (River Red Gum) **Endemic colonising shrubs:** *Acacia amblygona* (Fan Wattle), *Acacia falcata* (Sickle Wattle), *Acacia longifolia* **Forbs:** *Lomandra longifolia* (Spiny-headed Mat-rush) *Pratia purpurascens* (Whiteroot) Cynoglossum australe **Endemic grass species:** *Cynodon dactylon* (Common Couch) *Digitaria brownii* (Cotton Panic Grass) Echinochloa telmatophila *Lachnagrostis filiformis* (Blown Grass) *Oplismenus aemulus* **Endemic hydrophytic species** in low elevation points:	Regular planting in relatively small numbers of a diverse range of endemic grasses, shrubs and trees using both tube stock (grasses) and long stem stock (trees), to increase species diversity while minimising the extent of losses from periodic flooding. Building of the community to between 20 and 30 species. Species to include: **Trees** *Angophora floribunda* (Rough-barked Apple) **Shrubs** *Acacia paradoxa* (Kangaroo thorn) *Ficus coronata* (Sandpaper Fig) *Hymenanthera dentata* **Forbs:** *Cotula australis* (Common cotula) Plectranthus parviflorus (Cockspur Flower) **Endemic grass species:** *Aristida ramosa* (Three-awned Spear Grass) *Chloris truncata* (Windmill Grass) *Digitaria parviflora* (Small-flower Finger Grass) *Sporobolus creber* (Slender Rats Tail Grass) *Microlaena stipoides var.stipoides* (Weeping grass) **Endemic hydrophytic species** in low elevation points *Cyperus polystachyos* (Bunchy Flat-sedge) *Cyperus sesquiflorus* (Mullumbimby Couch) *Juncus subsecundus* (Clustered Rush) *Juncus usitatus* (Common Rush)	Continue to regularly plant in small numbers species reliant on being planted within an established woodland system, to achieve final diversity of between 40-50 species. This will include: **Trees** *Backhousia myrtifolia* (Ironwood) *Rapanea variabilis* (Muttonwood) *Trema tomentosa* var. *viridis* (Native Peach) **Shrubs:** *Myoporum montanum* (Water Bush) *Notelaea venosa* (Smooth Mock Olive) **Forbs:** Stellaria pungens (Prickley starwart) *Convolvulus erubescens* (Blushing bindweed) **Endemic grass species:** *Austrostipa verticilliata* (Slender Bamboo Spear Grass) *Chloris virgata* (Feathertop Rhodes Grass) *Panicum effusum* (Hairy Panic)

Table 5: Proposed Plant Species for Staged Revegetation

Phase 1: Site Stabilisation	Phase 2: Community Structure	Phase 3: Species Diversity
Persicaria decipiens (Slender Knotweed), *Persicaria lapathifolia* (Pale Knotweed), *Polygonum arenastrum* (Common Wireweed)		
Hunter Valley Red Gum Woodland (channel side slopes and adjoining upper flood terrace)		
Channel slopes below the 5 year ARI flood Mass planting of cell-grown seedlings with key structural community species with a high grassland content using both tube stock (grasses) and long stem stock (trees). Works have surface protection of erosion control matting, and are designed to provide quick cover with high ground-holding characteristics. Typical species will include: **Trees:** *Eucalyptus camaldulensis* (River Red Gum) *Eucalyptus tereticornis* (Forest Red Gum) *Angophora floribunda* (Rough-barked Apple) **Shrubs** *Acacia amblygona* (Fan Wattle), *Acacia falcata* (Sickle Wattle), *Acacia salicina* (Willow Wattle) *Eremophila debilis* (Amulla) and *Daviesia genistifolia* (Broom Bitter-pea) **Grasses:** Echinochloa telmatophila *Oplismenus aemulus* *Aristida ramosa* (Three-awned Spear Grass) *Austrostipa verticilliata* (Slender Bamboo Spear Grass) *Cynodon dactylon* (Common Couch) *Dichelachne micrantha* (Short-hair Plume Grass) *Panicum effusum* (Hairy Panic) *Paspalum distichum* (Water Couch) Channel slopes above the 5 year ARI flood and adjoining flood terrace Direct seeding and low density planting of cell-grown seedlings on prepared seed bed. Works are above the 1 in 5 year ARI flood and designed to provide cost-effective, early ground holding with a dense	**Channel slopes below the 5 year ARI flood** Substantial augmentation of species. Regular planting in relatively small number to increase species diversity while minimising extent of losses from periodic flooding. Build to 20-30 species. *Brachychiton populneus* subsp. *populneus* (Kurrajong) *Eucalyptus melliodora* (Yellow Box) *Eucalyptus crebra* (Narrow-leaved Ironbark) *Eucalyptus punctata* (Grey Gum) **Channel slopes above the 5 year ARI flood and adjoining flood terrace** Substantial augmentation of species diversity to approximately 30-40 species. **Shrubs:** *Notelaea neglecta* *Bursaria spinosa* (Boxthorn) **Forbs:** *Pratia purpurascens* (Whiteroot) *Dichondra repens* (Kidney weed) *Einadia hastata* *Calotis Lappulacea* (Yellow Burr Daisy) *Geranium solanderi var. solanderi* (Geranium) *Lepidium pseudohyssopifolium* (Peppercres) Rumex brownii (Swamp Dock) *Solanum americanum* (Glossy nightshade) **Grasses:** *Bromus molliformis* (Soft Brome) *Chloris truncata* (Windmill Grass) *Chloris virgata* (Feathertop Rhodes Grass)	**Channel slopes below the 5 year ARI flood** Add any last required species reliant on being planted within an establishment woodland system, to achieve final diversity of approximately 50 species for this community. *Melia azedarach* (White Cedar) **Channel slopes above the 5 year ARI flood and adjoining flood terrace** Add any last required species reliant on being planted within an establishment woodland system, to achieve final diversity of approximately 50 species for this community. Note: at this stage of the project there may be little requirement to plant the remaining species as they may have already naturally colonised the area. **Shrubs:** *Exocarpus strictus* (Dwarf Cherry) **Forbs:** *Amaranthus macrocarpus var. macrocarpus* (Dwarf Amaranth) **Grasses:** *Austrodanthonia setacea* (Small-flower Wallaby Grass) *Austrostipa scabra* subsp. *scabra* (Speargrass) *Cymbopogon refractus* (Barbed Wire Grass) *Panicum effusum* (Hairy Panic)

Table 5: Proposed Plant Species for Staged Revegetation

Phase 1: Site Stabilisation	Phase 2: Community Structure	Phase 3: Species Diversity
cover of native grasses, and low density cell-grown seedling planting of key structural species. Groundcover species will be supplemented with sterile ground stabilisation species to improve cover and plant establishment. Typical species will include those above, plus the following: *Austrodanthonia setacea* (Small-flower Wallaby Grass) *Austrostipa scabra* subsp. *scabra* (Speargrass) *Sporobolus creber* (Slender Rats Tail Grass) *Lomandra filiformis* subsp. *filiformis* (Wattle Mat-rush) *Lomandra multiflora* subsp. *multiflora* (Many-flowered Mat-rush) *Cymbopogon refractus* (Barbed Wire Grass) *Sorghum leiocladum* (Wild Sorgham)	*Digitaria brownii* (Cotton Panic Grass) *Eragrostis brownii* (Brown's Lovegrass) *Lachnagrostis filiformis* (Blown Grass)	
Buffer Planting / Weed Management		
<u>Buffer planting edge</u> Direct seeding to achieve dense cover of select native species on prepared seed bed to provide weed management buffer planting. Species to include: Capillipedium spicigerum (Scented-top Grass) *Cynodon dactlyon* (Common Couch) *Sorghum leiocladum* (Wild Sorghum) *Themeda australis* (Kangaroo grass) <u>Weed management edge</u> 50m width to the perimeter of the works, subject to regular slashing of weed infested pasture community to minimise weed colonisation to the works.	<u>Buffer planting edge</u> Low density augmentation planting with key structural species. Primary purpose of this zone is still to provide dense grassland buffer to adjoining weed infested flood terrace. *Aristida ramosa* (Three-awned Spear Grass) *Oplismenus aemulus* <u>Weed management edge</u> Encourage natural colonisation of native grasses out onto the flood terrace. This can be readily achieved by providing judicious weed management to assist early natural colonisation that will take place to this weed management edge.	<u>Buffer planting edge</u> Increase species number to approximately 10-15, to create simplified community form with relatively strong grassland buffer edge retained. *Bromus molliformis* (Soft Brome) *Chloris truncata* (Windmill Grass) *Chloris virgata* (Feathertop Rhodes Grass) *Digitaria brownii* (Cotton Panic Grass) *Eragrostis brownii* (Brown's Lovegrass) *Lachnagrostis filiformis* (Blown Grass) Echinochloa telmatophila *Austrostipa verticilliata* (Slender Bamboo Spear Grass) *Dichelachne micrantha* (Short-hair Plume Grass) *Panicum effusum* (Hairy Panic) <u>Weed management edge</u> Encourage natural colonisation of all native species out from the buffer edge and onto the flood terrace.

5.5 Soil Improvement

As described in Section 3 of the *Landscape Restoration Report* (Appendix 10 of the EA), the following soil preparation measures will be undertaken:

- **Low Active Floodplain** – For those areas of the works that comprise of placed cobble material, i.e. to the low active floodplain, no soil preparation will be required after the material has been placed. However, the placed cobble material will be carefully selected during the creek construction phase of works to ensure it contains a sand / silt / clay content sufficient to support an appropriate level of plant growth for the proposed plant species;
- **Inset Benches** – The inset benches will comprise of various alluvial materials. Soil testing will be undertaken to the benches to determine its suitability for planting into, and ameliorants applied as required sufficient to ensure an appropriate level of plant response;
- **Lower Side Slopes –** The lower side slopes are defined as that area below the 5 year ARI flood. It is proposed that this area be mass planted with cell-grown seedlings to ensure a relatively quick cover. Given that it is anticipated that the side slopes will constitute a series of alluvial lenses comprising of a range of materials, soil testing will be undertaken on a representative sample of each lens type to test chemical and physical soil properties and identify any requirements for amelioration to a level that seeks to provide a greater advantage to native seedlings than colonising weed species, e.g. low pH levels. Additionally, the lens material will be assessed to determine whether it can readily be planted into with cell size plants, e.g. if it comprises of a substantial cobble content, it may not be possible to plant cell size seedlings into it. If the lens cannot be planted into, than provision will be made for the installation of a thin (say, 75mm depth) layer of site topsoil as described below.
- **Upper Side Slopes and Flood Terrace** – The upper side slopes are defined as that area above the 5 year average recurrence interval flood. It is proposed that this area be subject to direct seeding of native grasses in the first place, in conjunction with a limited structural planting of cell-grown seedlings.
- **Site Topsoil –** Site topsoil will be stockpiled as part of the civil works package. Prior to stripping of topsoil, testing will be undertaken to determine the depth to which the majority of the weed seed load is situated. For areas to be stripped for their topsoil, this top layer (potentially in the order of 100mm) will be scalped and removed well away from stockpile sites, in order to remove the majority of the soil weed seed bank. The remaining topsoil will subject to soil testing and amelioration as required prior to stockpiling for later re-use in the restoration works, e.g. for topsoiling to the side slopes as required.

5.6 Weed Control

As set out in Section 3 of the *Landscape Restoration Report* (Appendix 10 of the EA), weed management will be a key factor in determining the success of the project, particularly within the first 12 to 18 months of the Plant Establishment Period (PEP). Very high weed densities are present on the flood terrace within which the diversion channels are constructed, particularly within the areas of improved pasture. In addition to the scalping of areas to remove the soil weed seed bank as described above, the following weed management process will be undertaken:

- Slash or otherwise manage the flood terrace for weeds within 50 metres of the creek diversion channels to minimise the extent of weed seed inputs to the area of the works – slashing will commence prior to commencement of the engineering works, and take place at intervals sufficient to stop substantial setting of weed seed for at least the first 12-18 months of the PEP;
- Undertake restoration treatments quickly upon completion of the civil engineering works to minimise the opportunity for weed colonisation;

- Weed manage prepared areas with glyphosate (e.g. Roundup Biactive) as required prior to undertaking restoration treatments;
- Regularly undertake initial weed management of the works until a dense native plant cover is in place, and that is of sufficient capacity to provide for natural regeneration of native species and minimise habitat / colonisation opportunities for weeds;
- Thereafter, undertake weed management as required.

5.7 Fencing

Stock proof fencing will be installed along all rehabilitated sections of Bowmans Creek as shown on **Figure 3** (*Figure 10.3 in the EA*).

5.8 Planting Methods

5.8.1 Long-stem Tubes

Planting to the low active floodplain and inset benches will include long-stem tubes of River Oak, which have been developed specifically for riparian situations. These tube plantings are essentially tall (about 1m high) plants with a single long stem, most of which in fact comprises of roots. Once established, other species from the Hunter Valley River Oak Forest community will be planted using a mix of long-stem tubes for those species for which they are available. Where proposed species are not able to be procured in a long-stem form, these will be planted as cell-grown seedlings progressively in small numbers throughout the period of the works to minimise losses to flood. The initial planting of long-stem tubes will be undertaken at average of 3-4m centres across the area of the low active floodplain and inset benches. This density allows for open cobble and bench areas as is characteristic of the community, as well proving niches for following-up planting of additional species.

5.8.2 Cell-grown Seedlings

Wherever practicable, Cell-grown seedlings will be planted to the lower side slopes at an indicative average density of about 8 plants per square metre, or based on the outcomes of trials during early phases of rehabilitation. The planting palette will comprise of a mix of robust and quick growing species from all structural layers to maximise early soil holding properties, including a substantial ground layer of native grasses and forbs such as Lomandra longifolia. An initial species diverse structural planting will be undertaken for this area, with an emphasis on the canopy and shrub layers, to assess the relative performance of different species within the Hunter Floodplain Red Gum Woodland community, including at different heights up the bank, and possible responses to periodicity of inundation and soil types. Once this initial planting is established, staged supplementary planting will take place to increase species diversity and plant density where required.

5.8.3 Direct Seeding

Direct seeding of a select suite of native grasses will be undertaken to the upper slopes and flood terrace edge in conjunction with a structural planting initially in limited numbers, to provide a dense, weed resistant cover, into which later staged planting can be undertaken to create a species rich community characteristic of Hunter Floodplain Red Gum Woodland. As with the planting to the lower side slopes, an assessment will be made of the relative performance of different species within the Hunter Floodplain Red Gum Woodland community, to help determine an optimal species composition for later supplementary planting. The outer 5m of the corridor restoration will be seeded initially to a dense cover of native grasses to provide a robust weed barrier between the works and the adjoining weed community on the flood terrace. Select native grass species will include: Kangaroo Grass (*Themeda australis*); Scented Top (*Capillipedium spicigerum*) and Wild Sorghum (*Sorghum lieocladum*), species which have previously performed well in direct seeding applications. Additionally, a sterile cover crop will be judiciously used during the initial period of direct seeding, sufficient to assist in weed suppression without unduly compromising the growth of the young native seedlings.

5.8.4 Watering

Watering, where needed, will be undertaken for a minimum period of 3 months after each planting or direct seeding event.

5.9 Rehabilitation Staging

As described in *Section 12.5 and Appendix 10* of the EA, rehabilitation of the diversion channels will be undertaken in three phases.

5.9.1 Phase 1 – Site Stabilisation

This phase of the works will take place over the first 2 - 3 years of the project. Key objectives of this phase would be to:

- Quickly stabilise the works;
- Provide a quick and robust weed suppressing native plant cover which will improve soil structure and microclimate.

The performance of the initial species (see **Table 5**) will be assessed weekly and additional planting will be undertaken to ensure adequate plant cover is achieved and exotic species cover is minimal for stabilisation against runoff on the batter slopes and scour on the low active floodplain and inset benches (see *Landscape Masterplans SK01* and *SK02* in the *Landscape Restoration Report* – Appendix 10 of the EA); and robust native plant cover to suppress weeds and improve soil structure and microclimate. Currently the banks of the system are dominated by exotic species, so the establishment of a groundcover ecosystem that is dominated by native grasses is the primary objective. Additional floristic and structural diversity will be achieved over a greater time frame.

5.9.2 Phase 2 – Vegetation Community Structure

This phase of the works will take place between years 3 and 6 of the project. Key objectives of this second phase of the project would be to:

- Augment species diversity of the communities sufficient to provide a significant level of species richness, characteristic of the community, e.g. in the order of:
  - 30 to 40 species for the Hunter Floodplain Red Gum Woodland community on the upper side slopes of the diversion channels (see **Table 5**),
  - approximately 40 species for the Hunter Floodplain Red Gum Woodland community on the lower side slopes (see **Table 5**), and
  - 20-30 species for the Hunter Valley River Oak Forest community within the low active floodplain and inset benches (see **Table 5**); and
- Increase numbers and density of particular species where required.
- Establish habitat elements for threatened bird species recorded in the local area.
- Dominance of local flora species established in Phase 1 will be complemented with the emergence of structural diversity.

5.9.3 Phase 3 – Species Diversity

This phase of the works will generally take place between years 6 and 8 of the project. Key objectives of this third phase of the project will be to:

- Further augment species composition of the communities to a comprehensive suite of up to 50 species for the Hunter Floodplain Red Gum Woodland community and between 40 and 50 species for the Hunter Valley River Oak Forest community;
- Provide the 'softer' and 'harder' to establish species in the now substantially ameliorated natural environment, which should by that stage provide many of the niches necessary for their establishment, e.g. areas with dappled light, elevated soil moisture, wind and sun protection, locally increased humidity, etc.;
- Increased fauna diversity will be a sound measure used in this phase for ecosystem restoration success. There will be an initial diversity spike that will stabilise, then as structural and floristic diversity peaks, occupation of habitats by a wider range of species, including significant species will be the goal. This in conjunction with dominance by native flora species and ecosystem comparisons with reference sites will be the final measures of ecosystem success.

5.10 Contingency Management

5.10.1 Weeds

Weeds of concern are those that are listed as Noxious under the provisions of the Act, and weeds that successfully outcompete native species. There are many other weeds that whilst being present in a system have no major effects, but should be minimised nonetheless. The initial earthworks, sculpting, stabilising planting and early ecosystem planting phases are the times of greatest risk in terms of exotic weed outbreaks. Regular monitoring of regeneration sites will identify potential problem areas before weeds take hold. If large areas are identified as being destabilised by weeds, the following weed removal methods will be implemented:

- intensive herbicide application,
- hand or mechanical removal.

Weed competition with tube stock for resources can be a major problem. This will be combated with the use of very long-stem tube stock. Long-stem tube stock of fast growing colonizing species will be farmed especially for contingency planting. These areas will be planted in very high densities to improve competitive advantage against weeds. Once established they will outcompete weeds.

5.10.2 Vegetation Establishment

To date rehabilitation programs undertaken by Ashton within the mine site area and adjoining landscapes have been successful, with established systems having being achieved within prescribed timeframes. Monitoring of a small scale planting area within the proposed rehabilitation area indicates that colonisation should be successful, with much higher success rates predicted where planting can be undertaken to take advantage of autumn rain periods.

If large areas of direct seeding fail to colonise the following actions will be undertaken:

- In areas where there is a risk of erosion and weed infestation, direct seeding will be repeated but with a greater focus on sterile stabilising grasses. Once the area is stabilised, the area will be planted with a combination of seeding and tube stock.
- In more stable areas, direct seeding of native local species will be repeated and followed up with increased maintenance and watering.

5.10.3 Fire

ACOL has an approved bush fire management plan – it will be revised to include the Bowmans Creek Diversion project.

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6 COMPLETION CRITERIA AND MONITORING

6.1 Channel Construction

The proposed completion criteria relating to the construction works are set out in **Table 6.**

Table 6: Proposed Completion Criteria for Channel Construction

Domain	Performance Criteria and Assessment Method	Corrective Action
Channel Geometry and Form (To be undertaken during and immediately following construction)		
Channel geometry conforms to design	"As constructed" survey of channel cross sections and longitudinal profile for validation against: • Engineering drawings • Key indicators set out in	Reconstruction of non-conforming elements
Adequate cobble material available to provide specified depth of bed	Depth of bed material audited by geomorphologist during construction	Import additional hard rock with similar grading to cobbles in creek
Rock bars, rock ramps	Construction as per design drawings established by post construction review by qualified fluvial geomorphologist.	Repair as necessary
Stockpile Rehabilitation (assessment at the end of channel construction)		
Presence of silt fencing	Required silt fencing in place	Install fencing
Revegetation	Stockpile vegetation achieves 70% ground cover within 2 months of seeding	Re-seed any bare patches
Free Draining Floodplain		
Maintain free draining floodplain	Visual inspection for subsidence induced ponding on the floodplain (Not to be confused with existing natural ponding areas which will be surveyed and documented)	Fill depressions or construct drainage to maintain free drainage

6.2 Geomorphology and Stream Health

The proposed geomorphology and stream health completion criteria are based on a number of reference sites within Bowmans Creek that have been monitored since 2005 (see **Section 3.1**) and will continue to be monitored in the future:

- Creek cross sections at 37 locations in the reaches of the creek that are to be retained. These cross sections and associated longitudinal profiles of the bed, which were previously surveyed in 2005 and 2008, will be surveyed periodically for comparison with 10 cross sections within each diversion channel. Bed samples will be collected at the same time for statistical comparison between the retained sections of the creek and the bed of the diverted sections.
- Stream health has been monitored in spring and autumn at a number of locations along Bowmans Creek including sites upstream, downstream and between the proposed diversion channels (see **Figure 10**). The stream health monitoring includes:
  - Aquatic Macro-invertebrate sampling using AusRivAS protocols for collection and taxonomy. Data are used to establish individual site diversity and individual site

SIGNAL indices per season plus mean site diversity and mean site SIGNAL index over time;

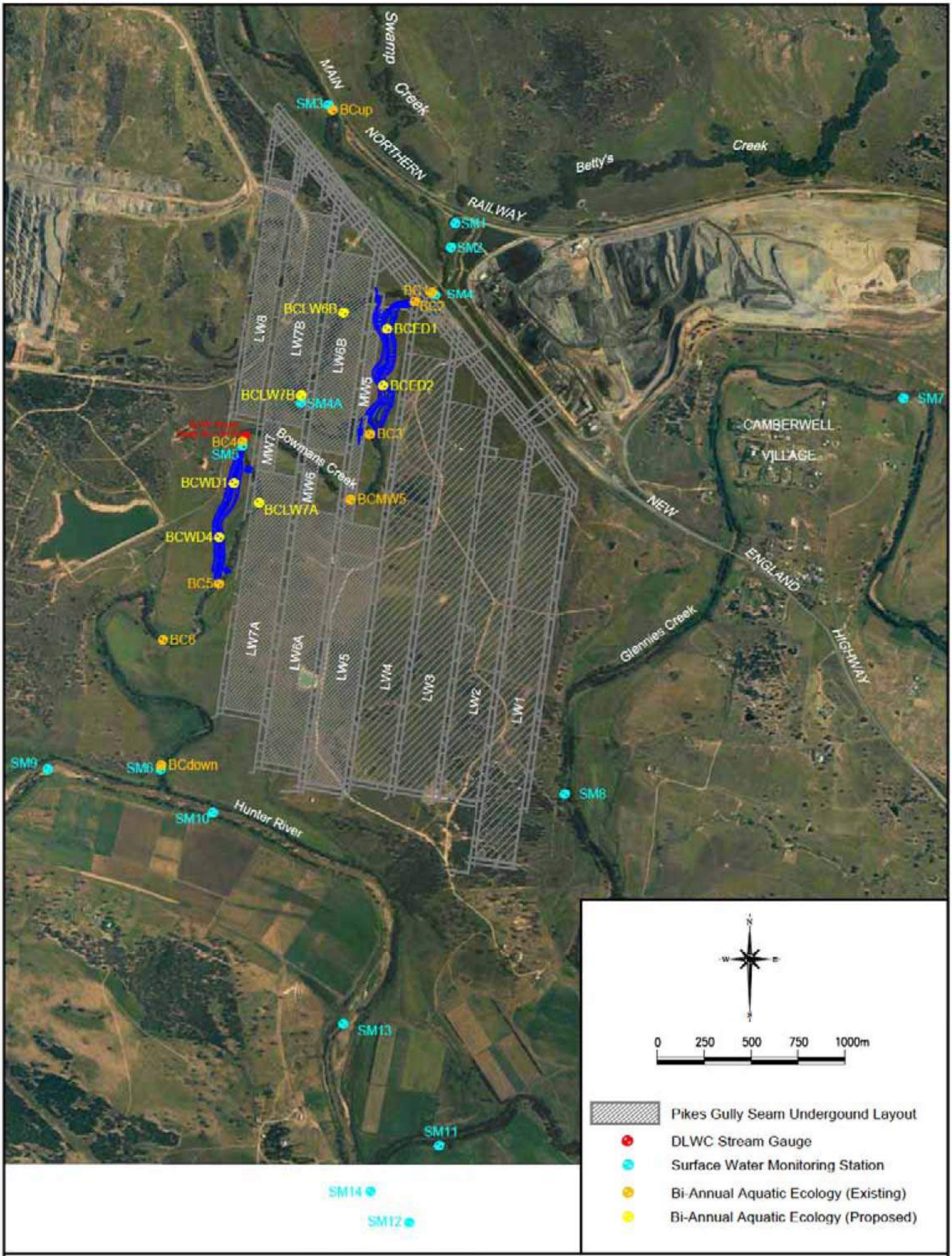
- Combined seasonal site data are used to provide mean and SD of stream site diversity and of stream SIGNAL index for seasonal comparisons over time;
- Fish sampling using bait traps set overnight plus direct observations and incidental captures during macro-invertebrate sampling. Data used to produce fish species lists per site per season;
- Site habitat diversity assessment using existing RCE method and site photo referencing;
- Metered and profiled water quality (EC, Temp, pH, NTU, DO). Data are used to provide specific season between-site comparisons to aid interpretation of site aquatic biota differences for that season.

Table 7: Proposed Completion Criteria for Geomorphology and Stream Health

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
Geomorphology and Channel Stability		
Absence of permanent channel scouring	Visual inspection after minor floods during first three years	Repair any significant scour and revegetate as necessary
Geometry of diversion channels	Establish 10 permanent survey sections in each diversion channel. Survey cross and long sections at the following times after opening of the diversion channels: • 6 months • 1 year • 2 years • 5 years • 10 years • after floods >150 m^3/s Compare channel section against earlier surveys and any changes in reference sites to assess trajectory towards long-term stability	Commission qualified fluvial geomorphologist to assess trend and recommend corrective actions. Undertake necessary corrective actions.
Channel geometry at existing reference sites	Re-survey cross sections in remaining active sections of channel every 5 years and after floods > 150 m^3/s	
Bed load transport	Sample channel bed for particle size analysis at same time as survey. Statistics of data from the diversion channels within 20% of that from the existing channel.	Commission qualified fluvial geomorphologist to assess trend and recommend corrective actions.
Stream Health		
Fish passage and aquatic ecology of diversion sections.	Fish passage and aquatic ecology of diversion sections to be same or better than pre-construction baseline conditions and in line with trends exhibited in the retained sections of the creek. Completion for sites within the diversion channels will be established by comparing diversion channel site scores (Macro-invertebrate diversity, Site SIGNAL index, Site fish lists and Site RCE scores against baseline site mean ± SD scores) with: • pre-excision baseline scores for the corresponding sites within the creek	The expectation will be that individual diversion creek site indices will show a more or less steady increase over time against their baseline data. The 'recovery time' deduced from seasonal/site diversity and SIGNAL Index data for Bowmans Creek since the major 2007 mid-year flood was around 5 sampling seasons (around 2.5 years). Thus a period of 2.5 years for growth towards the completion criteria should be expected. Over this period the trigger for possible corrective

Table 7: Proposed Completion Criteria for Geomorphology and Stream Health

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
	sections being excised; • trends in scores for reference sites in the retained sections of the creek Completion will be considered to be achieved once new site scores are consistently within or above the range (Baseline Excised Site Mean – SD) score and consistent with trend in reference sites. Establishment of four additional monitoring sites (two in each diverted section – see **Figure 10**) for bi-annual (spring and autumn) monitoring of same suite of indicators as used for monitoring to date: • Aquatic macro-invertebrate sampling using AusRivAS protocols. Calculation of SIGNAL indices; • Fish sampling using bait traps; • Site habitat diversity assessment using existing RCE method and site photo referencing; • Metered and profiled water quality (EC, Temp, pH, NTU, DO).	action for diversion creek sites would be persistently low steady or decreasing site criteria. In this case the aquatic ecologist will first investigate which specific site/criteria contribute to the low or decreasing scores, investigate the causes for particular criterion deterioration, and, once established, report on whether it is a 'natural' expected change (e.g., continuing climatic/seasonal variation), a site-specific non-deviation related change (e.g., a local bank slumping) or a possible deviation-related change (e.g., accelerated sedimentation, restricted fish passage). The aquatic ecologist will then make recommendations to ACOL for either further investigations or suggested remediation measures. For the retained "impact" creek sites, the aquatic ecologist will report on individual seasonal within-site low completion criteria results, using a decision tree similar to that devised for the diversion creek sites above.



AshtonCoal

Bowmans Creek Diversion Project

Figure 10
Existing and Proposed Water Quality and Stream Health Monitoring Sites

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6.3 Rehabilitation

The proposed monitoring regime for assessing the adequacy of the rehabilitation will be based on existing routine monitoring programs undertaken by ACOL (see **Section 5.1**). In particular the monitoring will extend the Landscape Functional Analysis methodology (see DnA & Carbon Based Environmental 2009a) and the program of rehabilitation and farmland monitoring undertaken at sites that will provide reference sites for some aspects of the program for Bowmans Creek (see **Figure 11** and **Figure 12**).

The proposed completion criteria relating to rehabilitation are set out in **Table 8** below. These proposed criteria and the associated monitoring regime and selection of reference sites will be formalised in a Rehabilitation Management Plan which will be prepared in consultation with relevant Agencies.

Table 8: Proposed Completion Criteria for Rehabilitation

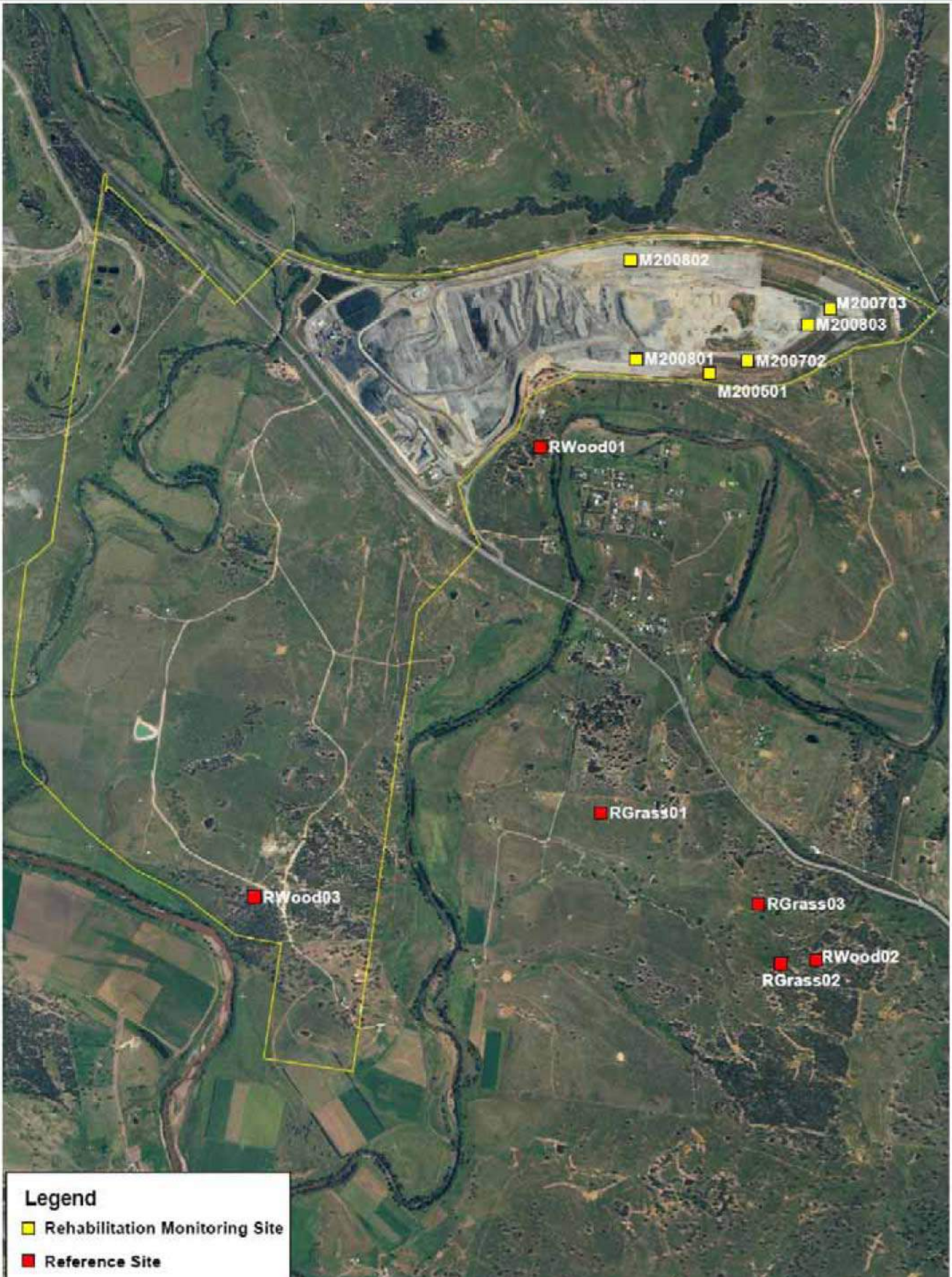
Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
Site Stabilisation (Phase 1)	The ground cover strategy controls erosion and reduces exotic weed dominance to minimal levels in community structure. During Phase 1: • Quantitative data collection on floristic composition and cover will be undertaken bi-monthly to measure success. • Weekly and stochastic (during rain) quantitative and qualitative measures of soil erosion impacts and ground disturbance will also be undertaken. • Weekly assessments of cover and erosion will be compared with available data and reference sites to assess success. Upon completion of this phase, • Vegetative cover will be dominated by local native species with minimal evidence of weed cover and erosion. • Weeds will be successfully managed so that they are not inhibiting the successful establishment of the future community structure and diversity. This will be determined by direct quantitative comparisons with reference sites, with the aim of achieving comparable mean species diversity and structural complexity scores.	When cover is insufficient to control erosion, additional planting and safeguarding will be implemented in the area of impact. Weed cover will be controlled to minimal levels through appropriate systematic control. However, when surveys identify outbreaks, additional intensive control measures will be implemented. If data shows that future structural and diversity goals will not be met, an adaptive reworking of the planting program will be undertaken to incorporate a wider range of species. The benefits of introducing additional growing material or providing additional soil ameliorants will also be investigated. Measures will be put into place, with the goal of increasing cover and diversity as compared with reference sites.
Community Structure (Phase 2)	Phase 2 will establish structural elements that provide habitat niches. Three structural elements are important to the landscape: • Groundcover is representative of tussock grass clumps, small areas of open ground and fallen timber which	Success of the regeneration in terms of structural elements has to be corrected "along the way". Bi-monthly surveys need to record growth rates, species abundance as well as percentage cover to determine a final structural complexity index. Where elements are

Table 8: Proposed Completion Criteria for Rehabilitation

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
	provides both important fauna habitat onsite, and a generally sparse shrubbery; • Mid-stratum is very open to sparse, and should reach beyond 2 metres in height to provide nesting for important species (i.e. Grey-crowned Babbler) and perch sites for others (i.e. Hooded Robin); • Over-storey structure will range from forest (i.e. riparian corridor) to woodland (i.e. floodplain areas), with a diverse yet clumped species composition that is consistent with the community reference sites. Structural complexity scores will be achieved by sampling complexity using a modified vegetation complexty assessment method as first developed by Newsome and Catling (1979). This quantitative data will be compared with data sets from reference sites to assess success of this phase.	lacking this needs to be fed back into the planting program.
Species Diversity (Phase 3)	Community diversity is reliant on many factors. As a measure of present diversity onsite, quantitative data collected (18 sample sites) has identified 91 native flora species as being endemic. These species will form the lowest benchmark for rehabilitation of floristic diversity. Many more species have been identified in the region as occurring within the types of vegetation communities recorded onsite (CMA data – *refer Appendices 3 and 4 of Landscape Restoration Report*). It is, however, impossible to predict whether all these species could potentially colonise the site, because there are many unknown factors to the establishment of flora species. Nonetheless, beyond this benchmark, species that can be successfully harvested and germinated will be included in the development of greater diversity in Phases 2 and 3.	If the diversity measures differ from reference sites beyond the performance criteria, additional adaptive measures will be implemented.
Floodplain Red Gum Woodland	There are two components here: 1. Assessing established River Red Gum individuals, and 2. Assessing the success of River Red Gum rehabilitaion to the floodplain terrace (as per **Figure 3**). The health of established River Red Gum individuals will be maintained until project completion. Comparative health assessments will be conducted annually, using reference	When changes in tree health such as water stress are evident, adaptive measures will be implemented.

Table 8: Proposed Completion Criteria for Rehabilitation

Functional Area / Key Functional Aspect	Performance Criteria and Assessment Method	Corrective Action
	sites as indicators of health in the absence of onsite impacts. Juvenile River Red Gum survivorship and long term recruitment of established communities cannot be compared to reference sites, as lack of recruitment is a key problem to the long term viability of the population. Experimental pilot studies in line with specific management actions will be used to establish a successful protocol for the establishment and long term survival of individuals.	
Hunter Valley River Oak Forest Community	Analysis of the success of establishing the community will be achieved by an analysis of similarity (Such as an ANOSIM test, Cluster Analysis or PermaNova) to test for differences in species assemblages across the rehabilitation and reference sites. The goal being to assess whether rank similarities within groups are greater than between groups. Therefore, allowing an assessment of the rehabilitation communities "fit": within broader community variability. Throughout the rehabilitation phases comparison between rehabilitation sites and reference sites will be undertaken to establish the progressive success of works. Initial planting phases will establish the great majority of species diversity onsite, this can be compared within structures, (for example, comparing the grass assemblage of sites only) to remove bias of comparing an established site with a rehabilitating site.	When this analysis identifies a divergence from the reference sites community assemblage adaptive planting and management will be implemented.
Floodplain Pasture Lands	Floodplain pastures will be established as viable grazing pastures for long-term agricultural purposes. The area will be dominated by grassland pasture species with minimal agricultural weed species.	If agricultural weed species colonise the area adaptive management will be put in place to remove.
Terrestrial Fauna	Terrestrial fauna species diversity and abundance changes in a non-linear manner. Reference sites will also have community structures that are different with each other and variable overtime. The suite of terrestrial fauna species recorded at all the reference sites (within one standard deviation) over the monitoring period will be the bench mark for terrestrial fauna diversity. Significant species populations in the area will be monitored and compared to reference sites to assess survivorship.	Measures such as, introducing habitat elements for species, introducing new flora species, creating habitat pockets, improving links and stepping stones, and physical management of the landscape (i.e. grazing some area) will be used to correct a lack of species diversity



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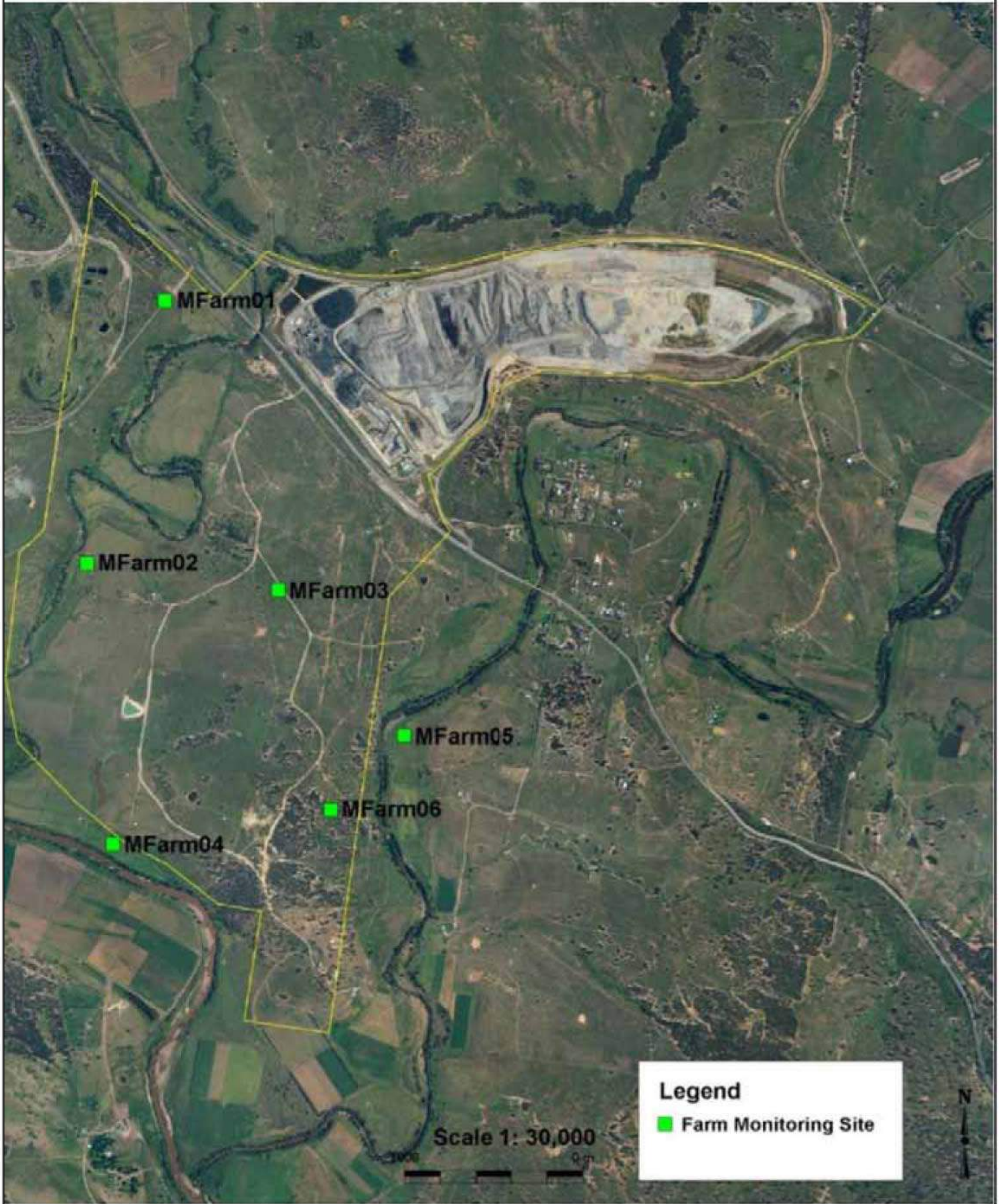
Bowmans Creek Diversion Project

Figure 11
Map Showing Location of Overburden Rehabilitation Reference Sites and Monitoring Sites



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Diversion Project

Figure 12
Map Showing Location of Farmland Monitoring Sites

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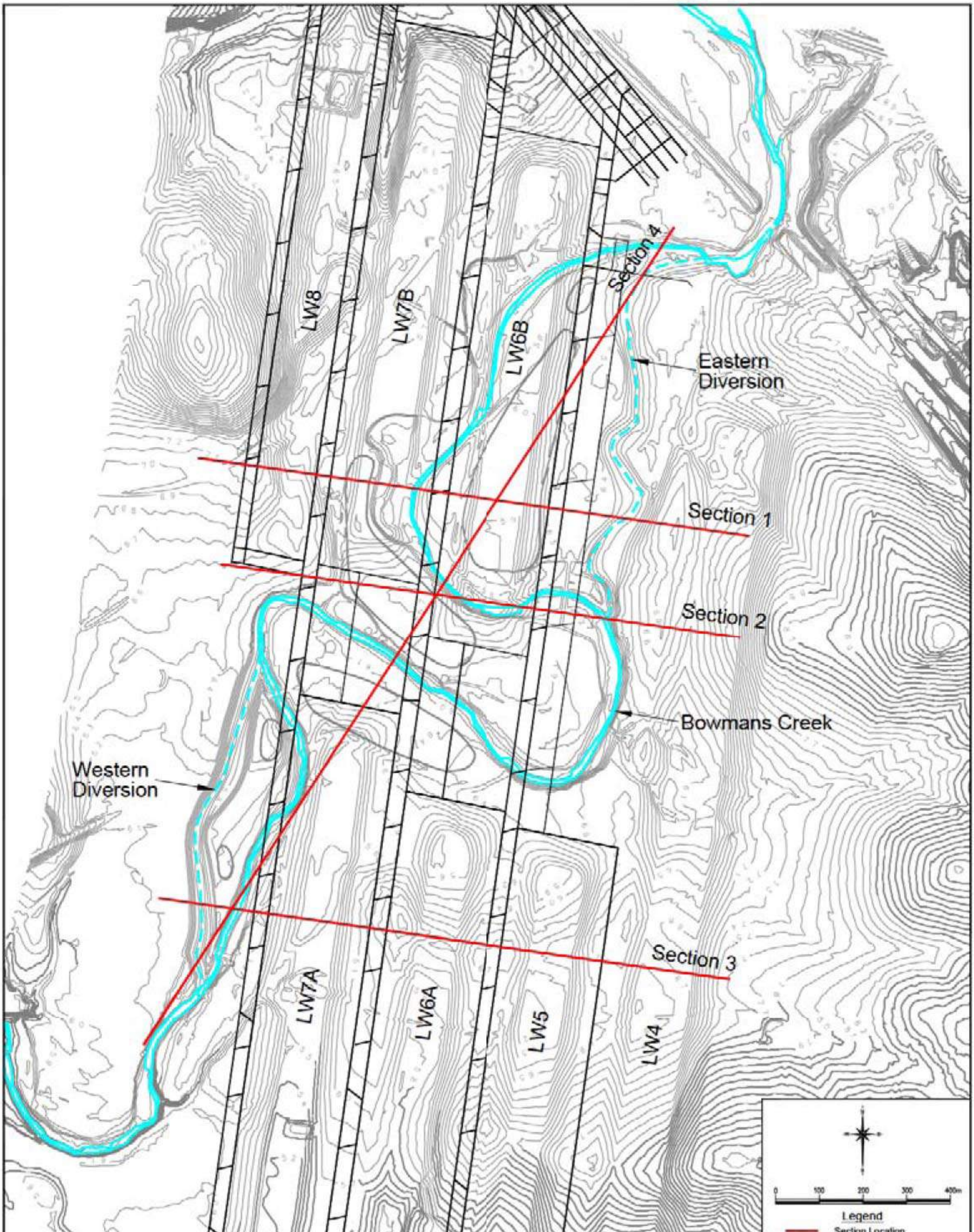
Annexure A: Proposed Final Landform



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Bowmans Creek
Diversion Project

Response Figure 1
Indicative Final Landform
Final Landform & Section Location Plan

Prepared by Pegasus Technical
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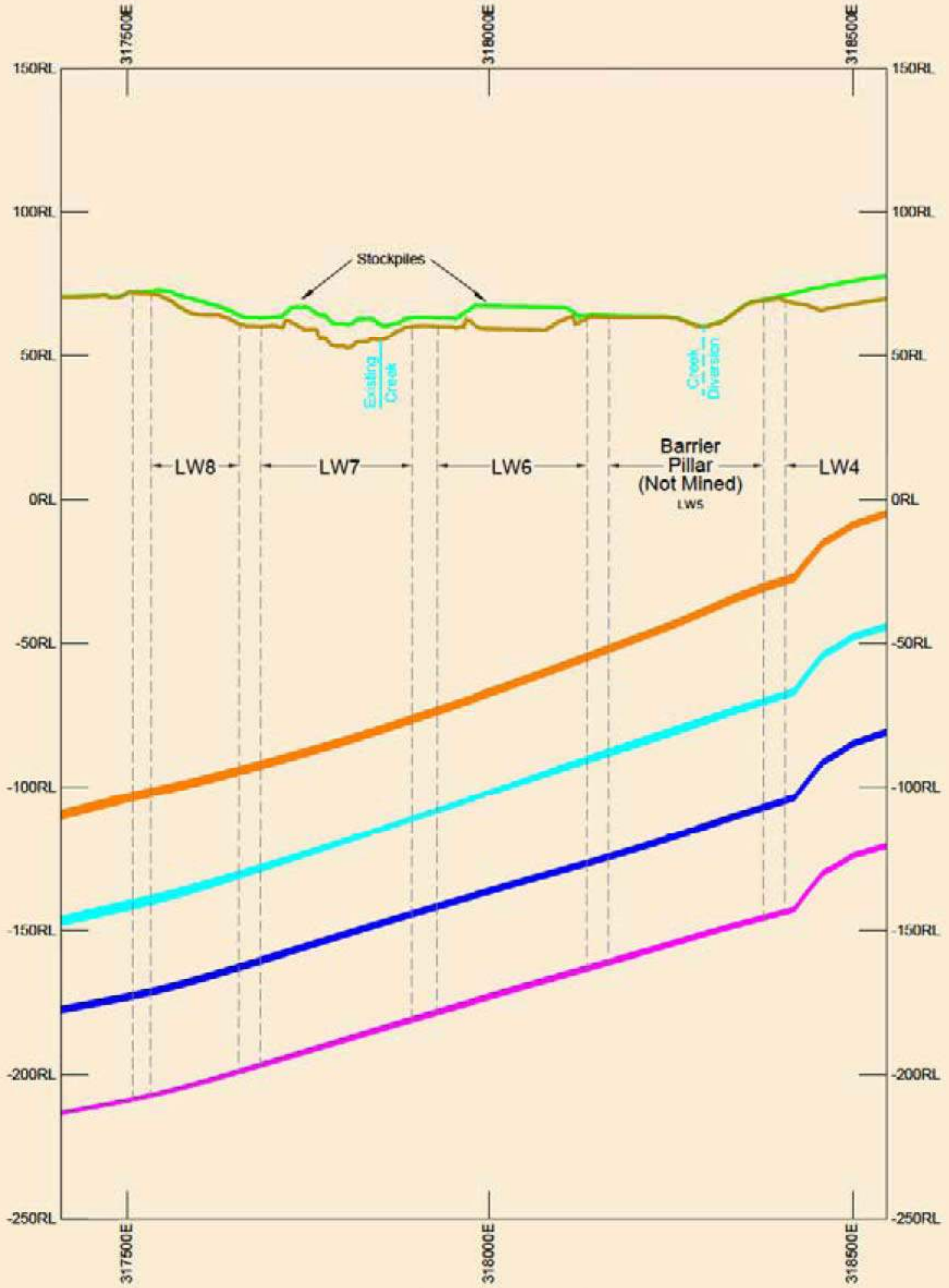

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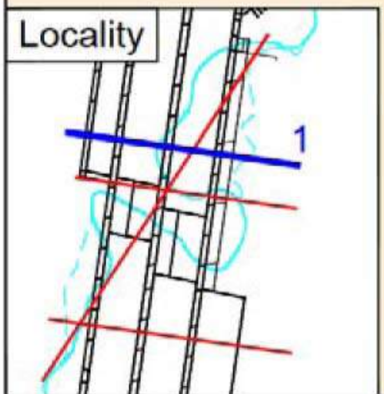

Legend
- Original Topography
- Subsided Topography
- Longwall Gate Road
- Seam - Pikes Gully
- Seam - Upper Liddell
- Seam - Upper Lower Liddell
- Seam - Lower Barret

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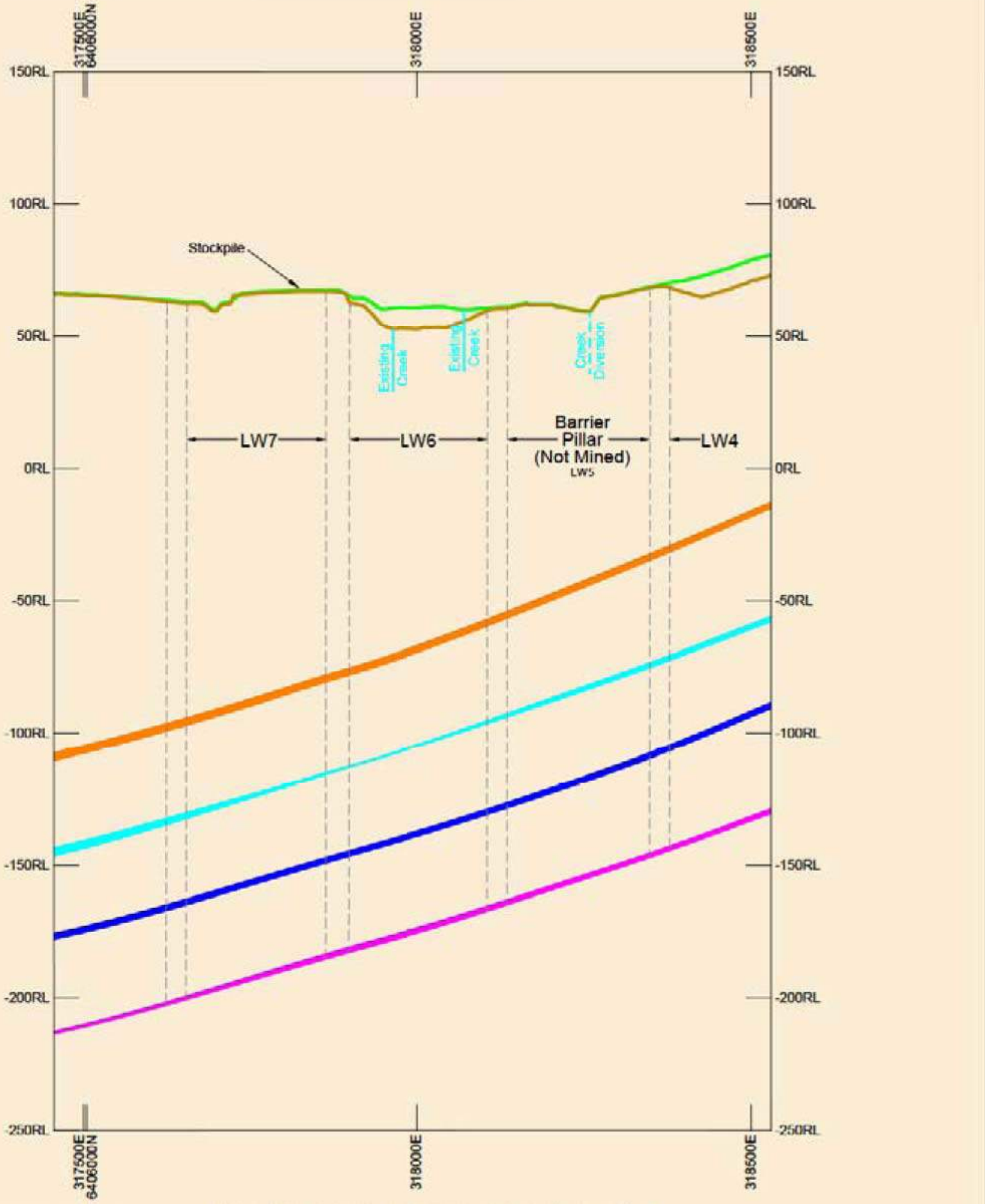
Bowmans Creek Diversion Project

Response Figure 2
Indicative Final Landform
Section 1

Prepared by Pegasus Technical



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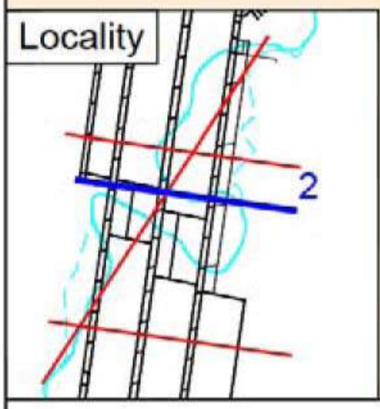

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Prepared by Pegasus Technical

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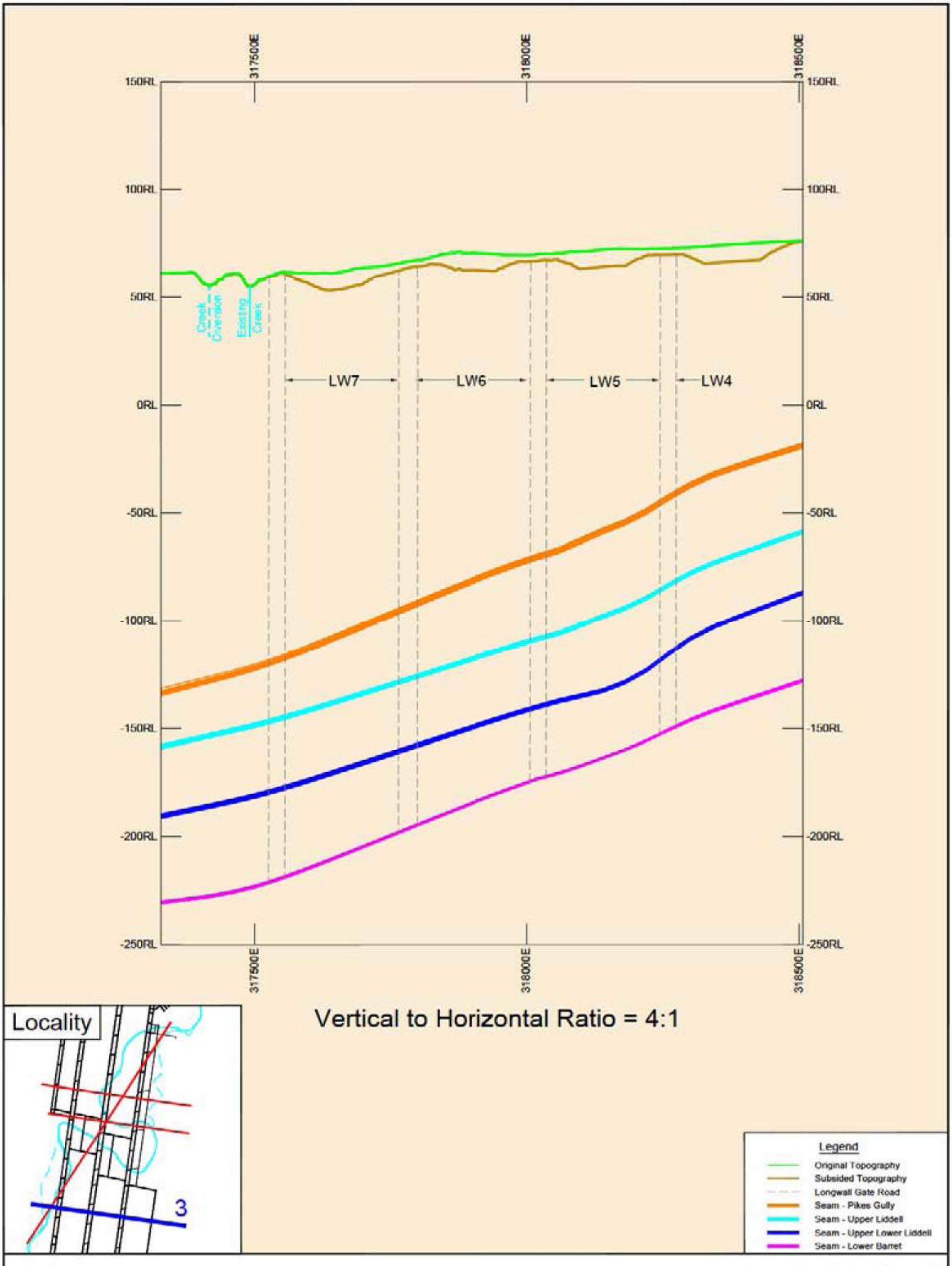
Bowmans Creek Diversion Project

Response Figure 3
Indicative Final Landform
Section 2



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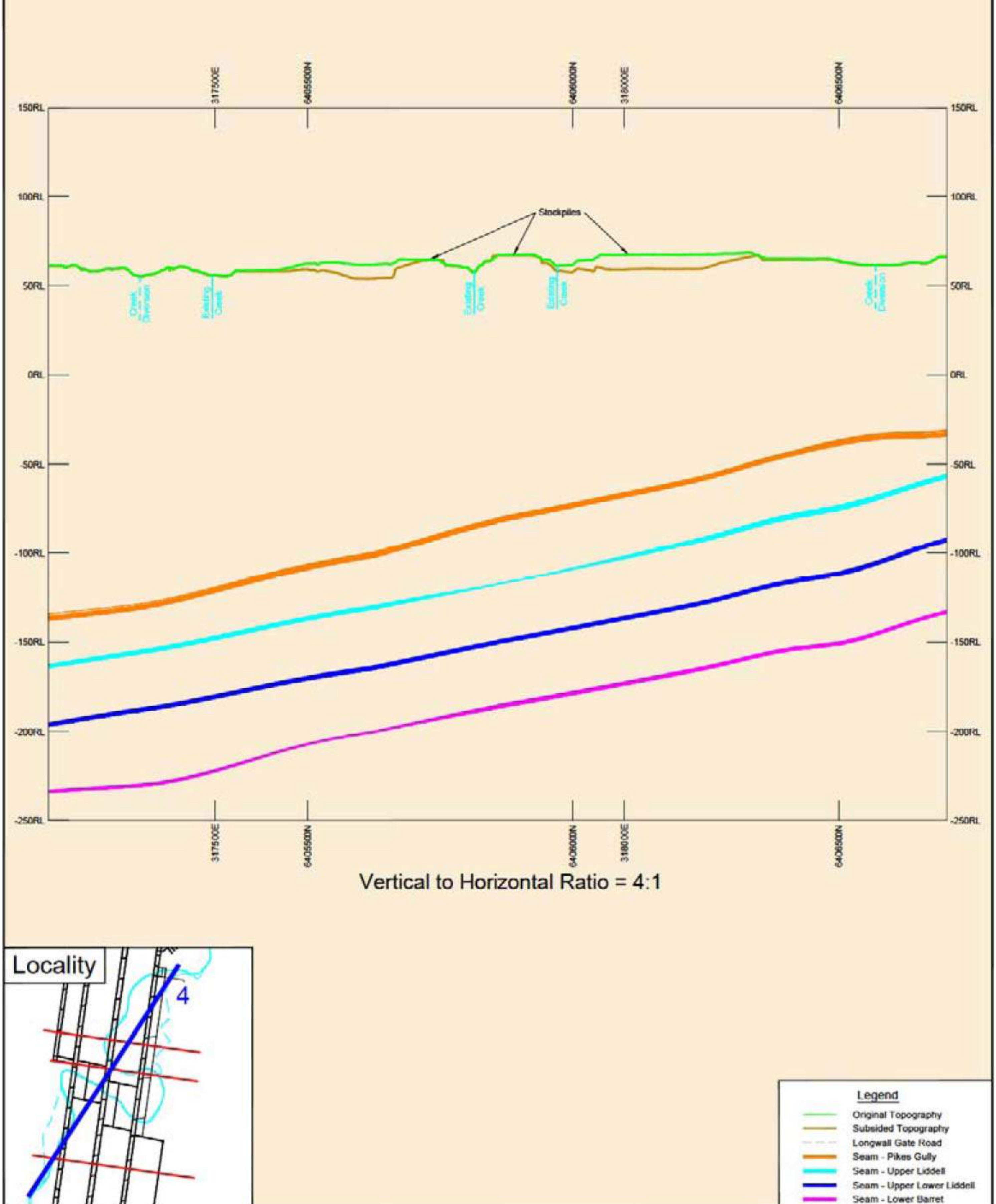
Bowmans Creek
Diversion Project

Response Figure 4
Indicative Final Landform
Section 3

Prepared by Pegasus Technical



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Bowmans Creek Diversion Project

Response Figure 5
Indicative Final Landform
Section 4

Prepared by Pegasus Technical

Appendix B

Construction Mining Operations Plan Amendments

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21 March 2010

Mr Michael Lloyd
A/Team Leader – Environment (Northern)
Industry & Investment NSW
PO Box 344
Hunter Regional Mail Centre NSW 2320

Dear Michael,

Bowmans Creek Diversion Construction Mining Operations Plan (MOP) – Minor Variation

On the 17 March 2011 Ashton Coal Operations Pty Limited (ACOL) representatives met with the Department of Environment, Climate Change & Water (DECCW) to discuss the status of an Aboriginal Heritage Impact Permit (AHIP) application for the Bowmans Creek diversion development. The AHIP is required to enable Aboriginal artefacts to be salvaged from areas within the creek diversion construction area. During this meeting it became evident that it could be at least six weeks before a decision is made on the AHIP application by DECCW. The AHIP application was submitted on the 14 January 2011, following grant of development consent by the Department of Planning on 24 December 2010.

This unanticipated delay in obtaining an AHIP for the development presents a significant constraint to the carrying out of construction activities as described in the MOP. It also presents the potential to halt longwall production for a significant period as the construction schedule for the creek diversions is timed to provide the least disruption to longwall mining. This has obvious ramifications to the mine and to ACOL.

To reduce this potential disruption to the least extent possible, ACOL will commence construction activities in areas devoid of Aboriginal objects. These areas have been identified through extensive field assessment following the appropriate DECCW' due diligence code of practice guidelines. However, this requires increasing the overall area of disturbance and the establishment of a temporary stockpile. Neither the increased disturbance extent nor temporary stockpile were contemplated or approved in the MOP for the creek diversions.

The additional disturbance area and use of a temporary stockpile for the construction activities has been discussed with Craig Campbell of I&I (Regional Environmental Officer). Hence the purpose of this letter is to provide a brief description of the additional disturbance and temporary nature of the proposed stockpile and to provide notice to I&I of the proposed minor MOP amendment.

The additional disturbance area and temporary stockpile will be located to the west of the southern part of the western creek diversion, as shown on the attached amended MOP Plan 4 & 5.

The area has already been silt-fenced to ensure there will be no offsite sediment release. As an additional sediment control measure, a small bund will be developed around the perimeter of the stockpile using the initial stripped topsoil from the excavation area. Further, the stockpile will be shaped to drain toward the excavation work. These measures will ensure dirty water runoff from the stockpile is contained within the excavation area.

It is expected that up to about 85,000 m^3 of excavated material may be required to be temporarily stockpiled in the indicated area. It is estimated that the stockpile will be in active use for a period of about 90 days, within which time ACOL expects to obtain the AHIP. Following this the stockpiled material will be relocated to the approved stockpile area, north of the western creek diversion (see attached plan). Once all the temporarily stockpiled material has been relocated the additional disturbed area will be rehabilitated as generally described in the MOP and presented in MOP Plan 6.

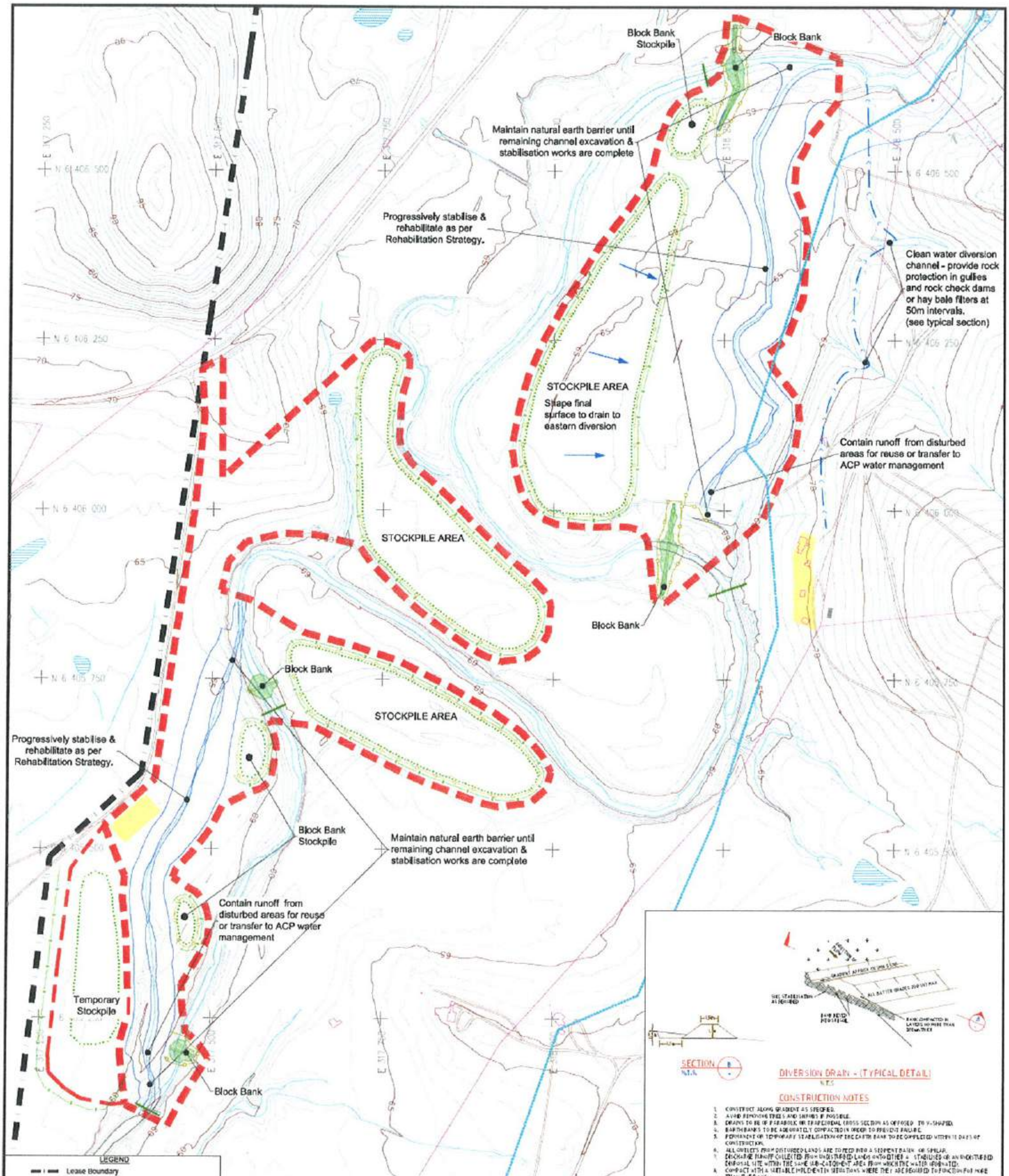
If you have any queries about this matter or require further information I can be contacted on 6570 9102 or via email at mmoore@ashtoncoal.com.au.

Yours faithfully

M. Moore

Michael Moore
Approvals Manager

Attached: Amended MOP Plan 4 & 5



LEGEND

- Lease Boundary
- Creek Diversion Disturbance Boundary
- Existing Dam
- Power Lines
- Water Course
- Farm Infrastructure
- 1m Surface Contour
- Hunter River Pipeline
- Barrier Fence
- Sedimentation Control Fence
- Sedimentation Control - Hay Bale Barricade
- Clean Water Channel (temporary)
- Stockpile Bund
- Site Infrastructure

NOTES:
Stockpile & erosion controls to be managed in accordance with the Construction Mining Operations Plan.

All measurements are in metres

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MINE OPERATIONS PLAN 4 & 5

Proposed Construction & Rehabilitation

Name of mine	ASHTON UNDERGROUND COLLIERY
Mining Leases	ML1533, ML1623, ML1529
MOP Commencement Date	10-02-2011
Name of Leaseholder	White Mining (NSW) P/L, Austral-Asia Coal Hldng P/L, ICRA Ashton P/L
Name of mine operator	ASHTON COAL OPERATIONS PTY LTD
Reporting Officer	Brian Wesley
Title	General Manager
Signature	....
Date	10-02-2011 Varied 21-03-2011

I, ..., holder of Mine Manager's Certificate of Competency No. ...., certify that the information on this plan is a true indication of the proposed development.

....

Date: ....

I, **Jeffrey Peck** ...., a Registered Mining Surveyor under the Surveying Act 2002, certify that to the best of my knowledge and belief this plan conforms to the accuracy standards required by the NSW Department of Primary Industries.

....

Date: ....

Drawing No.	Revision No.	Date	Scale:	Drawn	Sheet Size
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1 December 2011

Mr Michael Lloyd
A/Team Leader – Environment (Northern)
Department of Trade and Investment, Regional Infrastructure and Services
Division of Resources and Energy
PO Box 344
Hunter Regional Mail Centre NSW 2320

Dear Michael,

Bowmans Creek Diversion Construction Mining Operations Plan (MOP) – Additional Temporary Clean Water Diversion Structure

On 14 March 2011 the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) approved an amendment to the Ashton Coal Mine Mining Operation Plan for the construction of Bowmans Creek Diversion (Ashton Coal Mine Construction Mining Operation Plan Bowmans Creek Diversion). The Construction Mining Operations Plan (CMOP) sets out (inter alia) the construction activities for the creek diversions and the measures to be implemented to minimise the risk of environmental impact during construction. The purpose of this letter is to provide DTIRIS with a brief description of proposed additional temporary works required to enable construction of the diversions to commence.

Ashton is now preparing to commence construction of the creek diversions, having recently resolved residual subordinate approvals issues. I note that ACOL now holds an Aboriginal Heritage Impact Permit (AHIP) over the area of the Bowmans Creek Diversions, one of the conditions of the AHIP is that no construction is to be undertaken within 70m of the Waterhole Site Grinding Grooves. This new requirement has necessitated a minor alteration to the clean water diversions proposed to be utilised during the construction of the Eastern diversion and approved within the CMOP. The alteration requires the northern end of the Clean Water Diversion to be moved slightly to the west to avoid any construction within the 70m exclusion zone. As such attached is a replacement plan 4 and 5. This alteration has no practical impact on the implementation of the previously proposed water management strategies.

Further Ashton is still awaiting approval for an unrelated AHIP over an adjoining land area, which, until approved, restricts Ashton's ability to fully implement the intended clean water diversion strategy detailed in MOP Plan 4 and 5, for the eastern creek diversion channel. As such Ashton has designed an alternate clean water diversion structure to overcome this issue and to ensure an effective clean water diversion is still implemented for the construction of the eastern diversion. The design and location of this alternate clean water diversion structure is detailed on the attached plan and accompanying notes. It is planned that this clean water diversion would be used at the commencement of the diversion construction and if at such point in time the additional AHIP is received then the diversion as detailed in plan 4 and 5 may be implemented, however this would be reassessed at the time of receiving the AHIP.

Alternate Clean Water Diversion

Ref – Attached plan - Alternate Clean Water Management Strategy Bowmans Creek Eastern Diversion - A-5030A

The alternate clean water diversion will be implemented utilising a Clean Water bund and a small Earth Bank.

Clean Water Bund

The Clean Water Bund will be constructed on the eastern side of the Bowmans Creek diversion construction area. The bund will be established to ensure water coming from the eastern clean catchment is diverted to the north away from the Bowmans Creek construction area and into Bowmans Creek.

The bund will be constructed with minimal ground disturbance to ensure minimal disturbance to the clean water catchment. Any areas that are disturbed during construction will be seeded or otherwise stabilised immediately.

Due to the design of the Clean Water Bund there may be clean water stored behind it prior to overtopping to Bowmans Creek, to manage this during or following a rainfall event water may be pumped directly from this clean water catchment area to Bowmans Creek.

Installation

1. Bund to be located on site, using local materials and to the general dimensions shown in the typical section. The top of the embankment should be at least RL66.5m (as confirmed by survey) along its full length, and at least 500mm high at all points along its length.
2. Clear the location for the bank, clearing only the area that is needed to provide access for personnel and equipment
3. Remove roots, stumps and other debris and dispose of them properly. Do not use debris to build the bank.
4. Form the bank from the material, and compact.
5. Bank should be seeded or otherwise stabilised immediately

Maintenance

1. Inspect bank and upslope area at least weekly and after runoff-producing rainfall.
2. Obtain approval from Environmental Coordinator to pump any ponded clean water to Bowmans Creek, and undertake as directed.
3. Inspect the bank for any slumps, wheel track damage, or loss of freeboard and make repairs as necessary.
4. Check that fill material or sediment has not blocked the overflow area of the clean water storage area. Where necessary remove any deposited material to allow free overflow.
5. Dispose of any collected sediment of fill in a manner that will not create an erosion or pollution hazard.
6. Repair any places in the bank that are weakened or at risk of failure.

Removal

1. When the area downslope of the bank is finished and the area is stabilised, the bank should be removed.
2. Dispose of any sediment or earth in a manner that will not create an erosion or pollution hazard
3. Grade the area and smooth it out in preparation for stabilisation
4. Stabilised the area by grassing or as otherwise specified by the Environmental Coordinator.

Earth Bank

The earth bank is a minor diversion approximately 300mm high constructed to divert a minor clean water catchment at the southern end of the eastern diversion. As with the Clean Water Bund the Earth Bank will be constructed with minimal ground disturbance to ensure minimal disturbance to the clean water catchment. Any areas that are disturbed during construction will be seeded or otherwise stabilised immediately.

If you have any queries about this matter or require further information I can be contacted on 6570 9219 or via email at lrichards@ashtoncoal.com.au.

Yours faithfully

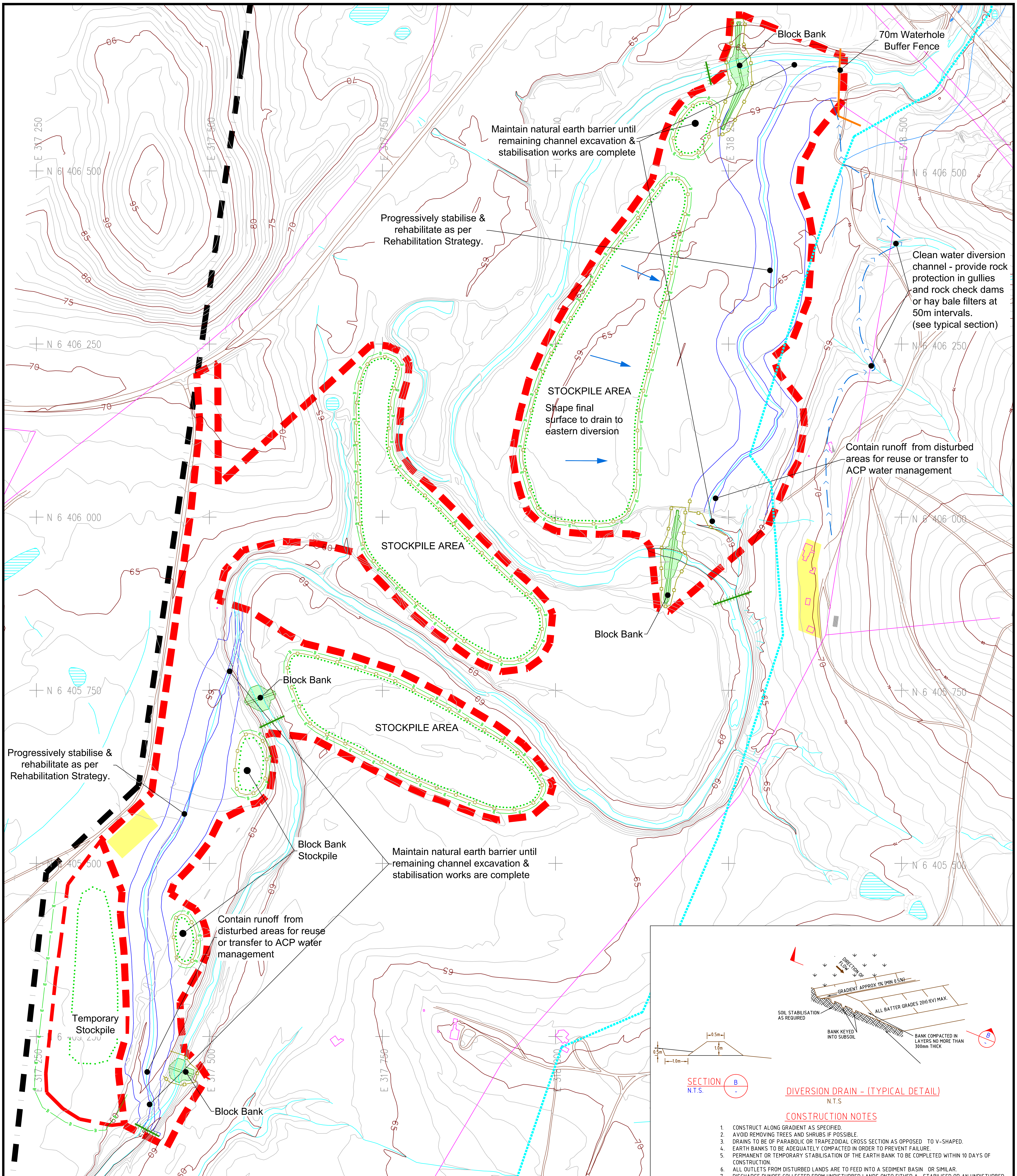
Lisa Richards

Environment Community Relations Manager
Ashton Coal Operation Pty Ltd

Attached:

Amended MOP Plan 4 & 5, A-5030

Alternate Clean Water Management Strategy Bowmans Creek Eastern Diversion, A-5030A



SECTION B - N.T.S.

DIVERSION DRAIN - (TYPICAL DETAIL)

N.T.S

CONSTRUCTION NOTES

1. CONSTRUCT ALONG GRADIENT AS SPECIFIED.
2. AVOID REMOVING TREES AND SHRUBS IF POSSIBLE.
3. DRAINS TO BE OF PARABOLIC OR TRAPEZOIDAL CROSS SECTION AS OPPOSED TO V-SHAPED.
4. EARTH BANKS TO BE ADEQUATELY COMPACTED IN ORDER TO PREVENT FAILURE.
5. PERMANENT OR TEMPORARY STABILISATION OF THE EARTH BANK TO BE COMPLETED WITHIN 10 DAYS OF CONSTRUCTION.
6. ALL OUTLETS FROM DISTURBED LANDS ARE TO FEED INTO A SEDIMENT BASIN OR SIMILAR.
7. DISCHARGE RUNOFF COLLECTED FROM UNDISTURBED LANDS ONTO EITHER A STABILISED OR AN UNDISTURBED DISPOSAL SITE WITHIN THE SAME SUB-CATCHMENT AREA FROM WHICH THE WATER ORIGINATED.
8. COMPACT WITH A SUITABLE IMPLEMENT IN SITUATIONS WHERE THEY ARE REQUIRED TO FUNCTION FOR MORE THAN FIVE DAYS.
9. EARTH BANKS TO BE FREE OF PROJECTIONS OR OTHER IRREGULARITIES THAT WILL IMPEDE NORMAL FLOW.

LEGEND

- Lease Boundary
- Creek Diversion Disturbance Boundary
- Existing Dam
- Power Lines
- Water Course
- Farm Infrastructure
- 1m Surface Contour
- Hunter River Pipeline
- Barrier Fence
- Sedimentation Control Fence
- Sedimentation Control - Hay Bale Barricade
- Clean Water Channel (temporary)
- Stockpile Bund
- Site Infrastructure

NOTES:
Stockpile & erosion controls to be managed in accordance with the Construction Mining Operations Plan.

N W E S

20 10 0 50 100 150 200
All measurements are in metres

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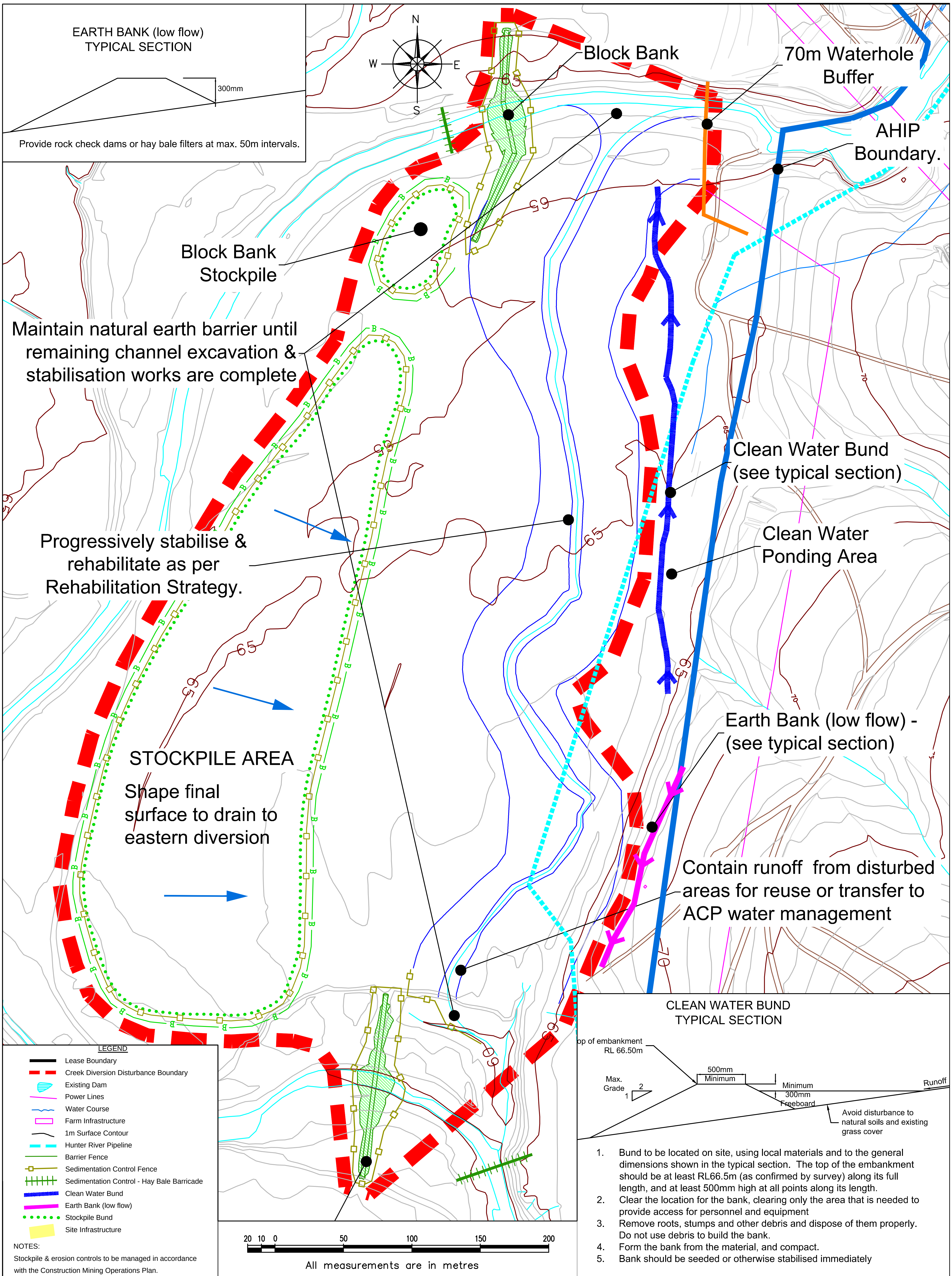
....

Date:..

Drawing No.	Revision No.	Date	Scale:	Drawn	Sheet Size
A-5030	3	29-11-11	1:2500	JIP	A1



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ASHTON UNDERGROUND COLLIERY

ALTERNATE CLEAN WATER MANAGEMENT STRATEGY

BOWMANS CREEK EASTERN DIVERSION

Drawing No.	Revision No.	Sheet Size
A–5030A	A	A3

Date	Scale:	Drawn	Checked	Approved
28/11/11	1:2500	AJ		