Bowmans Creek Diversion

Environmental Assessment

December 2009

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Statement of Validity

Environment Assessment prepared under Part 3A of the *Environmental Planning and Assessment Act 1979* and Regulations (NSW).	
This report has been prepared by:	Steve Perrens Principal Evans & Peck Pty Ltd Level 6, Tower 2 475 Victoria Avenue Chatswood NSW 2067
This report relates to:	Underground mining operations beneath Bowmans Creek alluvium, Bowmans Creek diversion and additional coal extraction by longwall mining.
Applicant's Name:	Ashton Coal Operations Limited.
Property Description:	Refer Appendix 2.
Declaration:	This Statement has been prepared in accordance with: • Part 3A of the Environmental Planning and Assessment Act 1979 and Regulations (NSW); and • The Director General's requirements dated 18 September 2009 in relation to this environmental assessment. This Statement contains all available information that is relevant to the environmental assessment of the development to which the Statement relates. To the best of my knowledge, the information contained in this report/documentation is not false or misleading.
Signed:	
Name:	Stephen Perrens
Date:	3 December 2009

Executive Summary

This Environmental Assessment report relates to an application by Ashton Coal Operations Limited (ACOL) for modification 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 NSW. The ACP, which comprises an open cut coal mine, an underground coal mine, a coal preparation plant and associated surface facilities, was granted development consent on 11 October 2002.

The ACP underground mine is a descending longwall operation targeting the Pikes Gully seam, Upper Liddell seam, Upper Lower Liddell seam and the Lower Barrett seam in an area that is bounded to the north by the New England Highway and to the south by the Hunter River. Other mines bordering on the ACP lease area include Ravensworth Underground mine to the west, Narama Open Cut to the west, Glendell Open Cut to the north and Integra Underground to the north–east. Underground mining at the ACP commenced in December 2005 and is expected that mining of the Lower Barrett seam will be completed by 2024.

Based on the information that was available at the time of the 2002 development consent, it was thought that direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurring through connective cracking would allow upward migration of saline groundwater following completion of mining and result in an increase in the salinity of the Hunter River. On this basis and other uncertainties Planning NSW approved longwall mining beneath Bowmans Creek and its associated alluvium provided no direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurred through connective cracking. The original proposal included a 2.4km long diversion of Bowmans Creek, which was removed from the approved project.

The current mine plan for the upper (Pikes Gully) seam, which has received subsidence management plan (SMP) approval, involves full longwall extraction in areas that lie outside the saturated zone of the Bowmans Creek alluvium and two 'miniwalls' that run under the alluvium and sections of the creek. (The term 'miniwalls' has been adopted to describe narrow longwall blocks designed to minimise subsidence and thereby satisfy the current development consent constraint in relation to direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking). Notwithstanding the SMP approval for the use of miniwalls in the Pikes Gully seam, miniwalls have the disadvantage of being inefficient in terms of resource extraction, having questionable economic viability and potential uncertainty in relation to the degree of subsidence that would occur as a result of their use in the lower seams.

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.

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 in **Figure S1** 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 in **Figure S1**). (Note that a proposed development consent modification of DA 309-11-2001 (MOD 4) to authorise the development and mining of an additional longwall panel in the Pikes Gully seam has previously been submitted to the DoP by ACOL.)

The project is a business critical project to ACOL that will ensure the job security of 195 personnel and the long-term sustainability of the mine and therefore its contribution to the local, state and federal economies.

Key Benefits of the Project

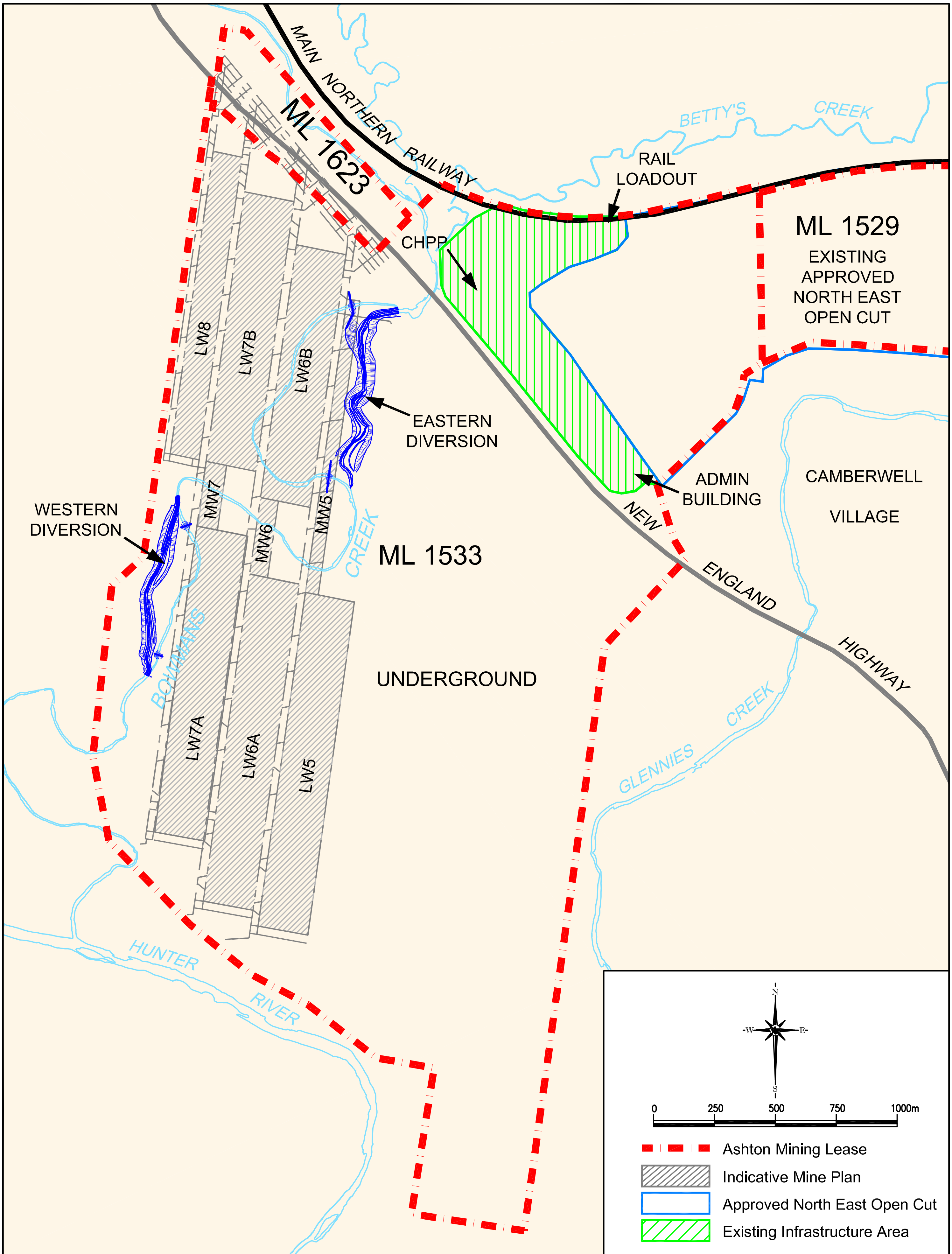
The revised underground mine plan (**Figure S1**), which is the subject of this proposal, contains the following key benefits:

- It permits the maintenance of a cost effective business, with sustainable capital and operating costs, and thereby provides security of employment for 195 direct employees and 35 construction positions as well as flow on effects to the regional economy;
- It provides access to an additional 5.3 million tonnes of run of mine (ROM) coal through significantly improved resource recovery, and reduced sterilisation, over the four targeted seams than would be possible under constraints imposed by the existing development consent;
- It provides approximately $80 million of additional revenue to the State and Federal Governments;
- It provides significantly improved flexibility to modify the mine plan within the mining footprint and certainty that mining of lower seams will be technically and economically feasible;
- In order to mitigate the effects of subsidence on the flow transmission capacity of Bowmans Creek, the project involves the diversion of two sections of Bowmans Creek (total 1.7km) that will mimic or enhance the hydraulic, geomorphic and habitat features of the existing channel including, pools and terraces within the stream bed, and large woody debris as a supplementary habitat feature;
- It will create diversions that can evolve in time to form ecologically diverse habitat in association with adjoining floodplain areas from which domestic stock will be excluded;
- It provides significant environmental benefits by way of enhanced riparian vegetation and a large area of existing creek and floodplain that will be excluded from degradation by domestic stock; and
- It reduces the salt load to Bowmans Creek and the Hunter River.

Background

The original underground mining proposal in the EIS (HLA, 2001) involved 250m wide longwall panels and a 2.4km diversion of Bowmans Creek around the northern and western sides of the proposed underground mine footprint. At the time of the original EIS, there were a number of concerns relating to the Bowmans Creek alluvial aquifer that influenced the approved project:

- The Bowmans Creek alluvium aquifer was considered worthy of preservation;
- Groundwater was considered to flow downwards from alluvium to underlying coal measures;
- Following underground mining, the groundwater levels in the coal measures were predicted to be higher than pre-mining, and higher than those in the alluvium; and
- In the event of direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking, saline groundwater would flow upwards from the coal measures and would contribute to the baseflow in Bowmans Creek. This would result in an increase in salinity in the Hunter River.



AshtonCoal

Bowmans Creek Diversion Project

Figure S1
Proposed Creek Diversions and Longwall Layout Assuming Stacked Arrangement

ACOL FILE: A-4058.dwg

In the light of these concerns, the DoP imposed conditions of consent that prevented mining that would allow direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking. Accordingly, the proposal to divert Bowmans Creek was removed from the project. The conditions of consent, that had a focus on ensuring the integrity of the Bowmans Creek alluvium, included the following requirements that are relevant to this report:

- No diversion of Bowmans Creek allowed (Condition 1.18);
- Underground mining operations were to be designed to ensure no direct hydraulic connection between the alluvium and the underground workings. The mine was to be designed to maintain sufficient sound rock to provide an aquiclude between the alluvium and the underground mine goaf (Condition 3.9);
- Underground operations were to be conducted so as to minimise impacts on the flow and quality of the alluvial groundwater resource (Condition 4.13).

New Understandings

With the benefit of additional monitoring of groundwater, subsidence and surface water since the commencement of the development of the ACP, several studies have been undertaken that have improved the understanding of the Bowmans Creek alluvium since the preparation of the original EIS. In particular, groundwater investigations have improved the understanding of the nature, extent and quality of Bowmans Creek alluvial aquifer and its degree of connection to Bowmans Creek. Monitoring of groundwater during the first five years of open cut mining and three years of underground mining has provided significantly better understanding and greater certainty in relation to potential impacts of longwall mining. The recent data and analysis shows that:

- The quality of water in the alluvial aquifer ranges from moderately to highly saline (up to 6,400 µS/cm EC). The alluvial groundwater is not a high quality resource and provides only limited environmental and economic value;
- Prior to mining there is a natural upwards seepage of saline groundwater from the coal measures to the alluvium;
- The alluvium has relatively low hydraulic conductivity and only makes a very small contribution to baseflow to Bowmans Creek;
- Contrary to the 2002 EIS prediction there will be a decrease in Hunter River salinity post mining; and
- The existing creek provides a range of aquatic and riparian ecosystem services but has been degraded as a consequence of past land use practices.

The Project

In addition to the improved understanding of groundwater and subsidence issues, the detailed features of this project are based on a range of physical, ecological and heritage issues that have been the subject of specialist studies which form appendices to the Environmental Assessment report. In particular, significant attention has been given to the development of designs for the diversion channels which will have similar hydraulic and geomorphic characteristics to the existing creek and provide opportunities for significant enhancement of the riparian and aquatic habitat.

Proposed Mine Plan

With the change in understanding of the groundwater and surface water systems and their response to mining, ACOL has developed an alternate underground mine plan that it considers would result in acceptable environmental impacts whilst providing resource optimisation together with business and employment security. The key features of the proposed plan (shown in **Figure S1**) are:

- Full longwall panel extraction (210m wide) of coal beneath parts of the excised sections of Bowmans Creek and the associated alluvium (particularly Longwalls 6 and 7 – abbreviated to LW6 and LW7) to maximise resource recovery in all four seams;
- Partial extraction of coal by means of miniwalls (MW5, MW6 and MW7) beneath short sections of Bowmans Creek in order to minimise the impacts on the functioning sections of the creek;
- Mining of an additional area of coal approximately 150m wide from the three lower seams on the western boundary of the mining lease (LW8);
- Diversion of two sections of Bowmans Creek (955m and 780m respectively) located in areas that will be subject to minimal subsidence;
- Except in areas of the old creek channel, progressive backfilling of subsidence troughs within the floodplain as required to create a free draining landscape; and
- Protection of the Hunter River and its connected alluvial aquifer, significant Aboriginal heritage sites, and significant surface infrastructure, including the New England Highway.

The final extraction design of each seam below the Pikes Gully seam would be subject to the results of subsidence monitoring from the preceding seam and would be detailed in a SMP consistent with the current SMP approval process.

Diversion of Bowmans Creek

The proposal involves the construction of two short diversions to mitigate the impact on flow in Bowmans Creek that would result from drainage of the alluvium following connective cracking caused by subsidence. Both diversions have been designed to be 'carbon copies' of the adjacent section of the existing creek in terms of variable channel cross section and variability in bed level. A key feature of the design is that a geosynthetic clay liner will be placed under the channel to minimise leakage from the creek and to preserve the transmission of flows in these section of channel.

- 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;
- 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; and
- Four block banks will be constructed to direct water into the diversion channels and to prevent backwater flooding of the excised section of the existing creek channel. These block banks will be constructed to approximately the same level as the adjacent floodplain which corresponds to about the level of a 5 year average recurrence interval (ARI) flood. Flows in excess of a 5 year ARI flood will overtop the block banks and flow across the floodplain and into the excised sections of the creek.

The landscape restoration is a key aspect of the proposal. It aims to establish plant communities that are characteristic of those that were present prior to European occupation. The objective is to create plant communities that establish rapidly, are species rich and have dense plant cover, so as to provide quick ground-holding characteristics sufficient to withstand flooding early within the plant establishment period and resistance to on-going weed colonisation. A staged rehabilitation program is proposed over a period of about eight years.

At the end of the engineering construction, 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 until they have been stabilised by vegetation. The risk of flood damage will be further mitigated by staged construction of the block banks. Initially, temporary low level banks (about 1m high) will be constructed 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. The temporary block banks will remain until just prior to mining of the Upper Liddell seam 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 immediately.

Detailed civil engineering designs have been prepared for the diversions and block banks, and these form part of the document set submitted for approval. Landscape masterplans and detail plans are also included in the document set for approval, a selection of which are provided at the end of this summary.

The assessment of noise, air quality and potential traffic impacts during construction indicates that there are no aspects of the project that cannot be adequately managed by normal construction management such as regulated working hours, use of water carts for dust suppression and road signs on the New England Highway warning of trucks leaving and entering.

Subsidence

This project recognises that longwall mining of all four seams will lead to extensive modification of the landform above the longwall panels and connective cracking that will partially drain the alluvial aquifer. The proposed measures to mitigate the consequences of these changes include:

- Construction of two diversion channels to maintain flows and fish passage between the section of Bowmans Creek between the Hunter River and the New England Highway bridge;
- Filling and drainage works to maintain a free draining landscape within areas of subsidence;
- Habitat replacement to more than offset the riparian and aquatic habitat that will be altered in the excised sections of the creek by the effects of subsidence and changed hydrologic regime; and
- Offsetting loss of baseflow from Bowmans Creek.

As part of the studies that support this application, SCT Operations Pty Ltd (SCT) has undertaken a detailed analysis, based on recent monitoring and research, in order to provide a high degree of certainty in the predictions of subsidence and the occurrence of connective cracking. The subsidence predictions are 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 1.6m following mining of the upper seam (Pikes Gully) to 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 includes an analysis of the effects of the miniwalls that are proposed to run under those sections of the existing creek that will remain functional.

The degree of subsidence and the impacts of connective cracking have been assessed and taken into account in developing the details of the proposed project, including the impacts on groundwater, the landscape, infrastructure and neighbouring mines. The predictions have also provided the basis for developing a range of mitigation measures which ACOL will implement to minimise or offset the impacts of subsidence that are described below.

The subsidence assessment indicates that there would be no impact on the Hunter River or the New England Highway. ACOL commits to avoiding, minimising or mitigating subsidence impacts on other surface infrastructure and neighbouring mines.

Groundwater

The groundwater assessment prepared for this EA takes into account the large quantity of monitoring data available (including 60 monitoring bores for calibration of the groundwater model compared to three at the time of the EIS). The improved availability of data, together with the data on the effects of mining Longwalls 1 to 3, has provided a significantly greater understanding of the hydrogeological system and this, together with improved modelling capability since the original EIS, provides a high degree of certainty in the predicted impacts of the proposed mine layout.

Groundwater modelling, based on a significant quantity of additional data obtained since the original EIS, has been used to assess the effect of connective cracking on the alluvial groundwater system and the consequential impact on baseflow to Bowmans Creek. This analysis has provided the basis for the development of the mitigation and offset measures that form an important part of this proposal, particularly the proposed inclusion of an impermeable seal under the base of the diverted sections of Bowmans Creek.

The detailed groundwater model has been set up and calibrated against observed groundwater levels and observed changes in the groundwater as a result of mining the first three longwalls in the upper coal seam at Ashton. The model covers an area sufficient to take account of the impacts of the surrounding open cut and underground mines and to undertake an analysis of the impacts with the proposed mining described in this EA as well as without any underground mining at Ashton. The modelling has included detailed analysis and an evaluation of the uncertainty and assumptions.

The groundwater modelling results show that the impacts of the proposed four-seam mine on the Bowmans Creek alluvium do not extend beyond the New England Highway or to the Hunter River. This section of Bowmans Creek alluvium is predicted to be largely de-watered by the end of mining except for a zone extending about 1km north of the confluence with the Hunter River. In this zone near the Hunter River which will not be de-watered, the maximum draw downs in the Bowmans Creek alluvial aquifer would vary from around 0.5m to 2m. Importantly though, drawdowns of less than 0.5m are predicted in the area where two stands of River Red Gum have been recorded in Bowmans Creek immediately upstream of the Hunter River confluence. This small amount of drawdown is not expected to have any impact on the River Red Gums.

During the post mining period, the groundwater within the mine workings and subsided overburden will be highly connected and will reach a dynamic equilibrium The modelling shows that changes in the post mining hydrogeological regime within the Permian strata will not significantly affect the Bowmans Creek alluvium and residual drawdowns in the majority of the alluvium will generally be small (<1m). However, small sections of the Bowmans Creek alluvium, generally those areas around the perimeter of subsidence zones, will remain dewatered.

The groundwater modelling indicates that prior to any mining, Bowmans Creek between the New England Highway bridge and the Hunter River gained about 10 ML/year (0.03 ML/day) from its alluvial aquifer. As a result of mining undertaken to date at adjoining mines as well as the ACP, the baseflow gain to Bowmans Creek is estimated to have reduced to about 8.5 ML/year in 2009. The modelling indicates that by the end of mining in about 2024, this section of the creek will lose about 39 ML/year but that, as alluvial groundwater levels recover following completion of mining, the loss will reduce progressively and reach a 'steady state' of approximately 11 ML/year 60 years after the end of mining. (It should be noted that the predicted loss of baseflow from this reach of Bowmans Creek would occur as a result of impacts from surrounding mines, even if no underground mining had occurred at Ashton).

In addition to minimising the potential for loss of water from the creek by providing an impermeable layer under the bed of the diverted sections of channel, ACOL commits to offset the remaining loss of baseflow as follows:

- ACOL will offset, under existing Water Access Licences, 47.5 ML per annum to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek for the duration of underground mining. (The figure of 47.5 ML/year comprises the difference between the current gain of 8.5 ML/year and the loss of 39 ML/year at the end of mining); and
- At the conclusion of mining in the ACP underground operations, ACOL will permanently surrender existing Water Access Licences with a share component of 20 ML to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek. (The figure of 20 ML/year is based on the difference between the current gain of 8.5 ML/year and the loss of 11 ML/year after recovery of groundwater levels in the Bowmans Creek alluvium, a net loss from current conditions of 19.5 ML/year, which has been rounded up to 20 ML/year).

As noted above, the additional monitoring since the preparation of the original EIS has led to a number of fundamental changes in the understanding of the hydrogeology of the alluvial aquifer and its interaction with Bowmans Creek. It is now understood that prior to mining the Bowmans Creek alluvial aquifer contributed about 10 ML/year to the reach of Bowmans Creek between the New England Highway bridge and the Hunter River. The current contribution of baseflow from this section of the alluvial aquifer also contributes an estimated 36 t/year of salt to Bowmans Creek and the Hunter River. A positive impact of the proposed modification will be the removal of this salt load.

Hydrology and Geomorphology

The design of the two proposed diversion channels has been based on detailed analysis of the hydrology and geomorphology of Bowmans Creek. In order to ensure the diverted sections of Bowmans Creek behave in a similar hydraulic and geomorphic manner to the existing sections that they would replace, the two diversion channels have been designed to be (as close a possible) 'carbon copies' of the sections of the existing channels that they would replace. Provision of near identical morphology and sediment transport processes will also mean minimal change to the availability of hydraulic habitat for biota and provision for fish passage.

The channel design incorporates elements that will reduce the risk of excessive geomorphic instability. These include a rock grade control structure near the downstream end of the Eastern Diversion, rock bars to stabilise the locations of riffles and prevent upstream migrating incision, rock beaching on the outside of meander bends, soft treatments (such as erosion control matting) on bare surfaces to provide temporary stability until vegetation becomes fully established, and a thicker channel bed layer where local scour holes are expected to form in the vicinity of large woody debris structures.

The geomorphic assessment indicates that, because Bowmans Creek is an incised channel, the creek would be highly unlikely to adopt an alternative alignment to that of the proposed diversion channels in the foreseeable future. While the channel will continue to move within the defined macro-channel corridor, and the side slopes of that macro-channel may occasionally erode as the channel widens its corridor, the chance of an avulsion under high flood conditions is remote.

The specialist studies undertaken to support this EA include detailed assessments of the hydrologic and geomorphic characteristics of Bowmans Creek which build upon studies undertaken at the time of the EIS and subsequent monitoring, including detailed cross section surveys at 51 locations along Bowmans Creek undertaken in 2006 and in 2008 following a significant flood (approximately a 35 year ARI flood) that occurred in June 2007.

A two dimensional hydrodynamic model has been used to examine the flow pattern in Bowmans Creek and its floodplain between the New England Highway bridge and the Hunter River. Two dimensional modelling was adopted in order to account for the complex pattern of flow that occurs once the creek breaks its banks and to allow and analysis of the effect of the proposed diversion channels on flow distribution. The model was used to assess a range of different channel shapes and layouts, and to develop the proposed channel designs that mimic the conveyance and geomorphic characteristics of the existing channel. Subsequently the model was used to assess the flood conditions for a range of floods both with and without the proposed diversion channels.

Flooding from the Hunter River can affect a large part of the floodplain between the New England Highway bridge and the Hunter river. However, historic data shows that the peak level in the Hunter River typically occurs about a day after the peak flood in Bowmans Creek. While the peak flood in Bowmans Creek can be expected to precede the peak in the Hunter River, a flood in Bowmans Creek would typically occur while the Hunter River was rising. For purposes of assessment of the effect of any changes in flow regime on Bowmans Creek resulting from the proposed diversions, the assessment of flow conditions has primarily focused on Bowmans Creek flow regimes when the Hunter River is low. This analysis therefore represents a 'worst case' in terms of potential changes in the flood regime.

The flood modelling indicates that the construction of the diversions and the subsidence of the landscape will not have a significant impact on flood conditions at the New England Highway bridge and will lead to a reduction in peak flow to the Hunter River because of the increased floodplain storage volume in the subsided landscape.

The geomorphic assessment of Bowmans Creek has drawn on a number of previous studies undertaken to monitor conditions in the creek as well as field investigations of the geomorphic characteristics and analysis of bed material size undertaken for this project. The data from these sources has been used as inputs to a numerical analysis of bed and bank stability in the existing creek and the proposed diversion channels.

Aboriginal Heritage

An Aboriginal heritage assessment process was undertaken inclusive of consultation in accordance with the DECCW guidelines and involved consultation with the Aboriginal community (individuals and groups). A total of 26 groups/individuals registered an interest in the Bowmans Creek diversion project, all of whom were provided with a draft copy of the Aboriginal archaeological assessment report, prepared by Insite Heritage.

The project will impact upon a small portion of the potential archaeological deposits within parts of the Bowmans Creek floodplain which has been assessed to have the potential for deposits buried by recent alluvial flood deposits. Any archaeological deposits within the terraces are likely to have been reworked by flood events and channel migration. Geomorphological assessment has shown that the terraces are Holocene in age and there is no potential for Pleistocene deposits within the proposed work area.

The potential archaeological deposits within the alluvial terraces of Bowmans Creek within the study area are considered to be of moderate scientific significance. All sites within the Bowmans Creek area are of cultural significance to the Aboriginal community. The Waterhole Site (37-4-0500), located north of the proposed Eastern Diversion, will not be impacted by this proposal. This site is rated as high significance, a rating reinforced by Aboriginal stakeholders in the course of consultation.

In order to protect sites of known Aboriginal heritage, all construction workers will be given a site induction involving cultural awareness and procedures to be followed in the event that an artefact or site is discovered. All local sites of significance will be clearly identified as 'no go' areas.

Riparian and Aquatic Ecology

The construction of two diversion channels represents an opportunity to provide overall better ecological function than the existing creek by addressing some of the factors that currently lead to deterioration of Bowmans Creek. The proposed diversion channels have been designed to provide sufficient aquatic habitat to offset that lost in the excised sections of creek. This is achieved by incorporating a number of off-line channel sections that will provide valuable and connected aquatic habitat, fish refuge and fish passage resting ponds, particularly during moderate flow events.

The design provides a comparable area of available riparian habitat of higher quality than the existing creek. Overall riparian habitat improvement will also be achieved by exclusion of stock from the riparian zone and active management of stock in buffer zones (including provision of on-demand stock watering points away from the protected riparian zones).

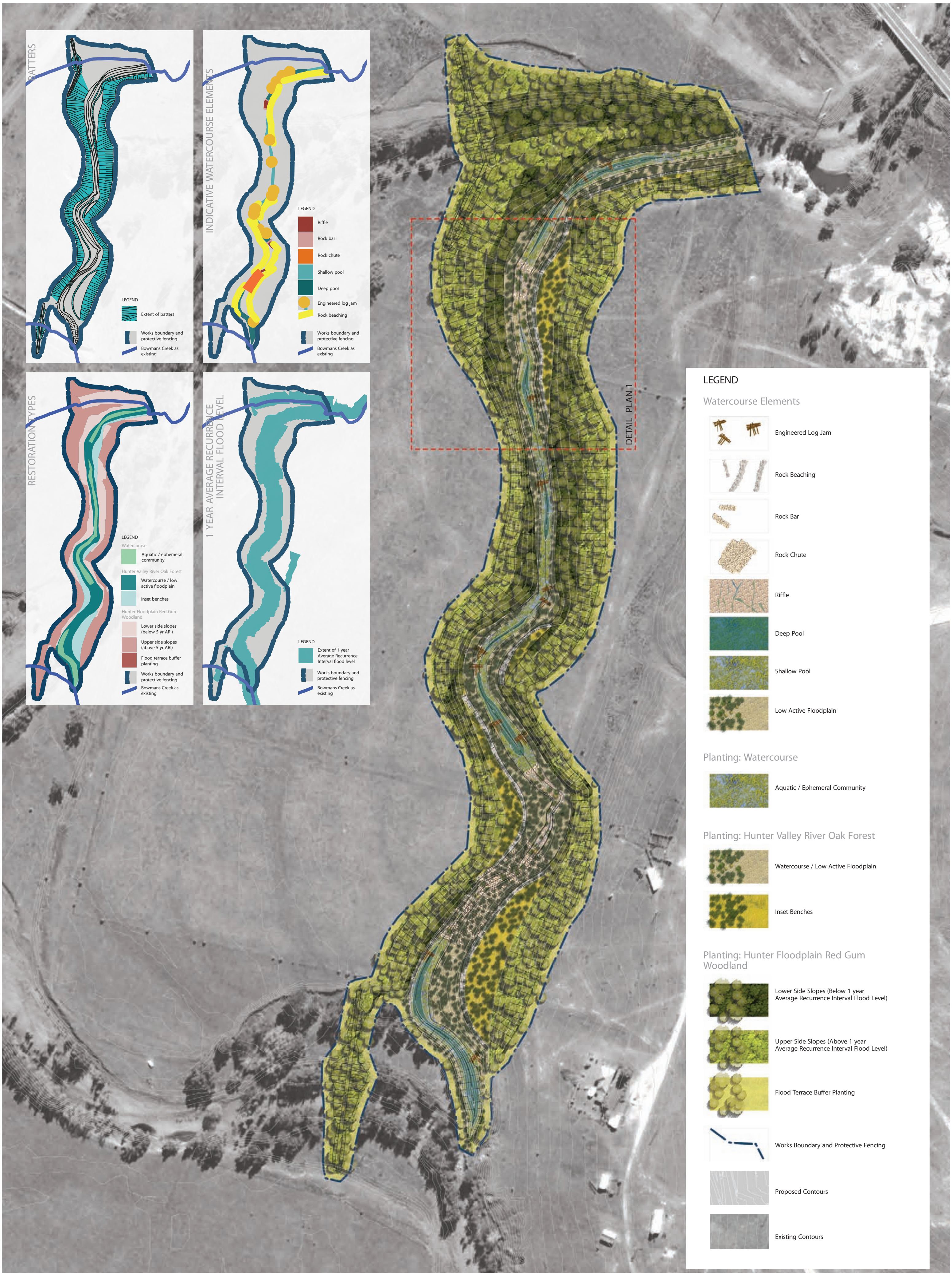
The proposed diversion and associated stockpiling will alienate 28.7ha of pasture grassland and up to 1.8ha of degraded riparian woodland. The 13.9ha of pasture grassland lost to the diversion channels will be offset by the provision of 13.9ha of aquatic and riparian woodland habitat to incorporate River Red Gum habitat as detailed in the landscape plans. The remaining 14.8ha of pasture grassland temporarily alienated for stockpiles will be progressively managed towards grassy floodplain woodland habitat and will be managed under the existing ACP *Flora and Fauna Management Plan*. Overall fauna habitat requirements, and particularly habitat requirements for the listed woodland birds and bats known from the locality, will be protected and enhanced.

The ecological assessments undertaken for this project have drawn on a significant number of past studies and routine ecological monitoring undertaken twice per year. The section of Bowmans Creek between the New England Highway and the Hunter River provides a range of important ecological functions including fish passage, off-line fish refuge habitat during Hunter River floods, fish nesting habitat (gravel bars in pools), drought refuge habitat in deeper pools, a complex of aquatic ecological habitats and riparian vegetation corridors. Whilst this section of Bowmans Creek provides these important functions, the section is not pristine and some of these functions are compromised by past practices (e.g., engineered bank protection), agricultural practices (clearing of riparian and floodplain vegetation, bank erosion and water quality deterioration exacerbated by loss of riparian vegetation and by stock damage) and introduction of exotic species (riparian species such as willows, pasture grasses and weeds plus aquatic pest species; carp and plague minnow). Fish passage is available intermittently owing to the combined variability of flow, the shallow nature of parts of the creek that dry out or where surface water flow is often through cobbles thus isolating pools. Water quality is also affected by the natural occurrence of saline seepage from outcrops of Permian rock which is particularly apparent in the pool immediately below the New England Highway.

Impacts and Mitigation Measures

The potential impacts and the proposed mitigation measures are summarised in the table below.

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.
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 37.5 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.
Groundwater	Drainage of 250 ML of alluvial groundwater	Account for water extracted from the underground workings under bore licences
Aboriginal Heritage	Disturbance of archaeological sites of low significance and disturbance of potential archaeological deposits.	Disturbance to sites will be managed by means of a management plan developed in consultation with Aboriginal stakeholders and the DECCW.
Coal Resource	Beneficial gain of 5.3Mt of ROM coal.	
Employment	Employment security and longevity	Positive



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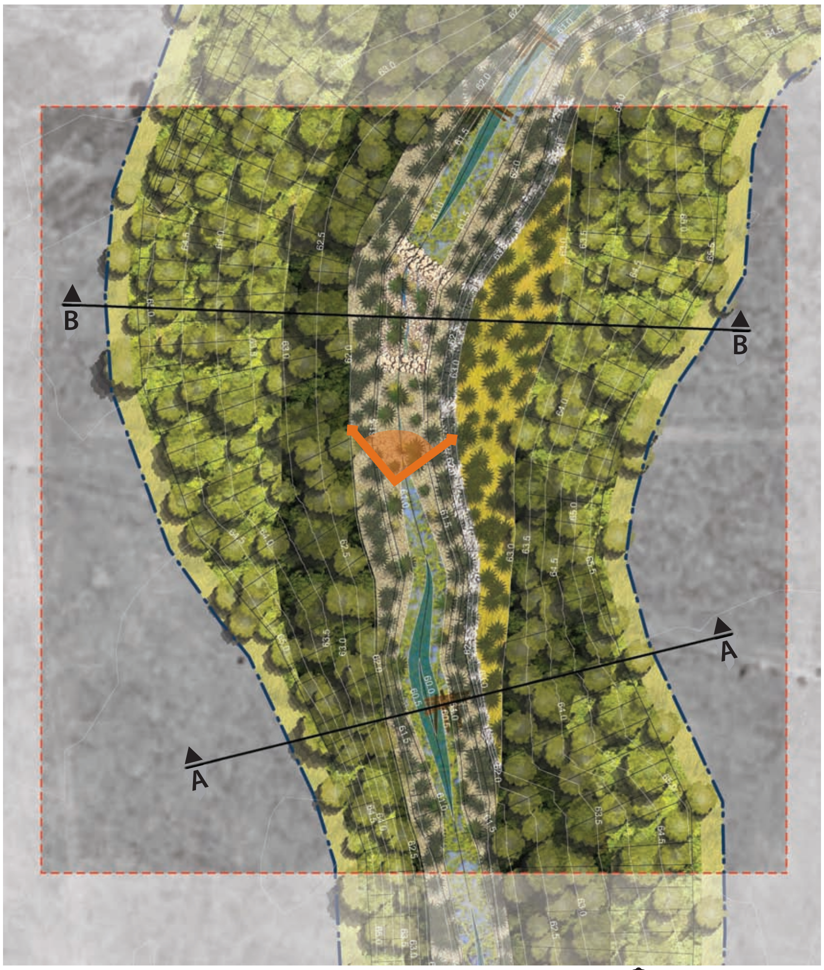
DRAWING NUMBER SK01
12 OCTOBER 2009

Bowmans Creek Diversion
Masterplan - Eastern Diversion



Detail Plan 1

Scale1:500@B1

Perspective View Looking Upstream

DETAIL LEGEND

Watercourse Elements

- Engineered Log Jam
- Rock Beaching
- Rock Bar
- Riffle
- Deep Pool
- Shallow Pool
- Low Active Floodplain
- Works Boundary and Protective Fencing
- Perspective Point for Perspective View

Planting: Watercourse

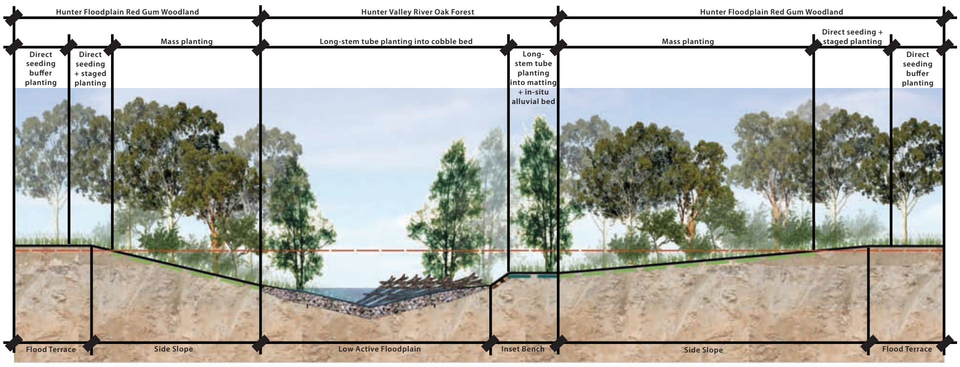
- Aquatic / Ephemeral Community

Planting: Hunter Valley River Oak Forest

- Watercourse / Low Active Floodplain
- Inset Benches

Planting: Hunter Floodplain Red Gum Woodland

- Lower Side Slopes (Below 1 year Average Recurrence Interval Flood Level)
- Upper Side Slopes (Above 1 year Average Recurrence Interval Flood Level)
- Flood Terrace Buffer Planting
- Proposed Contours
- Existing Contours



Section A-A

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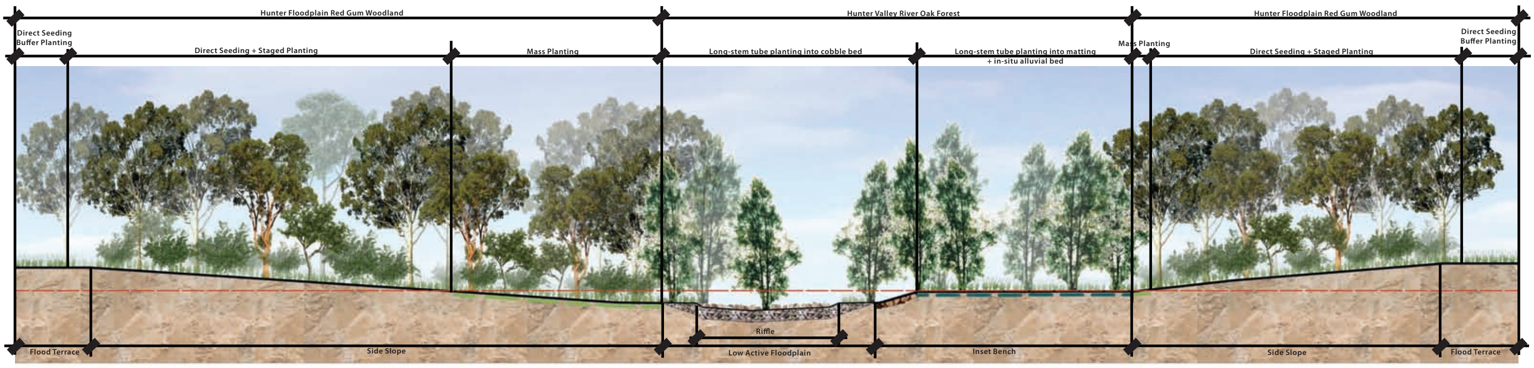
SECTION LEGEND

- Cobble Bed over Geosynthetic Clay Liner
- Rock Beaching
- Medium Duty Matting
- Heavy Duty Matting
- Engineered Log Jam
- 1 Year Average Recurrence Interval Flood Level



Section B-B

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09503243

DRAWING NUMBER SK02

12 OCTOBER 2009

Bowmans Creek Diversion

Detail Area / Sections - Eastern Diversion

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1 INTRODUCTION

Ashton Coal Operations Limited (ACOL) commissioned Evans & Peck to prepare an Environmental Assessment (EA) report under Section 75W of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the 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. The location of the project is shown on **Figure 1.1**.

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 in **Figure S1** 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 in **Figure S1**).

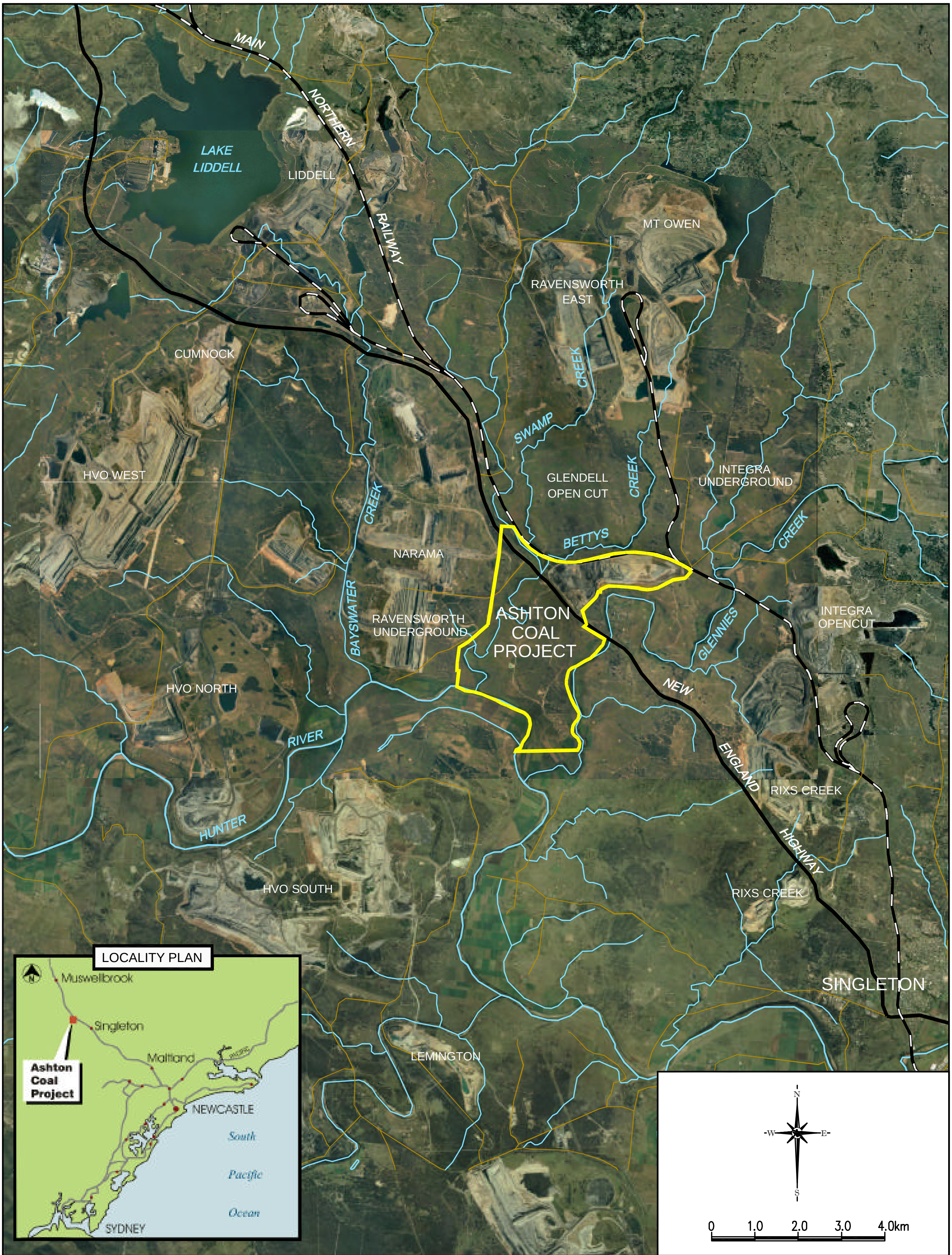
This modification is sought to provide for efficient resource recovery of coal reserves within the ACP area. It seeks to achieve this by diverting sections of Bowmans Creek to mitigate the effect of longwall mining beneath Bowmans Creek alluvium particularly from the lower seams. The greater certainty of resource recovery particularly from the lower seams will be reflected in the economic viability of the underground operation and certainty of employment for the existing work force. The environmental justification for the proposal, which involves diversion of two sections of Bowmans Creek, is based on significantly improved understanding of the nature and characteristics of the Bowmans Creek alluvium that has been gained as a result of extensive monitoring and further investigations since the original EIS. Based on these investigations ACOL considers that the potential environmental impacts from the longwall mining will be environmentally acceptable and the company proposes to make significant investment in measures to mitigate and offset any impacts.

1.1 Project Overview

The ACP was granted development consent under Part 4 of the EP&A Act 1979 by the Minister for Planning on 11 October 2002. The ACP comprises an open cut coal mine, a four seam underground coal mine, coal preparation plant and associated surface facilities.

The ACP underground mine is located south of the New England Highway and is bounded by Glennies Creek to the east, Bowmans Creek to the west and the Hunter River to the south. The underground mine is a descending longwall operation targeting the Pikes Gully, Upper Liddell, Upper Lower Liddell and the Lower Barrett seams. The mine is anticipated to have an operational life of approximately 18 years, with mining of the Lower Barrett seam expected to be completed by 2024.

In the intervening years ACOL has undertaken extensive monitoring and has assessed a range of options for mining in a manner since 2002 that would satisfy the original conditions of approval. The assessment of mining options indicated that options that strictly complied with the conditions of consent were inefficient, in terms of resource recovery by means of narrow long walls, and carried significant uncertainty that lower seams could be mined within the requirements relating to avoidance of direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurring through connective cracking. At the same time, investigations of the alluvial and hard rock aquifers indicated that the characteristics of the Bowmans Creek alluvium, which formed the basis for the Conditions of Consent, are fundamentally different from those that had been understood at the time of the original EIS.



AshtonCoal

Bowmans Creek Diversion Project

Figure 1.1
Location of Ashton Coal Project

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.

Additionally, within the original development application an area of coal was left unmined within the ACOL mining lease (ML) area to allow the passage of the original proposed creek diversion. To allow complete extraction of the coal resource within the ML area, approval is sought within this modification to enable this coal in the western section of the lease to be mined.

On 19 August 2009 application was made to the NSW Department of Planning (DoP) to modify the Development Consent DA 309-11-2001-i. The application was made pursuant to Section 75W of the EP&A Act 1979 and is referred to as DA 309-11-2001-i_MOD6. On 18 September 2009 Environmental Assessment Requirements were issued by the DoP for the project. This Environmental Assessment Report (EA) addresses these requirements. **Appendix 1** contains a copy of the requirements while **Section 1.4** summarises the requirements and identifies the section within this EA report that addresses each aspect of the requirements.

1.2 Project Need

The ACP development consent significantly restricts mining due to the limitations places on mining by the consent. The two key restrictions to mining are:

- ACOL cannot construct any diversion of Bowmans Creek (Condition 1.18); and
- Mining must ensure that no direct hydraulic connection between the Bowmans Creek alluvium and the underground workings can occur through subsidence cracking; and must provide an aquiclude of sound rock between the Bowmans Creek alluvium and the underground mine goaf. (Condition 3.9).

Figure 2.1 shows the current mine plan for the Pikes Gully seam that complies with the development consent conditions. This plan, referred to as the "Longwall/Miniwall (LW/MW) 5-8 Mine Plan", has been approved under the subsidence management plan (SMP) process for mining in the Pikes Gully seam. 'Miniwalls' – a term describing narrow longwall blocks, have been designed to minimise subsidence and enable compliance to Condition 3.9 with respect to provision of the sound rock aquiclude. (For the sake of completeness, **Figure 2.1** also shows the location of the proposed longwall/miniwall 9 (LW/MW9) which is the subject of a separate application for mining, in the Pikes Gully seam only in the western most part of the mining lease).

The proposed modification of the Ashton development consent for the Bowmans Creek diversion project is to enable continued economic operation of existing underground operations, provide security of existing direct and indirect employment and continued production of export quality coal to meet market demand and provide local economic and international energy benefits. Key elements include:

- It provides security of employment for 195 direct employees and 35 construction positions as well as flow on effects to the regional economy;
- Should the ability to economically mine the Bowmans Creek area be lost there would be a significant impact on the business and potentially lead to the early closure of the operation;
- Improved efficiency of resource recovery over the four targeted seams;
- Increased resource recovery totally an additional 5.3 million tonne (Mt) of run of mine (ROM) coal, comprising 2.7Mt from the modified mine plan under Bowmans Creel alluvium area and 2.6Mt from the additional longwall block in all four seams in the western extension area;

- It provides an additional $27 million direct contribution to the State Government and $52 million to the Federal Government;
- To satisfy the current conditions of consent, (no direct hydraulic connection) miniwall mining has been approved under Bowmans Creek and its alluvium for the uppermost Pikes Gully seam. It has not yet been proven that miniwall mining will achieve no direct hydraulic connection in respect to mining all of the lower seams. If only one or two seams are able to be extracted by miniwall methods under the alluvium, then there will be a loss in resource recovery (3.8Mt ROM coal per seam), revenue/royalty and mine viability;
- Removal of 11,000 metres of roadway development per seam resulting in a total cost reduction of $66 million total for all four seams; and
- Budget forecasts indicate a $13.00 cost differential for miniwall versus longwall methods for every tonne of coal sold from the Bowmans Creek mining area. These additional costs during a period of contracting coal prices, may lead to a questionable viability of the underground operation in this area.

1.3 Project Objectives

The principal objectives of this project are to:

- Minimise adverse social, environmental and amenity impacts;
- Maximise the recovery of the mineable resources within the area;
- Maintain a cost effective business, with sustainable capital and operating costs;
- Maintain security of employment for the mine employees;
- Create stable diversion channels with large main channel and smaller low flow channels, pools and terraces within the stream bed;
- Create diversion channels that can evolve in time to form ecologically diverse habitat; and
- Maintain flexibility to modify the mine plan within the mining footprint.

1.4 Director General's Requirements

On 18 September 2009 the Director General issued requirements (DGRs) for the preparation of an Environmental Assessment (EA) for this project. A copy of the DGRs is provided in **Appendix 1** while **Table 1.1** provides a summary and identifies the location within this EA in which each issue is addressed.

Table 1.1: Director General's Requirements

Aspect	Where Addressed in this EA Report
General Requirements	
• An executive summary.	Preceding the Table of Contents
• A detailed description of:	
– existing and approved mining operations in the vicinity of the site.	Sections 2.2 and 2.3
– historical mining operations on the site.	Section 2.2
– existing and approved mining operations and infrastructure on the site including a copy of all relevant statutory approvals.	Section 2.2 and Appendix 3
– any existing and/or approved biodiversity and heritage offset areas relating to these operations.	Table 2.1
– the existing environmental management regimes for these operations.	Section 2.2.2
• A detailed description of the proposal, including the:	
– need for the proposal;	Section 1.2
– alternatives considered, including justification for the proposed mine plan;	Table 14.1
– likely staging of the proposal;	Section 2.4.3
– likely interactions between the proposal and existing and approved mining operations;	Sections 2.3 and 2.5
– proposed life of the proposal.	Section 2.4.2
• A risk assessment of the potential environmental impacts of the proposal, identifying the key issues for further assessment.	Section 5
• A detailed assessment of the key issues specified below, and any other significant issues identified in the risk assessment (see above), which includes:	
– a description of the existing environment, using sufficient baseline data.	Sections 7.2, 7.3, 8.2, 9.2, 10.2, 11.3 and 11.4
– an assessment of the potential impacts of all stages of the proposal on this environment, including any cumulative impacts, taking into consideration any relevant laws, policies, guidelines and plans.	Sections 6.4,7.4, 8.3, 9.4, 10.4, 11.5, 12.5, 12.6.4, 12.7.2 and 12.8.3
– a description of the measures that would be implemented to avoid, minimise, and if necessary offset the potential impacts of the proposal.	Sections 6.5, 7.5, 9.5, 8.4, 10.4, 11.6, 12.4, 12.5, 12.6.1, 12.7.3, 12.8.5 and 12.9
• A statement of commitments, outlining the proposed environmental management and monitoring measures.	Section 13
• A conclusion justifying the proposal, taking into consideration: the suitability of the site; the economic, social	Section 14

Aspect	Where Addressed in this EA Report
and environmental impacts of the proposal as a whole, and whether the proposal is consistent with the objects of the Environmental Planning & Assessment Act 1979.	
• A signed statement from the author of the Environmental Assessment, certifying that the information contained within the document is neither false nor misleading.	Preceding the Executive Summary
Key Issues	
Subsidence including:	
• accurate predictions of the potential subsidence effects and	Section 6 and Appendix 4
• an assessment of the potential impacts of these subsidence effects on the natural and built environment, with particular reference to Bowmans Creek and the associated riparian environment.	Sections 6.4, 7.4, 8.3, 9.5, 10.4 and 11.5
Soil and Water including:	
• a detailed assessment of the potential impacts of the proposal, using appropriate quantitative modelling on:	
– the quantity and quality of both surface and ground water resources, with particular reference to alluvial groundwater;	Sections 7.4, 8.3 and Appendices 6 and 7
– water users, both in the vicinity of and downstream of the project;	Sections 7.4.6, 7.4.7 and 8.3.5
– the riparian and ecological values of the watercourses both on site and downstream of the proposal;	Sections 9.3, 10
– environmental flows; and	Section 8.3.2
– flooding;	Section 8.3
• a comparison of these impact predictions against those associated with the existing mine plan, including detailed explanations for any differences;	Section 7.4 and 8.3.3
• plans for the proposed realignments of Bowmans Creek, including:	
– detailed design and completion criteria;	Appendix 10. Plan Sets 2 and 3
– timeframes;	Section 2.4.3, 2.7 and 2.8
– a detailed assessment of the environmental, hydrogeological, hydrological and geomorphic considerations of the final alignment;	Sections 7.4, 8.2, 8.3, 9.3 and 9.4 Appendices 5, 6, 7, 9, 10
• a revised site water balance for the Ashton Coal Project;	Section 8.3.3
• **Biodiversity** including:	
– accurate predictions of any proposed vegetation clearing; and	Section 10.4
– a detailed assessment of the potential impacts of the proposal on any terrestrial and aquatic threatened species, populations, ecological communities or their habitats;	Section 10.5
• **Aboriginal Heritage**;	Section 11

Aspect	Where Addressed in this EA Report
• **Air Quality & Noise**; and	Sections 12.6 and 12.7
• **Rehabilitation** including	
– details for the long-term management of additional reject and tailings material;	Sections 2.5 and 12.5
Consultation	
During the preparation of the Environmental Assessment, you should consult with the relevant local, State or Commonwealth Government authorities, service providers, community groups or affected landowners. In particular you must consult with the: • Department of Environment, Climate Change and Water, including its Office of Water; • Department of Industry and Investment; • Roads and Traffic Authority; and • Singleton Shire Council. The consultation process, and the issues raised during this process, must be described in the Environmental Assessment.	Section 4

1.5 The Applicant

The proponent for the project is ACOL, a wholly owned subsidiary of Felix Resources Limited (FRL), a publicly listed company on the Australian Stock Exchange and the operator of the ACP. The ACP is owned by the Ashton Joint Venture which currently comprises the following participants:

- Felix Resources Limited (60%);
- International Marine Corporation Group (30%);
- ICRA Ashton (10%).

FRL is an Australian resources company developing, operating and investing in resource-related projects with a primary focus on coal. FRL's key assets are the ACP and Moolarben coal mining project in New South Wales and the Yarrabee and Minerva coal mines and Athena and Harrybrandt exploration projects in Queensland. The Ultra-Clean Coal (UCC) technology and associated patents are also owned by FRL.

FRL has grown strongly since 2003 through expansion, new developments and acquisitions, based on coal sales from its existing and proposed mining operations, whilst being conscious of its environmental responsibilities. FRL contributes to the Coal 21 Fund, a voluntary fund established by the coal industry to invest in various clean coal demonstrations.

1.6 Project Team

This EA report was prepared with the management and assistance of ACOL by Evans & Peck and the specialist consultants listed in **Table 1.2**.

The key ACOL personnel who assisted with the project include:

- Peter Barton – Ashton Coal Mine - General Manager;
- Brian Wesley – Ashton Coal Mine – Underground Mine Manager;
- Phil Fletcher – Ashton Coal Mine - Approvals Planning Manager; and
- Lisa Richards – Ashton Coal Mine - Environment and Community Relations Manager.

Table 1.2: Specialist Consultants Involved in the Preparation of the Environmental Assessment Report

Project Role	Consultant
Project management, Environmental Assessment report co-ordination, assessment of impacts and safeguards.	Evans & Peck
Review and input to Environmental Assessment report	Wells Environmental Services
Drafting and plan preparation.	Pegasus Technical
Subsidence assessment	SCT Operations Pty Ltd.
Groundwater assessment.	Aquaterra Pty Ltd.
Civil engineering design	Hyder Consulting
Fluvial geomorphology and flood hydrology	Fluvial Systems
Flooding and hydraulic assessment	Hyder Consulting
Landscape restoration	EDAW
Archaeology	Insite Heritage.
Noise impact assessment	Spectrum Acoustics Pty Ltd.
Air quality assessment	PAEHolmes Air Sciences
Ecological impact assessment	Marine Pollution Research.
Water balance assessment	WorleyParsons

1.7 Report Structure

This Environmental Assessment report comprises three volumes which are structured as follows:

Volume 1 – Environmental Assessment Report

This volume is structured so as to provide the reader with an understanding of the existing ACP operations and the background to this project (**Sections 2-5**) before describing the various detailed studies (**Sections 6-11**) that have been undertaken to provide the technical basis for this project. These sections provide the reader with the necessary information to understand the range of technical issues that have been taken into account in the design of the proposed diversion channels and the methods of construction and rehabilitation described in **Section 12**. Finally, **Section 13** consolidates the various commitments for the monitoring, management and mitigation actions in relation to the project and **Section 14** provides a justification for the project in terms of the project need and alternatives together with an analysis of the project against the objects of the Environmental Planning and Assessment Act, 1979.

Volume 2 - Appendices

The volume of appendices contains supporting material including the specialist technical studies listed below:

No	Title	No	Title
1	Department of Planning Director General's Requirements	8	Water Balance Modelling
2	Property Title Information	9	Terrestrial and Aquatic Ecology Assessment
3	Conditions of Consent and Environment Protection Licence	10	Landscape Restoration Report
4	Subsidence Assessment	11	Aboriginal Archaeological Assessment
5	Groundwater Impact Assessment	12	Air Quality Assessment
6	Flood Study	13	Noise Assessment
7	Flood Hydrology and Geomorphology	14	Traffic Impact Assessment

Volume 3 – Plans

Volume 3 contains sets of A3 size plans that support the EA and provide details of the engineering and landscape designs developed for the project.

No	Title
1	Project Overview Plans
2	Civil Design Drawings
3	Landscape Drawings

2 EXISTING AND PROPOSED DEVELOPMENTS

2.1 Introduction

The ACP currently comprises the three main operational entities shown on **Figure 2.1**:

- The North East Open Cut (NEOC), which operates day and afternoon shifts (seven days per week) and produces 2.0 – 2.4 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal;
- The Ashton Underground Mine, which uses longwall extraction methods to produce 2.9 – 3.2 Mtpa of ROM coal; and
- The Ashton CHPP which processes the ROM coal and loads product coal onto trains for shipment.

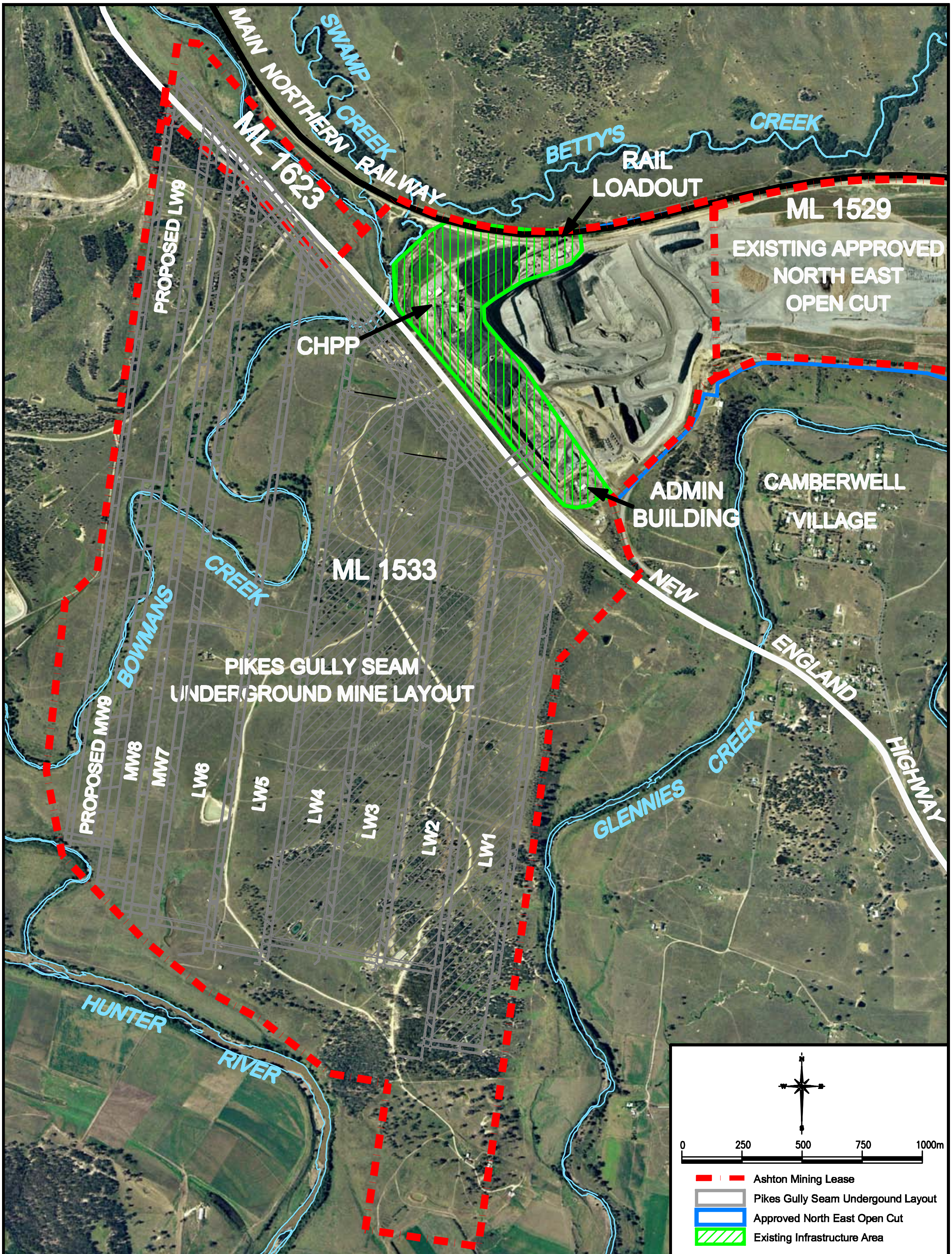
The proposed modification to the Conditions of Consent relates to a component of the Ashton Underground Mine. In 2001, ACOL sought development consent to carry out longwall mining beneath Bowmans Creek. Due to relatively shallow depths of cover between Bowmans Creek and the coal seams, mining operations had the potential to impact Bowmans Creek and its associated alluvium. As a result of this potential impact, ACOL sought approval to relocate sections of Bowmans Creek to maintain creek flows and to prevent surface water inflow to the mine. **Figure 2.2** is a copy of the mine plan layout from the original EIS.

During the assessment of the development application the Department of Planning considered that longwall mining could occur beneath Bowmans Creek and its associated alluvium provided no direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurred through connective cracking. It was thought at the time that following completion of mining, a hydraulic connection would allow upward migration of saline groundwater to the surface. At that stage it was believed, based on industry experience, that 150m was the depth of cover required to preclude the potential for inter-connective cracking between the longwall mining operations and the alluvial groundwater. ACOL committed to a monitoring program to determine the depth of cover necessary to prevent direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking. Accordingly, on 6 September 2002, ACOL modified the proposed mine plan to include full width longwall mining which would be carried out a manner so as to prevent direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking, and removed the creek diversion. The development consent was issued on this basis. **Figure 2.3** shows the current SMP approved mine plan for "Longwalls 5-6 and Miniwalls 7-8 only" for the Pikes Gully seam to comply with the development consent.

As a result of extensive studies and monitoring carried out since the grant of the 2002 development consent, ACOL considers that Bowmans Creek and its connected alluvium, and the impacts predicted from longwall mining, are now significantly better understood. ACOL now considers that longwall mining beneath the Bowmans Creek alluvium can be carried out in an environmentally acceptable manner.

Accordingly, 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 in **Figure 2.4** 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 in **Figure 2.4**).



AshtonCoal

Bowmans Creek Diversion Project

Figure 2.1
Current General Arrangement of Ashton Coal Project (Showing SMP Approved Mine Plan & Proposed LW/MW9)

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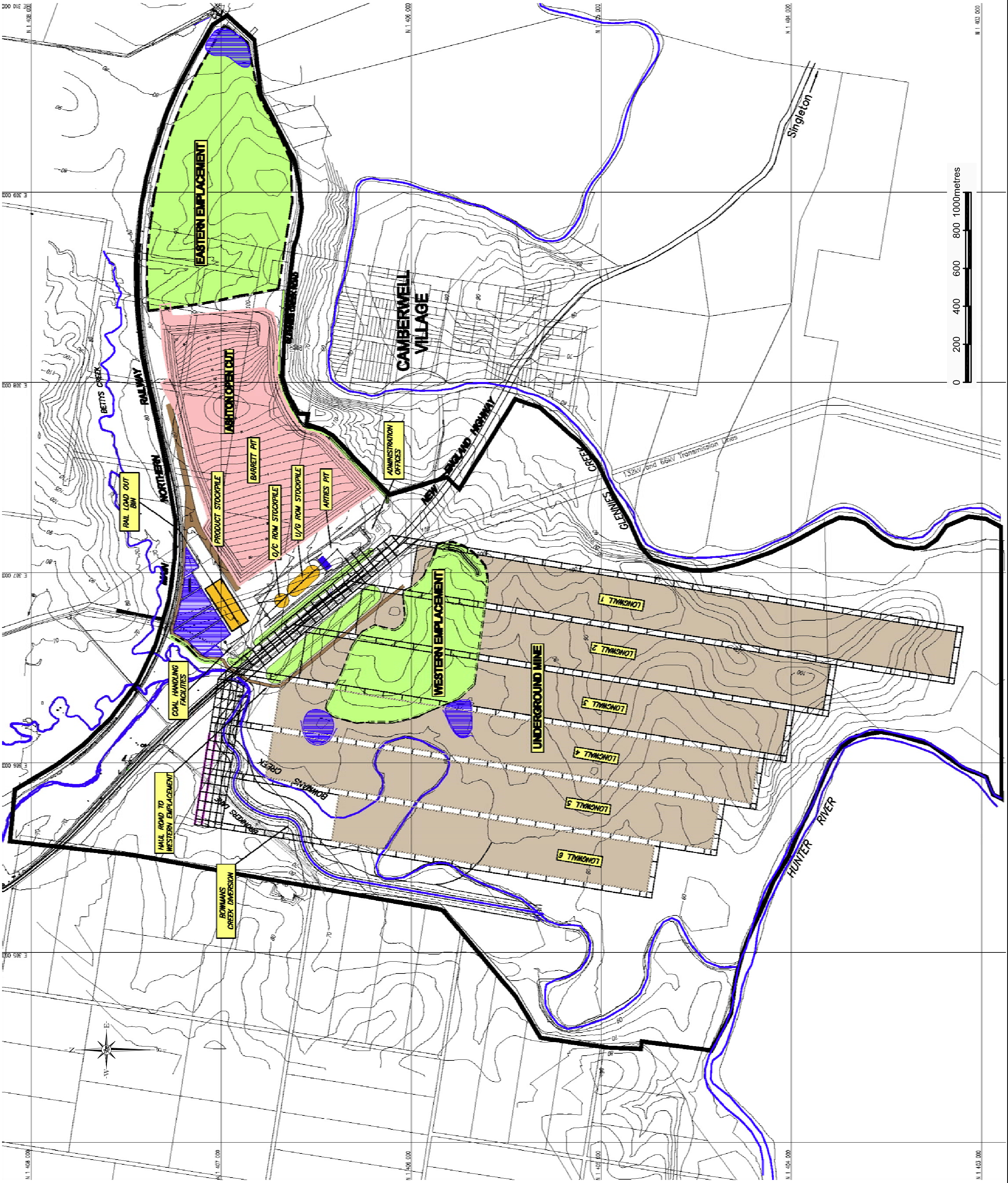

AshtonCoal

Bowmans Creek
Diversion Project

Figure 2.2
Ashton Coal Project EIS Layout

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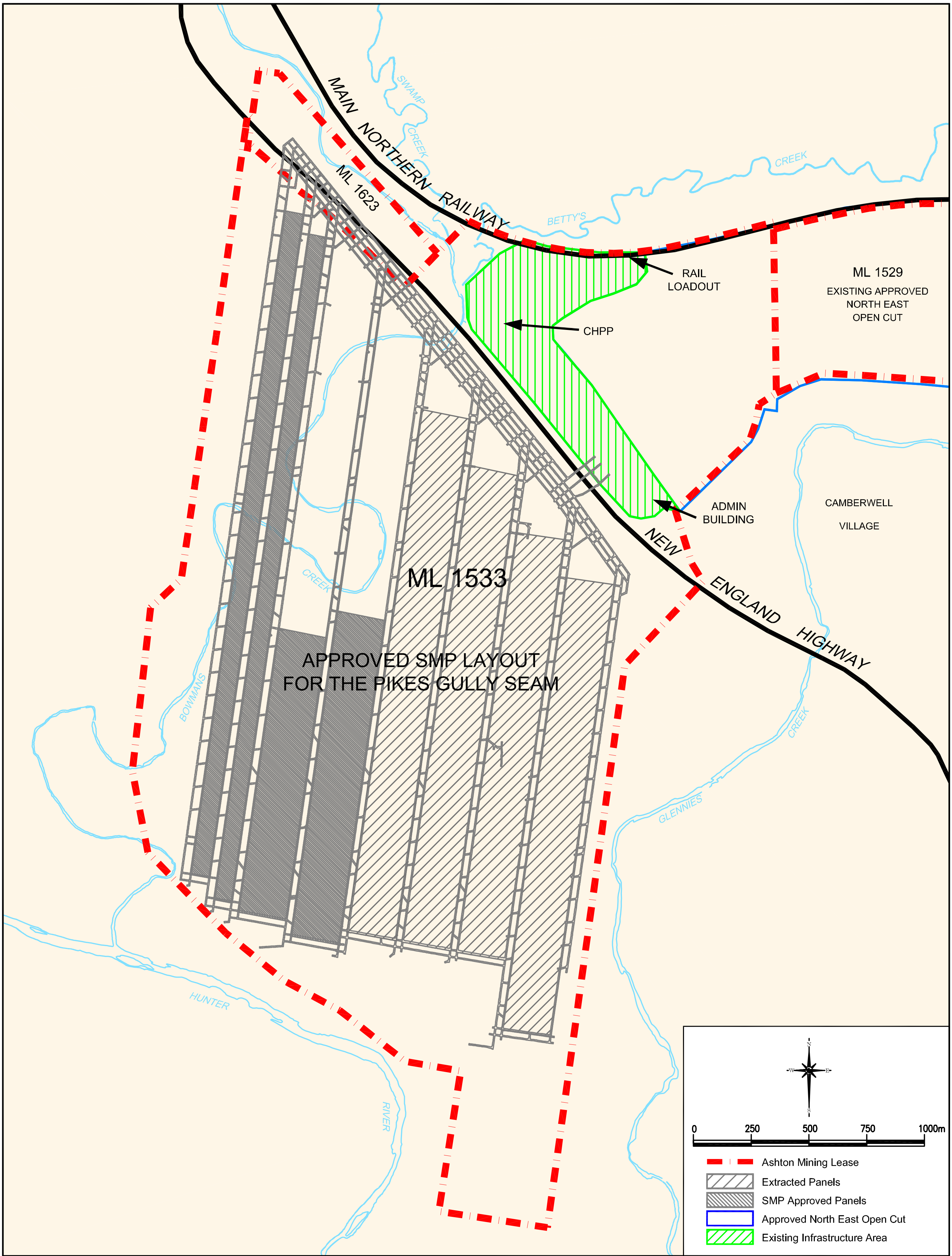

AshtonCoal

Bowmans Creek Diversion Project

Figure 2.3
Approved SMP Layout for the Pikes Gully Seam

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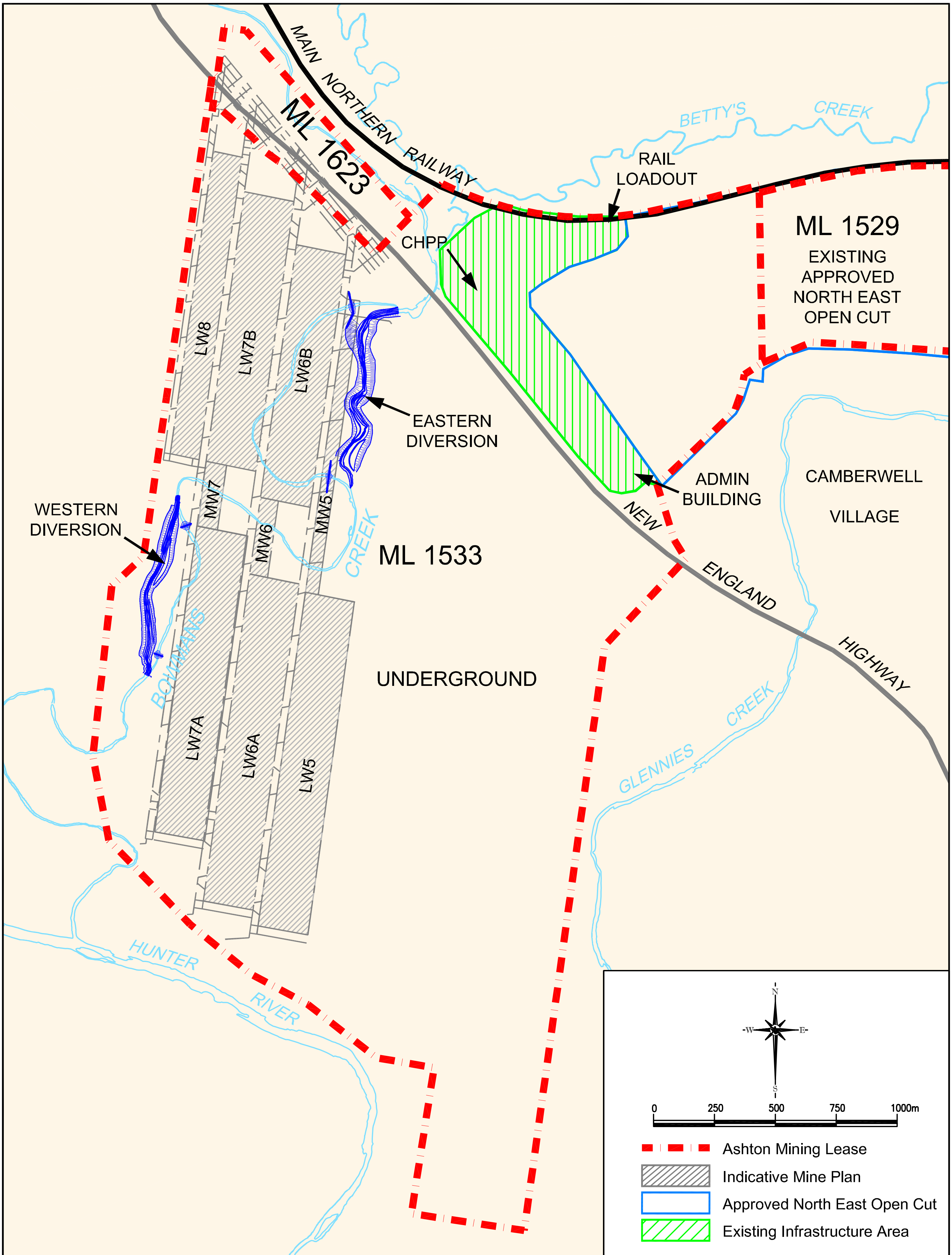


AshtonCoal

Bowmans Creek Diversion Project

Figure 2.4
Proposed Creek Diversions and Longwall Layout Assuming Stacked Arrangement

ACOL FILE: A-4058.dwg

2.2 The Existing Ashton Coal Project

2.2.1 Mining

The open cut mine, which is located north of the New England Highway, commenced operations in 2003. Coal is recovered from several seams of varying thickness in two open cuts – the smaller Arties Pit and the larger Barrett Pit. These are collectively known as the North East Open Cut (NEOC). The underground mine is located south of the New England Highway, and is accessed from the northern side of the highway via a portal in the Arties Pit. The general layout of the existing ACP is shown by **Figure 2.1**.

The initial underground mine plan comprised seven longwall panels (LW1 to LW7), four of which (LW1 to LW4) received Subsidence Management Plan (SMP) approval for mining of the Pikes Gully seam under an SMP Application lodged in 2006. Underground mine development commenced in December 2005, and mining of the first longwall panel (LW1) in the Pikes Gully seam began in March 2007.

The SMP for LW5 to LW8 in the Pikes Gully seam received conditional approval on 2 July, 2009. This SMP provides for a combination of longwalls (largely in areas outside the area of the saturated Bowmans Creek alluvium) and 'miniwalls' under the areas overlain by saturated alluvium and the creek. Further detail in relation to the longwall and 'miniwall' configuration is provided in **Section 2.4**.

A summary of the existing ACP approvals under Development Consent (DA) 309-11-2001-i (as amended) is provided in **Table 2.1** which also identifies the modifications requested under this application.

Table 2.1: Summary of the Approved ACP Operations and their Status

Aspect	Approved Operations	Existing Status of Operations	Modification Required
Project Life	ACP approved in October 2002 for 21 years from grant of Mining Lease.	ML 1529 covers the eastern end of the NEOC and was granted on 10 September 2003, and expires on 11 November 2012. ML 1533, covers the CHPP and underground area and was granted 26 February 2003 to 25 February 2024. ML1623 covers the north-western corner of the underground area and was granted on 30 October 2008 for 21 years until 30 October 2029.	No Existing consent sufficient.
Mine Production	Production from open cut and a descending underground coal mine. Annual production of coal from the ACP not to exceed 5.2 million tonnes per annum (Mtpa) of ROM coal.	During the 2007 – 2008 reporting period ACOL produced approximately 4.4 Mtpa of ROM coal.	No
Open Cut	Two pits – Arties Pit and Barrett Pit (forming the NEOC).	Expected to be completed by October 2010.	No
	Total output of open cut 12Mtpa of product coal over 7 year period.	Anticipated as per approval.	No
	Construction of environmental bunds.	Completed as per EIS and under vegetation.	No
	Construction of the Eastern Emplacement Area (north of the highway) to RL125m (modified in January 2005 by MOD 2 to	Completed as per EIS and modification.	No

Aspect	Approved Operations	Existing Status of Operations	Modification Required
	elevate to RL135m).		
	Construction of Western Emplacement (south of the highway) to RL 105m.	Effectively became redundant following approval of MOD 2.	No
	Use of highwall mining at appropriate times.	No highwall mining has occurred to date.	No
	Final void filled with reject material.	As per approval (see coal handling, preparation and processing).	No
	Rehabilitation to combination of woodland and pastures.	Consistent with approval.	No
Underground	EIS estimated 18 years total production for the four descending seams.	Commencing in December 2005, the Underground would be estimated to be completed by 2024. (Assumes maximum production rates).	No
	Entry via highwall of the Arties Pit on the north side of the New England Highway with main headings aligned beneath the New England Highway.	Development of the underground entries and infrastructure commenced in December 2005, with the extraction of the first panel commencing following the SMP Approval in March 2007.	No
	Approval for underground mining 24 hours per day 7 days per week.	The underground mine currently operates as per the project approval.	No
	Diversion of Bowmans Creek proposed within EIS to minimise impacts to alluvials. Diversion excluded from Approval.	Studies undertaken determined that mining design could be modified through alteration of panel width to reduce potential of connective cracking and protection of Bowmans Creek alluvium. SMP lodged on 2 July 2009 documents these studies.	Yes
	Six panels approximately 250m wide proposed within EIS, later replaced by 7 panels (LW1 to LW7) approximately 210m wide, conditional on no direct cracking to Bowmans Creek Alluvium.	The SMP for Longwall (LW) Panels 1 to 4 in the Pikes Gully seam was approved on 8 March 2007. SMP prepared and approved on 2 July 2009 for the remaining panels WITHIN the Pikes Gully seam. The mine design now consists of longwall panels and miniwall panels, ranging from 60 to 210m wide starting at Longwall 5 through to Miniwall 8. LW/MW 9 is the subject of a modification (MOD 4) and is located west of MW8.	Yes
	Descending multi seam operation targeting Pikes Gully, Upper Liddell, Upper Lower Liddell and Lower Barrett seams.	Currently working the Pikes Gully seam.	No
Coal handling, preparation and processing	Train loading and CHPP operation 24 hours per day, 7 days per week.	Currently operated 24 hours per day, 7 days per week.	No
	Construction and operation of pit top facilities for coal preparation, stockpiling, train loading.	Constructed as per EIS and approved modifications.	No
	Coarse and fine rejects to be disposed of within final void.	Final void will continue to be filled with rejects, however MOD 3 dated February 2007 provided for the disposal of fine rejects within voids of the Ravensworth Open Cut.	No
Water demand and supply	Water supply from site run-off, underground mine dewatering, excess mine water from neighbouring mines, potable water collected from roof tops, and imported water when required.	Water is currently sourced as approved, with a water sharing agreement with the Glennies Creek Coal Mine and from licensed water allocations on Bowmans Creek, Glennies Creek and the Hunter River.	No

Aspect	Approved Operations	Existing Status of Operations	Modification Required
Support facilities and utilities	Administration, car parking, stores and bathhouse facilities.	Constructed as per EIS.	No
	Power and water supply infrastructure.	Consistent with approval.	No
Conservation and offsets	Conservation Agreement Under Part 4 Division 12 of the National Parks And Wildlife Act 1974 for 65.66ha land known as the "Southern Conservation Area" containing: - Hunter Valley vegetation, comprising Open Grassy Woodland, characterised by Bull Oak, Narrow-leaved Ironbark, Yellow Box and Grey Box. - Containing populations and habitat for the threatened Grey-crowned Babbler (eastern subspecies). - Important Aboriginal cultural heritage with occupation evidence in addition to the landscape setting and context. The draft agreement recognises that underground mining may disturb the surface and require rehabilitation.	Final stage of agreement with DECCW pending. Area subject to regular flora and fauna survey.	No
Mine access	Via Glennies Creek Road.	As per approval.	No
Operating Hours	Open cut operations 7am to 10pm Monday to Saturday and 8am to 10pm on Sunday.	Operating as approved.	No
	Blasting 9am to 5pm Monday to Saturday.	Operating as approved.	No
	Underground operations 24 hours per day, 7 days per week.	Currently operating as approved.	No
	Coal handling and preparation facilities 24 hours per day 7 days per week.	Currently operating as approved.	No
Employment		Currently employ 386 personnel and contractors, made up from: 160 in open cut. 180 in underground. 27 in CHPP. 19 management and support staff.	No

2.2.2 Environmental Management and Monitoring

ACOL has implemented management systems for continual improvement of safety, health, environmental and community performance and requires these aspects be managed to a high degree.

ACOL has adopted a structured and systematic approach to the management of safety, health, environment and community relations to specifically meet the needs of the operation. The safety and health of its employees and contractors, the protection of the environment and interaction with the community are paramount. Ongoing success in these areas is a fundamental requirement of its continued operation and growth.

The Safety, Health, Environmental and Community Policies and Procedures that have been developed by ACOL are to protect the health and safety of employees, contractors, sub-contractors, visitors and the general public, to protect the environment and to ensure compliance with all relevant Acts and Regulations. It is the policy of ACOL to ensure that all employees maintain a high standard of Occupational Health and Safety and Environmental Management to achieve the operations objective of nil incidents. The Operations Team are committed to this objective and will, in so far as is practical, provide a safe hazard free workplace for all persons associated with the operation.

The Safety, Health, Environmental and Community Management System (SHECMS) cover the following:

- Policies;
- Systems and Standards to be adopted to achieve these policies;
- Site Safety Procedures and Forms for the management of risks; and
- Risk Assessments and Job Safety Analysis for specific tasks and jobs.

The ACOL Safety Health Environment and Community Management System (SHECMS) comprises six generic elements:

- Leadership and Commitment;
- Policy;
- Planning;
- Implementation;
- Monitoring and Evaluation; and
- Management Review.

As required by the current development consent (DA 309-11-2001), ACOL has established a comprehensive environmental management and environmental monitoring regime which has been approved by relevant government agencies and implemented throughout the construction and operation of the ACP. All approved management plans are available on the Ashton Coal website (www.ashtoncoal.com.au). These management plans contain comprehensive environmental reporting procedures incorporating principles of operating the ACP in an efficient and environmentally responsible manner. ACOL has established the following suite of management plans:

- Environmental Management Strategy.
- Construction Air Quality Management Plan.
- Noise Management Plan.
- Blasting and Vibration Management Plan.
- Erosion and Sediment Control Management Plan.
- Site Water Management Plan.
- Groundwater Management Plan.
- Archaeology and Cultural Heritage Management Plan.
- Flora and Fauna Management Plan.
- Weed Management Plan.
- Landscape and Revegetation Management Plan.
- Land Management Plan.
- Soil Stripping Management Plan.
- Rail and Road Closure Management Plan.
- Lighting Management Plan.
- Spontaneous Combustion Management Plan.
- Bushfire Management Plan.
- Waste Management Plan.
- Subsidence Management Plan.

ACOL will, where applicable, apply the management strategies of the above mentioned management and monitoring regime to the Bowmans Creek Diversion Project. Where necessary the additional management strategies identified for the Bowmans Creek Diversion Project will be integrated into the existing management and monitoring regime.

2.3 The ACP Underground Mining Layout

The Ashton Underground mine aims to obtain maximum resource utilisation from four seams within an area generally bounded by the Hunter River to the south, Glennies Creek to the east, Bowmans Creek to the west and the New England Highway to the north. Adjoining mines include Narama Open Cut and Ravensworth Underground to the west and Glendell Open Cut to the north. Coal extraction is by means of a descending longwall operation commencing in the uppermost seam (Pikes Gully) followed in descending order by the Upper Liddell, Upper lower Liddell and Lower Barrett seams.

The longwall panels have been consistently aligned in a north – south direction, with the configuration changing to satisfy conditional requirements to minimise impacts to Bowmans Creek and its alluvium. There are three different mine configurations relevant to the underground mine operations – EIS layout (**Figure 2.2**), conditional EIS layout (Option 4) and the currently approved SMP layout for the Pikes Gully seam (**Figure 2.3**) - these are discussed in the sections below.

2.3.1 The EIS Layout

The original project described in the EIS (**Figure 2.2**) for the ACP (November 2001) comprised the following key elements:

- Six (6) longwall panels of approximately 250m wide face;
- Four (4) seams;
- 18 year operating life;
- Single 2,420m diversion of Bowmans Creek, with uniform cross section and alignment.

2.3.2 The 2002 Conceptual Layout to Achieve Consent Conditions

During the assessment process Planning NSW (now the Department of Planning) concluded that there was uncertainty in relation to the impact predictions for the EIS mine plans, in particular relating to:

- The extent and impact of subsidence cracking on geological strata below the alluvium;
- Impacts of cracking on hydraulic properties of subsided strata and the applicability of groundwater modelling; and
- Post mining water quality impacts on the alluvial aquifer, Bowmans Creek and the Hunter River.

To address these concerns an alternative was proposed that consisted of the following:

- Seven (7) longwall panels of approximately 210m wide face;
- Four (4) seams;
- 18 year operating life; and
- No diversion of Bowmans Creek.

During the assessment of the development application the Planning NSW considered that longwall mining could occur beneath Bowmans Creek and its associated alluvials provided no connective cracking resulted. It was thought at the time that connective cracking would allow upward migration of mine saline water to the surface post mine closure. At that stage it was believed, based on industry experience, that 150m was the depth of cover required to preclude the potential for inter-connective cracking between the longwall mining operations and the alluvial groundwater. This formed the basis of the 'Option 4' layout and ACOL committed to a monitoring program to determine the depth of cover necessary to prevent connective cracking. A copy of the development consent is included as **Appendix 3**, with the following conditions being of particular relevance:

- Condition 1.18

  "The Applicant shall not construct any diversion of Bowmans Creek as proposed in the EIS."

- Condition 3.9

  "The Applicant shall design underground mining operations to ensure no direct hydraulic connection between the Bowmans Creek alluvium and the underground workings can occur through subsidence cracking. In order to achieve this criteria the Applicant shall assess levels of uncertainty in all subsidence predictions, and provide adequate contingency in underground mine design to ensure sufficient sound rock is maintained to provide an aquaclude between the Bowmans Creek alluvium, and the underground mine goaf."

- Condition 4.13

  "All surface and underground operations including long wall mining shall be conducted to minimise potential impacts on groundwater flow and quality of the alluvial groundwater resource, integrity of the alluvial aquifer and to minimise off-site effects."

2.3.3 Subsidence Management Plans

Under the Mining Act 1992, ACOL is required to gain approval for a SMP. The conditions of development consent predate the current SMP requirement under the Mining Act 1992 and, as such, require ACOL to prepare a Subsidence Environmental Management Plan (SEMP). The Department of Planning have approved the amalgamation of these documents to minimise duplication.

To date, ACOL have submitted and received approval for two SMPs, these are:

- The Subsidence Management Plan for LW1 to LW4 in the Pikes Gully seam, approved on 8 March 2007 comprising:
  - Four (4) x 210m panels essentially as approved in the 'Option 4' plans, with exception to Longwall Panel 1 that was shortened due to a hard sandstone band.
- The Subsidence Management Plan for LW5 to LW8 in the Pikes Gully seam conditionally approved on 2 July 2009, comprising:
  - 210m wide longwalls for LW5 and LW6; and,
  - Miniwalls, with a width to depth ratio of 0.6 to maintain compliance to the development consent Condition 3.19 with respect to ensuring no direct hydraulic connection between the Bowmans Creek alluvium and the underground workings and to provide an aquiclude of sound rock between the alluvium and the mine goaf. Two miniwalls were approved for LW7 and LW8.

Figure 2.3 shows the approved SMP mine layout for the Pikes Gully seam.

2.4 The Proposed Underground Mining Layout

The proposed underground mining layout for this application has been developed with regard to a change in the understanding of the groundwater systems in the area, allowing ACOL to prepare a plan that maximises resource recovery; maintains the economic viability and stability of the operations and provides security of employment for the workforce whilst taking account of the principles of ecologically sustainable development. The change in understanding is discussed below in **Section 2.4.1**, with the resulting improved mine plan discussed in the following sections.

2.4.1 Improved Understanding of Groundwater

With the benefit of substantial additional investigation and monitoring of groundwater, subsidence and surface water since the commencement of the ACP, deficiencies have been identified in the understanding of the groundwater regime that were developed during the preparation of the original EIS. The key differences in understanding are summarised in **Table 2.2**.

Monitoring of groundwater during the first five years of open cut mining and three years of underground mining has shown that, prior to mining, groundwater did not flow down from the alluvium to the coal measures as stated in the EIS, but rather that there is a natural upwards seepage of saline groundwater from the coal measures to the alluvium. Also, based on modelling of post mining recovery, it is now considered that the EIS prediction of an increase in Hunter River salinity post mining is incorrect. Hence, the increased salt contribution to Hunter River predicted in the original EIS will not occur. It should be noted that this was a significant concern during the original assessment process.

Recent hydrogeological investigations have also improved the understanding of the nature, extent and quality of Bowmans Creek alluvium and its degree of connection to Bowmans Creek itself, an aspect that was also of particular concern at the time of the assessment of the original EIS. Investigations have concluded that the quality of the alluvial aquifer is not uniform and ranges from moderately to highly saline. In addition, the alluvium does not provide a pathway for significant groundwater flow between the New England Highway and the Hunter River, and only provides limited baseflow contribution to Bowmans Creek.

Table 2.2: Comparison of the Understanding Between 2001 and Present

Aspect	EIS Understanding (2001)	Present Understanding (2009)
Groundwater Model	• Calibrated to 3 piezometers. • Model not verified.	• Calibrated to 60+ piezometers. • 5+ years of mining impacts to verify model.
Pre-mining Conditions	• Groundwater flows downwards from alluvium to underlying coal measures (rate 250,000 litres/day). • Removes 0.5 tonne salt per day from Hunter River.	• Groundwater flows upwards from coal measures to alluvium (rate 20,000 litres/day). • Adds 0.1 tonne salt per day to Hunter River.
Post-mining Conditions	• Predicted using unverified model. • Groundwater levels in coal measures will be higher than pre-mining. • Groundwater levels in coal measures will be higher than in alluvium. • Upwards seepage of saline groundwater from coal measures to alluvium (22,000 litres/day). • Result will be increase in salinity in Hunter River.	• Predicted using a verified model. • Recovery modelling indicates groundwater levels in coal measures will likely be lower than pre-mining. • Groundwater levels in coal measures are predicted to be lower than in alluvium. • There will be reduction in upwards seepage of saline groundwater, not an increase. • Result will be a decrease in salinity of Hunter River
Bowmans Creek Floodplain Alluvium	• Alluvium is a high quality resource. • Contributed only 0.07% of Hunter River baseflow (negligible contribution). • Salinity range 900 to 2,00 µS/cm EC • More saline than Hunter River.	• Alluvium contains a groundwater resource of limited value. • Baseflow contribution is negligible – Bowmans Creek ceased flowing in 2007 (ie baseflow less than evaporation). • Salinity range 1,190 to 6,420 µS/cm EC. • More saline than Hunter River (500 to 1,000 µS/cm EC).

2.4.2 Updated Subsidence Assessment

Based on the assessment and the hydrogeological assessment of Bowmans Creek alluvium, ACOL now considers that longwall mining beneath the Bowmans Creek alluvium can be carried out in an environmentally acceptable manner. This includes allowing direct hydraulic connection between the underground workings and the undermined parts of the Bowmans Creek alluvium where full panel extraction occurs.

Estimates of the subsidence have been prepared based on the current best understanding of multi-seam subsidence described by Li et al (2007) and monitoring results from subsidence that has occurred as a result of mining the Pikes Gully seam in LW1 to LW4.

Maximum subsidence impacts (subsidence over the centre of each longwall panel, maximum tilt and maximum strain) are expected to increase incrementally with each seam mined as shown in **Table 2.3** below.

Table 2.3: Estimated Maximum Subsidence Impacts

Seam	Maximum Subsidence (m)	Maximum Tilt (mm/m)	Maximum Strain (mm/m)
Pikes Gully	1.6	70	30
Upper Liddell	3.7	150	70
Upper Lower Liddell	5.8	240	110
Lower Barrett	8.3	350	160

Ground disturbance caused by the combined subsidence from four seams is expected to impact on infrastructure and natural features. However as the subsidence will occur progressively with mining of each successive seam, impacts will be assessed, generally as part of the SMP process, and ACOL will put in place management plans and consult with the owners of the impacted infrastructure to address the impacts. The multi-seam nature of the ACOL and Ravensworth Underground Mine (RUM) operations allows impacts and contingencies to be monitored, interpreted and resultant actions included in the mine plans prior to extraction of each descending seam.

To mitigate impacts of subsidence the following measures have been applied:

- In accordance with its existing conditions of consent, ACOL will maintain a free draining landscape by progressively constructing drainage works or filling subsidence areas on the floodplain, with the exception of the excised sections of the creek channel. This will minimise the potential water inflow into the mine and minimise pooling of surface water.
- The mine plan minimises subsidence in areas of the proposed diversion channels and in areas of retained sections of Bowmans Creek including riparian areas. Notwithstanding, the design of the diversions incorporates a flexible impermeable membrane below the channel which will be capable of minimising leakage from the channels in the event of minor subsidence.
- Lower seam mine plans will be reviewed and modified in response to actual subsidence and geotechnical behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice - in particular with respect to major infrastructure, Bowmans Creek, aboriginal archaeology and RUM.

Therefore a number of key design criteria have been applied in the mine design. These are outlined in the following section.

2.4.3 Proposed Mine Plan and Scheduling

With the change in understanding of the groundwater and surface water systems and their response to mining, ACOL have developed an alternate underground mine plan. The key features of the proposed mine plan (shown in **Figure 2.4**) are:

- Full longwall panel extraction (210m wide) of coal beneath the parts of the excised sections of Bowmans Creek and Bowmans Creek alluvium (particularly LW6 and LW7);
- LW6 and LW7 will be divided into two sections (A and B respectively) in order to retain a section of creek that runs east-west which is commonly referred to as the "oxbow section" of Bowmans Creek;
- Partial extraction of coal with 'miniwalls' (MW5, MW6 and MW7) beneath short sections of Bowmans Creek in order to minimise impacts on the functioning sections of the creek;
- Mining of an additional area of coal approximately 150m wide for the three lower seams on the western boundary (LW8); and
- Diversion of two sections of Bowmans Creek and construction of associated block banks in the existing creek channel.

The proposed mine plan for the Pikes Gully seam is shown in **Figure 2.4**. The final extraction design of each subsequent seam below the Pikes Gully would be subject to the results of subsidence and monitoring from the preceding seam and would be detailed in a SMP consistent with the current SMP approval process.

For the purpose of assessment of the subsidence impacts described in this EA, the longwall panels in each successive seam have been stacked vertically beneath the one above. The stacked multi-seam panel layout presents the worst case subsidence impacts compared to the possible alternative "offset" multi-seam panel layout. Mine planning has been, and will continue to be, an iterative process that takes into account a variety of parameters including; monitoring and interpretation of the previously extracted panels; developments in understanding of subsidence within the industry; and the economics of the mining operation. Modification of the mine plan for subsequent seams may include modifying aspects of the design such as; offsetting longwall blocks; optimising pillar dimensions; changing longwall widths based on geotechnical or equipment requirements; and modifying the start and end points of a panel.

As the mining process proceeds from east to west across all panels in one seam before commencing on the next lower coal seam, there is a period of about four years before the lower seam is mined in any given longwall location, this schedule is shown in **Figure 2.5**. Due to this mining schedule, the impacts on the surface landform and the surface and groundwater systems will be incremental in nature. The incremental nature of these impacts has been taken into account in developing the mitigation measures proposed for the project.

2.5 Coal Processing, Rejects and Tailings

The proposed modification will result in the extraction of an additional 5.3Mt of ROM coal that will be processed, and loaded onto trains at the existing and approved ACP CHPP, at the approved processing rate.

The additional ROM coal is estimated to generate in the order of 2.1Mt of rejects and tailings that will be disposed of in the approved tailings and reject storage areas.

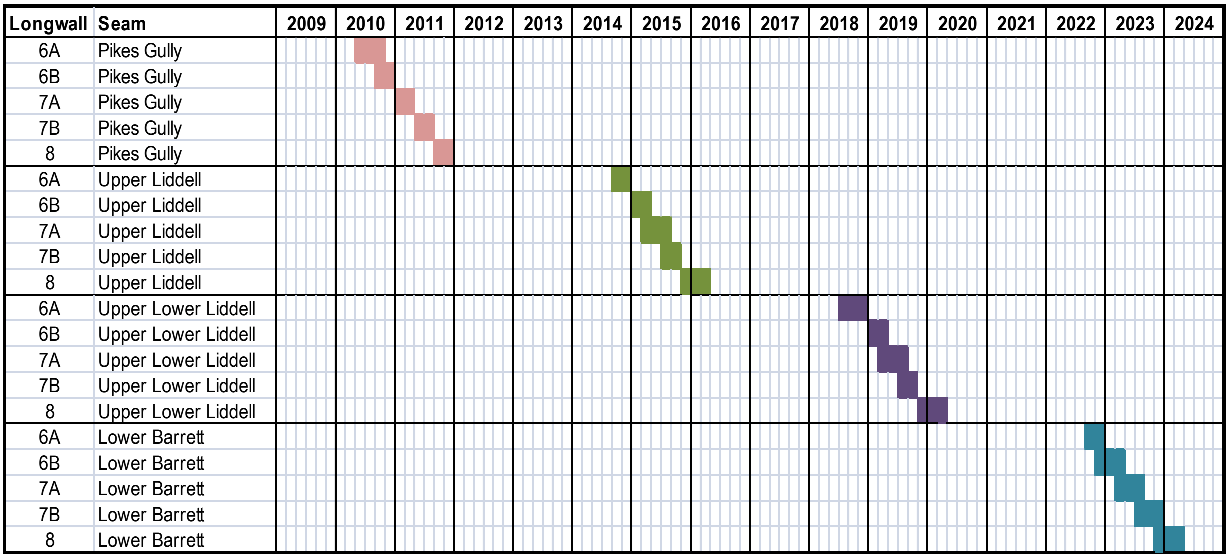


Figure 2.5:
Indicative Extraction Schedule

2.6 Proposed Creek Diversion

The proposal involves the construction of two diversions 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 is varies from 4.0m to 5.5m. The volume of material to be excavated is approximately 140,000m^3; 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.

Figure 2.6 provides an overview of the proposed diversions and associated block banks (to redirect flow) together with the location of stockpiles for excavated material that will subsequently be used to fill subsidence troughs in order to create a free draining landscape. The stockpiles locations have been selected to be mainly in areas that are not affected in a flood with an average recurrence interval (ARI) of 20 years. 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. The stockpile locations have also been selected to be in areas that do not require haulage across the creek channel either for initial placement of material or for subsequent re-use of stockpiled material for filling of subsidence troughs.

The design of the diversion channels (see **Plan Set 2**) 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 2.7** which shows perspective views of the existing and proposed channels. (Note that the two excised sections of the creek are quite different in many geomorphic respects);
- Provide 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 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 2.4 summarises the key objectives, the numerical criteria or strategy adopted for the design of the diversion channels and the features of the proposed diversions. These include maintenance of comparable flow conditions in the vicinity of the New England Highway bridge.

Flow will be directed into the diversion channels by means of block banks across the existing creek. These block banks will eventually 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 channel once the alluvial groundwater has been drained, 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 natural stream bed conditions. **Figure 2.9** shows a typical cross section through a diversion channel showing the extent of the stream bed zone and the location of the geosynthetic clay liner

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. **Table 2.5** and **Table 2.6** below summarise the main features of the existing and proposed creeks between the New England Highway and the Hunter River with the various reaches defined (A, B, etc) for direct comparison.

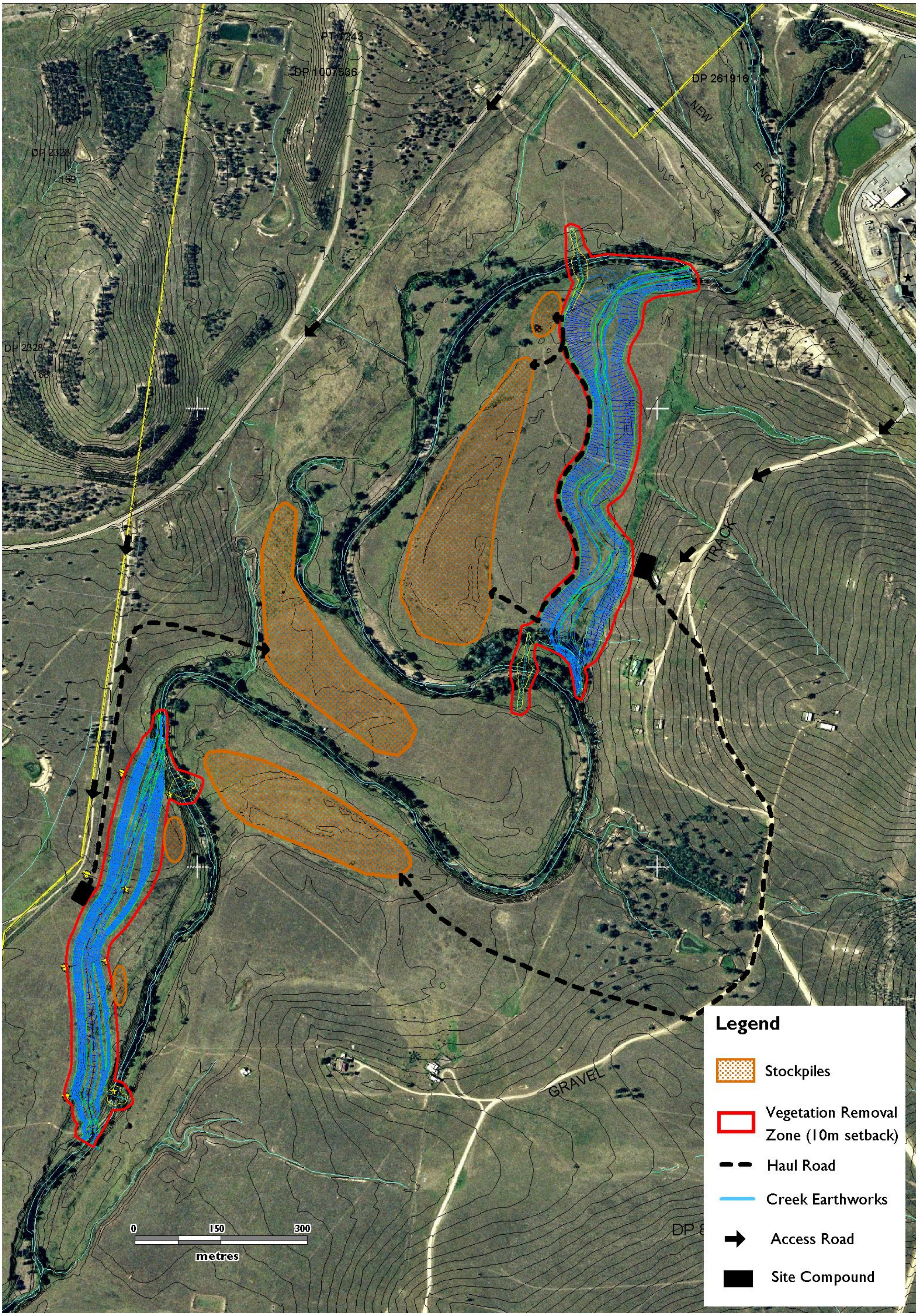
Table 2.4: Key Design Objectives and Features of the Proposed Diversion Channels

	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
5	**Fish Passage and Aquatic Habitat**		
5.1	Fish passage when creek flowing	Passage possible in moderate flow	Flow conditions similar
5.2	Provide appropriate pool and riffle sequence	Mimic existing channel	Pool and riffles mimic existing creek
5.4	Maximum bed slope of riffles	Approximately 5%	Approximately 5%
5.5	Maintain comparable pool area	0.9 ha[1]	1.1 ha
6	**Riparian and Floodplain Ecology**		
6.1	Maintain area of lower active floodplain area inundated in 1 year ARI flood	6.7 ha	6.4 ha
6.2	Improve habitat value of lower active floodplain	Revegetate and exclude domestic stock	Establish plant communities characteristic of those present prior to European colonisation
6.3	Ecosystem resilience	Create robust, relatively self-sustaining ecosystem	

Note 1. Existing pool areas estimated from 2006 survey (taken during drought conditions) with adjustment to account for field observation of pool extent in 'normal' flow conditions (see **Section 10.2.3**)

Table 2.5: Existing Reaches of Bowmans Creek

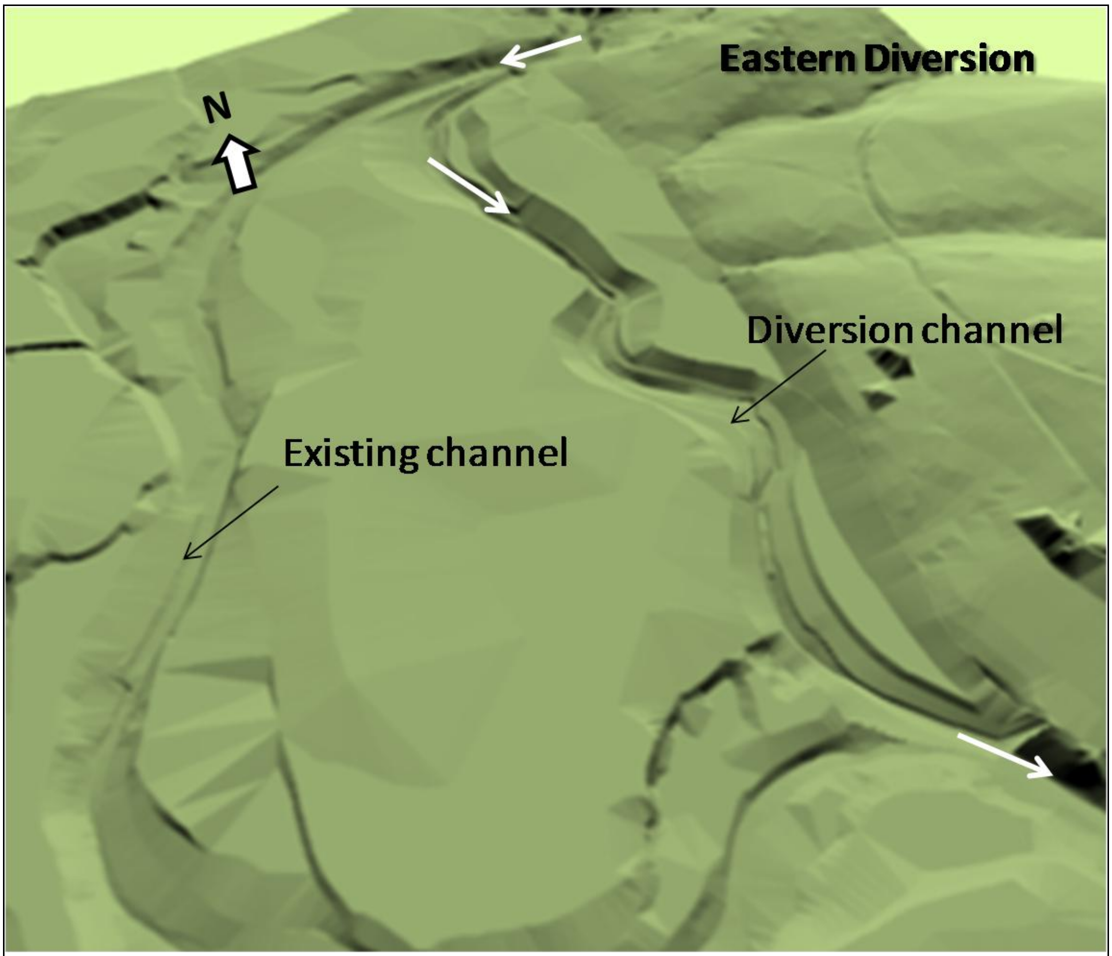
Reach		Length (m)
A	Existing channel downstream of New England Highway	176
B	Existing creek between ends of Eastern Diversion	1,480
C	Existing channel flowing east - west	1,196
D	Existing creek between ends of Western Diversion	838
E	Existing channel downstream to Hunter River	2,535
	Total	**6,225**



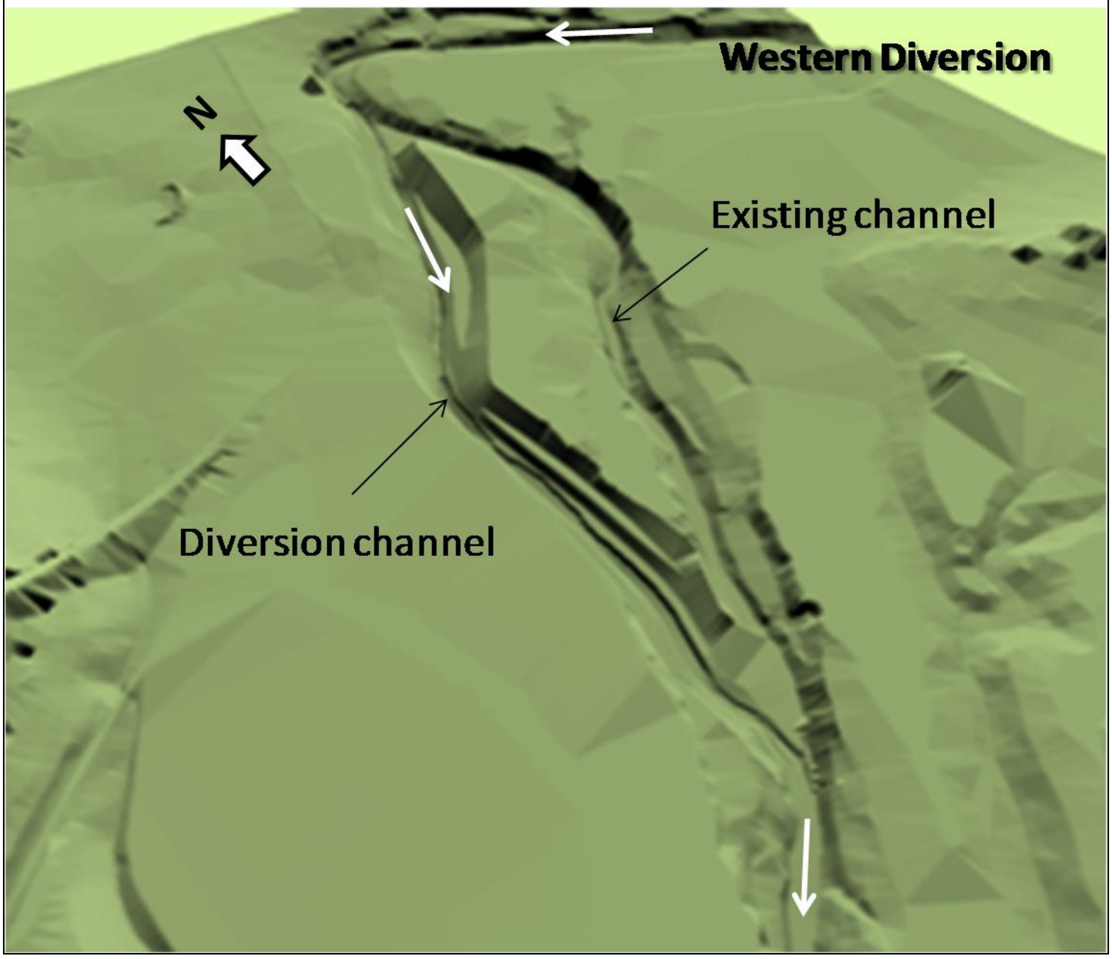
AshtonCoal

Bowmans Creek
Diversion Project

Figure 2.6
Site Works Overview



Eastern Diversion
N
Diversion channel
Existing channel



Western Diversion
N
Existing channel
Diversion channel

Table 2.6: Future Reaches of Bowmans Creek

Reach		Length (m)
Active Channel		
A	Existing channel downstream of New England Highway	176
B	Eastern Diversion Channel (including existing lagoon – 125m)	955
C	Existing channel flowing east - west	1,196
D	Western Diversion Channel	779
E	Existing channel downstream to Hunter River	2,535
	Total Active Channel	**5,642**
Backwater Pools		
B1	West of upstream end of Eastern Diversion	170
B2	West of downstream end of Eastern Diversion	90
D1	South of upstream end of Western Diversion	65
D2	North of downstream end of Western Diversion	60
	Total Backwater Pools	**385**
	Total Riparian Length	**6,027**

The data in the tables shows the following key aspects of the proposed diversions:

- The both diversions will be shorter than the excised sections of the existing creek; and
- Notwithstanding the shorter length of the active conveyance sections of the creek, the retention of backwater pools means that the overall length of creek available to support riparian and aquatic ecological functions is only reduced by 198m.

2.7 Channel and Block Bank Construction

Commencing with the Eastern Diversion, construction and revegetation in 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**. Excess spoil from the diversion channels will be stockpiled as shown on **Figure 2.6** for subsequent re-use for filling subsidence troughs to create a free draining landscape.

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. The risk of flood damage will be further mitigated by staged construction of the upstream block banks that will direct flow into the diversion channels. Initially, temporary low level banks (about 1m high) will be constructed 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. The temporary block banks will remain until just prior to mining of the Upper Liddell seam 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 (approximately 5 year ARI flood level) will be constructed immediately.

The proposed strategy for construction of temporary low level block banks seeks to balance the risks of damage to the diversion channels immediately after construction against the risk of excess water draining into the mine workings. Whilst the subsidence predictions indicate a maximum of 1.6m of subsidence following mining of the Pikes Gully seam, drainage of the alluvium and significant cracking and loss of surface flows from the creek at that stage is considered unlikely.

The proposed strategy involves the installation and regular monitoring of a number of piezometers in close proximity to the southern end of LW6A (to give early warning if drainage of the alluvium occurs) as well as in close proximity to the area where LW6B runs under the section of creek to be excised.

Visual monitoring of stream flows and pools within Bowmans Creek will also 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 design height block banks will be constructed in order to protect the mine workings. In the event that the full height block banks are required before mining of the Upper Liddell seam is about to occur, and a flood causes serious damage to the rehabilitation works in the diversion channels, the damage will be repaired. To further mitigate against this event occurring, the revegetation works will be undertaken in a staged manner which will allow the establishment of a robust protective layer of vegetation in the initial instance to protect the channel against flood damage. The initial planting will be followed by subsequent infill planting of various vegetation communities over a period of 8 years to establish a robust functional ecosystem as described in further detail in **Section 12.5** and **Appendix 10**.

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 up to four years after construction of the diversion channels in order to allow fauna to migrate from the blocked section of the existing channel. The construction of the downstream block banks will be undertaken immediately prior to mining of the Upper Liddell seam or when surface and groundwater monitoring indicates that significant leakage from surface water flows and or pools or alluvial groundwater to the Permian rocks is occurring, whichever occurs first.

Construction will commence at the downstream end of each diversion and progress upstream so as to ensure that all joins in the geosynthetic clay liner have the exposed edge on the downstream side. An indicative schedule for construction, which is expected to take about 6 months, is shown in **Figure 2.8**.

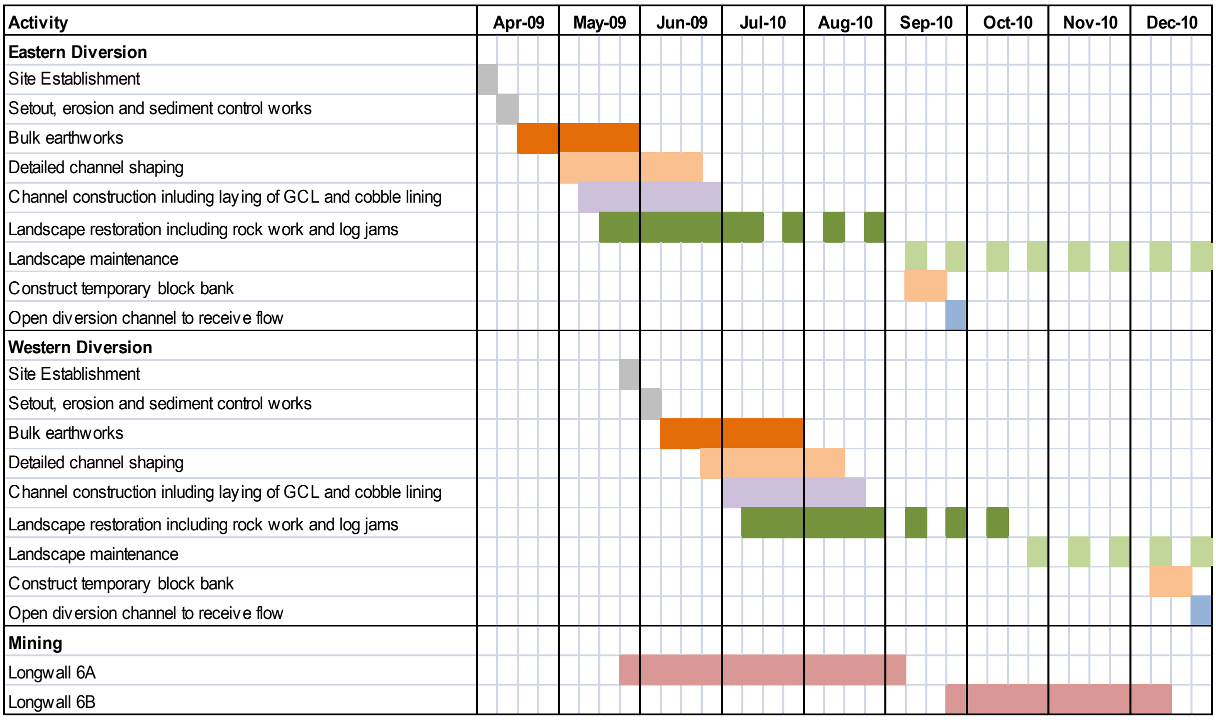


Figure 2.8:
Indicative Schedule for Creek Diversion Construction

2.8 Rehabilitation

The landscape restoration for the Bowmans Creek diversions is an integral part of the project. The objective 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 landscape restoration 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 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. Restoration is proposed to take pace in three phases over the first eight (8) years of the project. This approach has the advantage of facilitating:

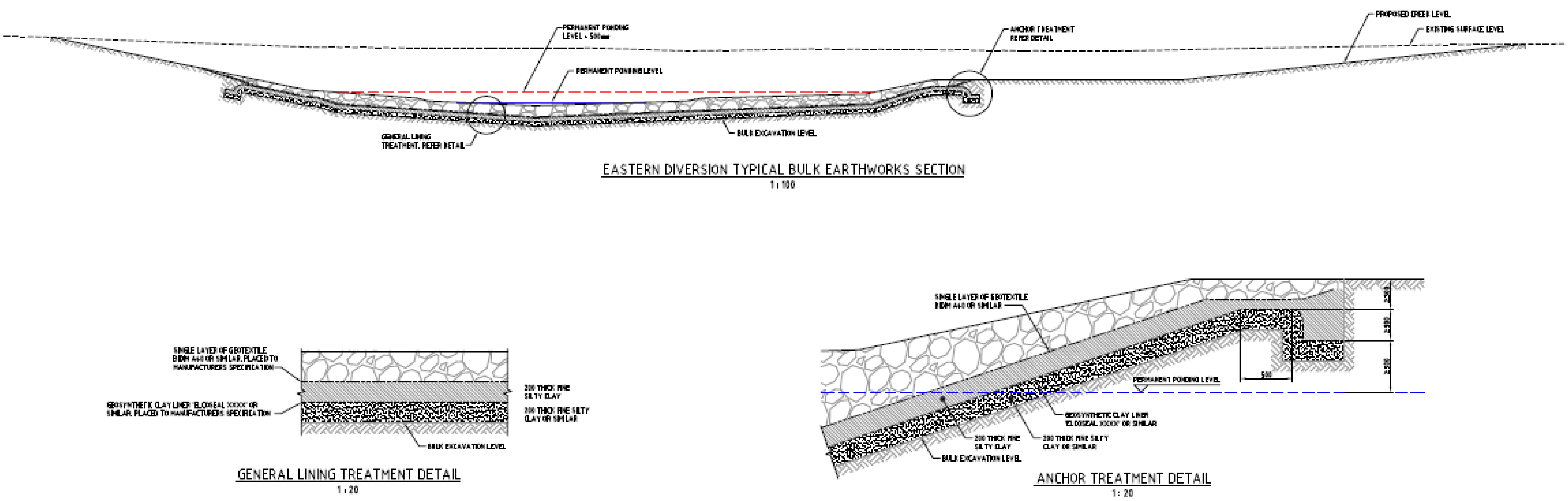
- An early focus on ground stabilisation and associated functional, simplified maintenance requirements;
- Early commencement of the works, as seed is required initially for only a limited number of grass species, and initial cell planting numbers will procurable in achievable numbers;
- Appropriate lead time to procure a diverse suite of species;
- Collection of provenance seed for River Red Gum (*Eucalyptus camaldulensis*), which in the Hunter catchment is listed as an endangered population under the *Threatened Species Conservation Act 1995*; and
- A gradual building up of species diversity commensurate with niches that develop over time as the structure of the communities develops.

The restoration will take a measured approach to flood risk and cost, commensurate with ACOL's requirement for early commencement of the works, 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.

As discussed in **Section 2.7**, it is proposed to initially construct temporary block banks to a level that will direct flows up to about 6 month ARI into the diversion channels. Larger flows will then split between the existing channels and the diversions. The effect of this flow split will be that a 5 year ARI flood in Bowmans Creek would lead to a flow in the diversion channels equivalent to about a 1 year ARI flow if all flow was directed into the diversion channel. On this basis, the 'flood resistant' treatment of the low level benches has been set at the notional 1 year ARI flood level as determined from the flood analysis (**Section 8**). It is considered that this 1 in 5 year ARI storm level provides an acceptable level of risk from flood damage to the restoration works in the early stages of the project.

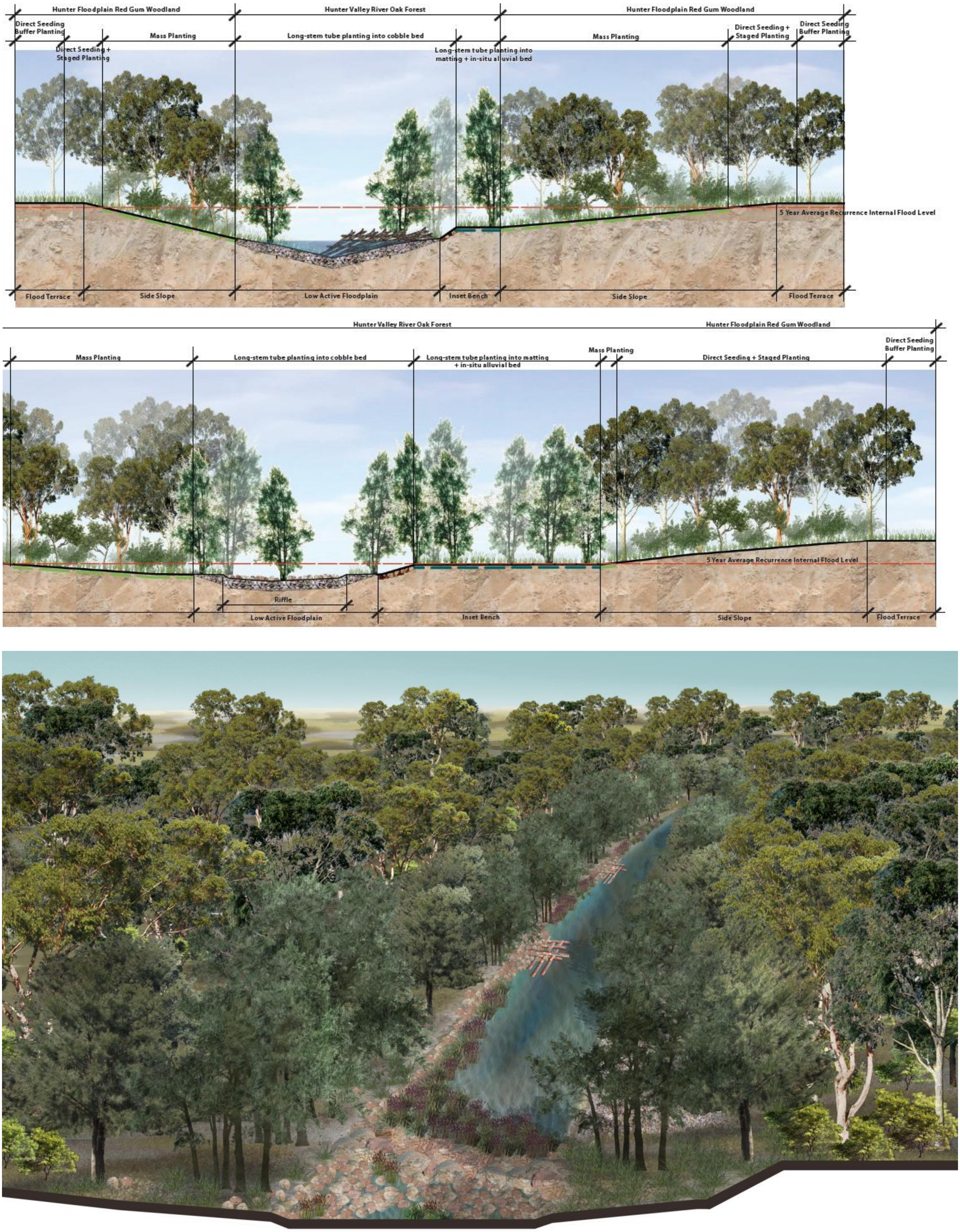
Further details of the proposed landscape restoration works are provided in **Section 12.5** and landscape masterplans and detailed designs are presented in **Plan Set 3**. Representative landscape restoration principles and outcomes are illustrated in **Figure 2.10** below.



AshtonCoal

Bowmans Creek
Diversion Project

Figure 2.9:
Diversion Channel Cross Section Details
(Source: Hyder Consulting)



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Bowmans Creek Diversion Project

Figure 2.10:
Creek Cross Sections and Perspective Following Full Landscape Restoration
(Source: EDAW)

3 PROJECT APPROVAL FRAMEWORK

3.1 Introduction

This section provides an assessment of the proposed modification to the existing ACP development consent for the Bowmans Creek Diversion having regard to State and Commonwealth legislation.

In New South Wales, the New South Wales Environmental Planning and Assessment Act 1979(EP&A Act) is the principal form of legislation that governs, controls and guides land use (planning and development) throughout the state. The EP&A Act is supported by a series of State Environmental Planning Policies (SEPPs), and Local Environmental Plans.

The principal legislative provisions relevant to the consideration of the application for the Proposed Modification are:

- Section 75W of the EP&A Act, which provides the approval process for the modification to major projects;
- State Environmental Planning Policy (Major Development) 2005 (Major Development SEPP), which establishes the types of projects that require Part 3A approval, which includes development for the purposes of mining that is coal mining;
- SEPP (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP);
- Section 75U of the EP&A Act, which provides that certain authorities and approvals under other legislation are not required for approved projects;
- Section 75V of the EP&A Act, which provides that certain authorities and approvals under other legislation cannot be refused and is to be issued in terms substantially consistent with any Part 3A approval; and
- The Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act), which provides a legal framework to determine controlled activities and protect matters of national environmental significance.

Other New South Wales legislation that applies to the Proposed Modification application is discussed below.

3.2 EP&A Act

On 19 August 2009, ACOL lodged a request with the Director General seeking to modify the 2002 development consent pursuant to section 75W in respect to the Proposed Modification.

On 18 September 2009, the Director General notified ACOL of environmental assessment requirements with respect to the Proposed Modification that must be complied with before the request will be considered by the Minister. A summary of the requirements and where they are addressed in this report are contained in **Section 1.4**, while a copy of the requirements is contained in **Appendix 1**.

3.2.1 Approval Authority

The ACP was granted development consent under Part 4 of the EP&A Act as designated, state significant, integrated development in October 2002 by the Minister for Planning.

ACOL is seeking approval from the Minister for Planning to modify the 2002 development consent pursuant to section 75W of the EP&A Act.

Had the ACP been approved after the commencement of Part 3A of the EP&A Act, the ACP would have been a project to which Part 3A applies as it comprises development for the purposes of mining that is coal mining (Schedule 1, Major Development SEPP).

Consequently the ACP is "*A development consent in force immediately before the commencement of Part 3A*" of the EP&A Act "*…that would be a project to which Part 3A of the [EP&A] Act applies but for the operation of clause 6(2)(a) of State Environmental Policy (Major Projects) 2005*".

As such the 2002 development consent meets the prerequisite in clause 8J(8) of the EP&A Regulations 2000 empowering the Minister to "*…approve of the development consent [2002 Consent] being treated as an approval for the purposes of section 75W of the [EP&A] Act*".

3.2.2 Other Applications

The 2002 development consent has been modified on three occasions since the grant of consent.

On 11 March 2009, ACOL lodged an application pursuant to Part 3A of the EP&A Act for project approval to carry out the South East Open Cut Project (SEOC). On 20 May 2009, the Director General's Requirements for the environmental assessment of the project were issued.

At the time of the lodgement of this EA, two separate applications to modify the 2002 development consent have been lodged with the Department of Planning. These are:

- Mod 4, which seeks to modify pursuant to section 75W the 2002 development consent to allow for the mining of an additional longwall panel; and
- Mod 5, which seeks to modify pursuant to section 75W the 2002 development consent to provide for the interaction of the existing surface facilities with the proposed SEOC and to increase the approved production rate by 250,000pa to 5.45Mtpa of ROM coal.

The Proposed Modification is independent of these modification applications.

3.2.3 Proposed Modification

Section 75W allows a proponent to request that the Minister modify an approval to carry out a Part 3A project. A modification of an approval means changing the terms of a Minister's approval including revoking or varying a condition of the approval or imposing an additional condition of the approval (Section 75W(1)).

The 2002 development consent has the following key components:

- Development of an open cut mine (known as the North East Open Cut) and an underground mine;
- A maximum extraction rate of 5.2Mtpa of ROM coal; and
- The construction of surface facilities including coal handling preparation plant, stockpiles, rail load out facilities and administration buildings.

Proposed modifications must meet three broad requirements in order to be considered under section 75W. These three broad requirements are:

a) The approval which is to be modified is a part 3A approval;

b) The proposed modification will have limited environmental consequence beyond that which has already undergone assessment; and

c) The consent authority for the development is the Minister.

As discussed above, due to the operation of clause 8J(8) of the EP&A Regulations, the 2002 development consent is able to be considered a Part 3A approval thereby meeting (a) above.

Based upon the studies undertaken for this EA, the Proposed Modification will be of limited environmental consequences beyond those consequences which were assessed by the Minister for Planning in granting the 2002 development consent.

Further, the Proposed Modification will not lead to a radical transformation of the 2002 development consent as longwall mining is undertaken on a very similar basis to the plan which was as approved by 2002 development consent.

Therefore the Proposed Modification is able to be considered by the Minister under section 75W of the EP&A Act.

3.2.4 Assessment and Determination

ACOL has prepared this EA in order to comply with the Director General's environmental assessment requirements to allow the Minister to consider the Proposed Modification.

The Minister may modify the 2002 development consent (with or without conditions) or disapprove or the Proposed Modification.

3.3 Environmental Planning Instruments

The following State Environmental Planning Policies (SEPPs) may apply for consideration by the Minister for Planning of the Proposed Modification.

3.3.1 State Environmental Planning Policy No. 44 – Koala Habitat Protection

This SEPP encourages the conservation and management of koala habitats, to ensure permanent free-living koala populations will be maintained over their present range. The SEPP requires the consent authority to consider whether land the subject of a development application is "potential koala habitat" or "core koala habitat".

An assessment of potential and core koala habitat has been undertaken for the modification area and has determined the area does not contain any potential or core koala habitat.

3.3.2 State Environmental Planning Policy No. 55 – Remediation of Land

This SEPP was enacted to provide a state-wide approach to the remediation of contaminated land for the purpose of minimising the risk of harm to the health of humans and the environment. Potentially contaminated sites within the project area may include dips, workshops/machinery sheds used for fuel, chemical and fertiliser storage and landfills.

No contaminated lands have been identified within the project area that will be disturbed by the proposed diversions. Should contaminated sites be encountered during construction of the diversions, these sites will be assessed and treated as required.

3.3.3 State Environmental Planning Policy (Major Development) 2005

This SEPP identifies development to which the development assessment and approval process under Part 3A of the EP&A Act applies and establishes the Minister for Planning as the consent authority for development classified as a "major development".

Development for the purpose of mining that is coal mining is considered to be a "major development" under this SEPP.

3.3.4 State Environmental Planning Policy (Infrastructure) 2007

This SEPP aims to provide a consistent planning regime for infrastructure and the provision of services across New South Wales, along with requiring consultation with relevant public authorities during the assessment process.

ACOL will observe the conditions of this SEPP in regards to infrastructure development and when modifying or disturbing existing infrastructure.

3.3.5 Mining SEPP

This SEPP aims to provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of the State. The SEPP allows underground mining and mining at surface level to be undertaken with development consent, providing the provisions of the relevant planning instruments are satisfied. It establishes appropriate planning controls to encourage ecologically sustainable development.

The Mining SEPP also establishes relevant matters for consideration by a consent authority. Whilst not applicable, the considerations set out by clauses 12 to 17 of the Mining SEPP are examined and reported upon throughout this EA report.

3.4 Relationship to other New South Wales Legislation

In addition to major project approval under the EP&A Act the Proposed Modification will also require authorisations under various laws. These are discussed as follows.

3.4.1 Application of Section 75U & Section 75V to the Proposed Modification

Pursuant to clause 8J(8) of the EP&A Regulations, the 2002 development consent if modified by the Minister does not become a project approval under Part 3A. However, if the Proposed Modification is approved the provisions of sections 75U and 75V of the EP&A Act attach to that part of the development which was approved by the Minister under the provisions of part 3A.

3.4.2 Section 75U EP&A Act 1979

Pursuant to Section 75U of the EP&A Act there are a number of authorisations that will not be required for the Proposed Modification. Relevantly, the authorisations that will not apply because of section 75U include:

- A permit under Section 87 or a consent under section 90 of the National Parks and Wildlife Act 1974 (NPW Act);
- A water use approval under Section 89, a water management work approval under Section 90 or an activity approval (specifically a controlled activity approval) under section 91 of the Water Management Act 2000;
- A permit under Section 219 of the Fisheries Management Act 1994 to erect works or structures that may block the passage of fish;
- Approval under Part 4 or a permit under Section 139 of the Heritage Act 1977 to disturb a relic; and
- An authorisation to clear native vegetation as referred to in Section 12 of the Native Vegetation Act 2003.

3.4.3 Section 75V EP&A Act 1979

Pursuant to Section 75V of the EP&A Act there are a number of authorisations that must be issued in terms substantially consistent with any approval for the Proposed Modifications. These authorisations are (relevantly):

- A mining lease under the Mining Act 1992 (however since the proposed modification works are wholly within ML 1533, further mining leases are not required);
- An environment protection licence (EPL) for any of the purposes referred to in section 43 of the Protection of the Environment Operations Act 1997, under Chapter 3 of that Act (however the proposed modification works will be permissible under the existing EPL, so a further EPL is not required); and
- Consent under section 138 of the Roads Act 1993 (not required for the Proposed Modification).

3.4.4 Mining Act 1992

The proposed modification works are wholly within the existing ML 1533.

3.4.4.1 Mine Operations Plan and Subsidence Management Plan

The Proposed Modification will necessitate the amendment of the existing approved Mine Operations Plan and Subsidence Management Plan (SMP) to ensure underground mining is undertaken in a safe and environmentally responsible manner.

3.4.4.2 Property Subsidence Management Plan

The guidelines for securing SMP approval requires that the miner complete a Property Subsidence Management Plan (PSMP) assessing the effect of subsurface mining on the surface of and improvements on each parcel of land in which sub-surface mining is to occur. These effects will be assessed within the amended SMP.

3.4.4.3 Mine Subsidence Board

Any landholder whose infrastructure is damaged by mine subsidence is entitled to compensation for that damage from the Mine Subsidence Board as provided in the Mine Subsidence Compensation Act 1962.

3.4.5 Protection of the Environment Operations Act 1997

ACOL hold Environment Protection Licence (EPL) 11879 issued under the Protection of the Environment Operations Act 1997. The existing licence will not require amendment as a result of the Proposed Modification.

3.4.6 Water Act 1912 and Water Management Act 2000

The ACP area is currently administered under both the Water Act 1912 and the Water Management Act 2000 (WM Act) with respect to water approvals and licensing.

The following water sharing plans are in force for the area:

- Water Sharing Plan for the Hunter Regulated River Water Source 2003 – applies to the Hunter River and the unconsolidated alluvial sediments underlying waterfront land (i.e. within 40m of the top bank); and
- Hunter Unregulated and Alluvial Water Sources Water Sharing Plan – applies to the unregulated alluvial water sources located within the Jerrys Extraction Management Unit within the Hunter Catchment.

The licensing provisions of the WM Act 2000 apply to all of the waters contained within the project area other than water within the fractured rock aquifers and basement rock. Waters within the fractured rock aquifers and basement rocks is governed by the Water Act 1912.

Under the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan (HUAWSWSP), the licensing of activities, water use, water works and approvals provisions of WM Act 2000 (contained within Parts 2 and 3 of Chapter 3 of the WM Act 2000) will apply to the area of the proposed modification.

By virtue of section 75U of the EP&A Act 1979 water use approvals under section 89, water management work approvals under section 90 and activity approvals under section 91 are not required for a project which has been approved under Part 3A of the EPA Act.

Section 75U does not provide any exemption from the obligation to secure a Water Access Licence (WAL) under section 56 of the WM Act. Section 60A of the WM Act provides that it is an offence to 'take water from a water source to which this Part applies' without a WAL. As noted above, the WM Act applies to water within the surface flow and alluvium of Bowmans Creek.

In **Section 13** ACOL has committed to offsetting and accounting for the water which flows from the water sources subject to the HUAWSWSP. Further, ACOL has committed to extracting water from the areas which remain subject to the Water Act 1912 in accordance with the 2002 development consent and the Water Act 1912.

3.4.7 Coal Mine Health and Safety Act 2002

The primary objective of the Coal Mine Health and Safety Act 2002 is to assist in securing the objects of the Occupational Health and Safety Act 2000 in relation to coal operations and to put in place special provisions necessary for the control of particular risks arising from the mining of coal. Under the Coal Mine Health and Safety Act 2002 ACOL will be required to comply with the requirements for minimum barriers for underground workings.

3.4.8 Crown Lands Act 1989

The bed of Bowmans Creek is within the boundary of Lot 3 DP 11114623. This land is owned by ACOL. Accordingly no licence under the Crown Lands Act 1989 is required to carry out the works within the bed of the creek.

3.4.9 Fisheries Management Act 1994

The New South Wales Fisheries Management Act 1994 declares and lists threatened species of fish and marine vegetation and endangered populations and ecological communities. It contains measures to conserve those identified species, populations and communities and to promote ecologically sustainable development. By virtue of Section 75U of the EP&A Act, permits under Sections 201, 205 and 219 of this Act are not required for the Proposed Modification.

The mitigation measures proposed by ACOL to minimise the impact of the proposed diversions on aquatic ecology are discussed in **Section 10.5.2.**

3.4.10 Threatened Species Conservation Act 1995

The Threatened Species Conservation Act 1995 identifies threatened species, populations and ecological communities and key threatening processes. It contains measures to conserve those identified species, populations and ecological communities and integrates assessment regarding activities which might impact upon those species, populations and ecological communities and those activities considered key threatening processes into the assessment and planning process.

The requisite assessments and processes required under the Threatened Species Conservation Act 1995 are detailed in **Sections 10.5.1** and **10.5.3**.

3.5 Commonwealth Legislation

3.5.1 Environment Protection and Biodiversity Conservation Act 1999

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Cth defines actions that are likely to have a significant impact on matters of national environmental significance (MNES) as "controlled actions". The EPBC Act prohibits the taking of controlled actions without an approval under Part 9 of the EPBC Act.

MNES includes (relevantly) listed threatened species, listed ecological communities and listed migratory species.

Flora and fauna surveys undertaken as part of the assessments for this EA have determined there will be no significant impact or likelihood of significant impact from the diversion upon MNES.

3.6 Section 94 Contribution and Voluntary Planning Agreement

The Singleton Section 94 Contribution Plan (S94 Plan) provides for the provision, extension or augmentation of public amenities and services to satisfy the additional demand that may result from a development. The Proposed Modification will not result in any additional permanent jobs, nor additional demand on public amenities and services provided by Singleton Council. Therefore no such contribution under the S94 Plan is proposed.

3.7 Summary of Licences, Approvals and Permits

Table 3.1 contains a summary of the licences, approvals and permits currently held by ACOL for the existing ACP and those that will be required or amended as a result of the proposed modification. Copies of the development consent (as amended) and the Environmental Protection Licence (EPL) are provided in **Appendix 3**. Copies of the other approvals can be downloaded from the Ashton Coal website at www.ashtoncoal.com.au.

Table 3.1: Summary of Existing and Required Licences, Approvals and Permits

Detail	Granted	Expiry	Status	Amendments / New Approvals Required.
Planning Approvals				
309-11-2001-i Development Consent	11/10/02	11/10/23	Current	MOD 6 proposed to amend consent
309-11-2001-i (MOD 1) Modification to development consent (allows EPA to specify noise criteria in Table 5)	15/10/03	11/10/23	Current	-
309-11-2001-i (MOD 2) Modification to development consent (permits 10 m increase in height of Eastern Emplacement Area)	27/01/05	11/10/23	Current	-
309-11-2001-i (MOD 3) Modification to development consent (for the construction and operations of tailings pipelines between the mine and the former Ravensworth Mine)	19/02/07	11/10/23	Current	-

Detail	Granted	Expiry	Status	Amendments / New Approvals Required.
309-11-2001-i-(MOD 4) – Modification to development consent (for an additional Longwall Panel, an increase in annual underground coal ROM production to 3.2Mtpa and deletion of specific conditions of consent)			Under consideratio n by Minister of Planning	-
309-11-2001-i-(MOD 5) – Modification to development consent to integrate coal from the SEOC, increase in peak underground ROM coal production to 5.0Mtpa, disposal of reject in the SEOC, amended conditions as required.			Under consideratio n by Minister of Planning	-
Approval of DA 309-11-2001-MOD6 pursuant to S75W in Part 3A of the EP&A Act 1979				Approval required
Mining Tenements				
ML 1533 (Open Cut & facilities)	26/02/03	26/02/24	Current	-
ML 1529 (Underground)	17/09/03	11/11/12	Current	-
ML 1623 (Underground)	30/10/08	30/10/29	Current	-
Exploration Licence (EL) 5860	14/03/04	21/05/09	Current	-
Exploration Licence (EL) 4918	17/09/99	17/12/10	Current	-
Authorisation (A) 81 (held by Navidale Pty Limited)	04/04/77	16/12/09	Current	-
Environment Protection Licences (EPL)				
EPL 11879 (as amended) (Open Cut Area and processing facilities)	02/09/03 (28/04/09)	06/11/11	Current	-
Subsidence Management Plan				
Subsidence Management Plan (for the extraction of LW1–4)	08/03/07	01/03/14 or upon expiry or release of ML 1533	Current	-
Subsidence Management Plan (for the extraction of LW5-9)	02/07/09		Current	Amendment required to modify the underground mining layout.
Mining Related Approvals				
Clause 88(1) approval for safe operations and stability of workings and resource recovery longwall mining	28/02/07	1/06/11	Current	-
S126 Approvals for emplacement of carbonaceous materials Ravensworth Void 4	08/04/04	NA	Current	-
S126 Approvals for emplacement of carbonaceous materials Ravensworth Void 4	17/01/07	NA	Current	-
Water Licences				
Surface Water Licences:				
20AL201311 Glennies Creek High Security 3ML		30/06/17		-
20AL203056 Glennies Creek Supplementary 4 ML		11/03/19		-
20AL200568 Glennies Creek Stock and Domestic 3 ML		14/03/19	Current	-

Detail	Granted	Expiry	Status	Amendments / New Approvals Required.
20AL201712 Glennies Creek Stock and Domestic 3 ML		30/06/17		-
20AL201083 Glennies Creek Stock and Domestic 3 ML		27/05/18		-
20AL200508 Glennies Creek Stock and Domestic 3 ML		30/06/17		-
20AL200690 Glennies Creek Stock and Domestic 3 ML		TBC		-
20AL201031Glennies Creek Stock and Domestic 8 ML		30/06/17		-
20AL201624 Hunter River High Security 3 ML		07/04/19		-
20AL201625 Hunter River General Security 335 ML		07/04/19		-
20AL203106 Hunter River Supplementary 15.5 ML		07/04/19		-
20SL044434 Bowmans Creek Irrigation 366 ML		16/10/09		Applications in respect of this licence have been lodged
20SL042214 Bowmans Creek Irrigation 14 ML		23/02/12		-
Surface Water Licence for dams above the MHRDC.				-
Groundwater Licences:				
20BL136766 Stock Domestic	12/01/88	Perpetuity	Current	-
20BL168848 Test Bore	27/08/03	Perpetuity	Current	-
20BL168849 Test Bore	27/08/03	Perpetuity	Current	-
20BL169508 Mining 10 ML	15/03/05	14/03/10	Current	-
20BL169937 Mining 100 ML	06/04/06	05/04/08	Current	Applications in respect of this licence have been lodged
20BL170596 Monitoring	16/10/06	Perpetuity	Current	-
20BL171364 Mining 100 ML	17/05/07	16/05/12	Current	-
Water Approvals				
Part 3A (Rivers and Foreshores Improvement Act 1948 – Act now repealed) permit No P1819 to install two power poles near Bowmans Creek	05/12/03	05/12/04	Current	-
Permit No CW802609 to construct levee bank on Bowmans Creek	08/09/03	07/09/13	Current	-
Heritage				
AHIMS Permit No 1591 to collect Aboriginal artefacts north of the New England Highway under S90 of NPW Act	21/07/03	21/07/08	Complete	-
AHIMS Permit No 2783 to collect Aboriginal artefacts EWA86 under S90 of NPW Act	28/09/07		Current	-
S/S – superseded *N/A – Not available*				

4 STAKEHOLDER AND COMMUNITY CONSULTATION

4.1 Introduction

ACOL, since the grant of EL 4918 and EL 5860 has placed a high level of importance on ongoing community consultation with landowners and residents, particularly within the adjacent village of Camberwell, and with relevant government agencies and community groups.

Consultation with the local community occurs via newsletters, community information days, meetings with individual landowners and residents, briefings to key government agencies, local and state government and state and federal Members of Parliament and to the ACP Community Consultative Committee.

Consultation requirements for the project were reviewed and identified the following key stakeholders:

- Government agencies, including:
  - Department of Planning (DoP)
  - Department of Industry and Investment (DII)
  - Department of Environment, Climate Change and Water (DECCW- including the NSW Office of Water – NOW)
  - The NSW Roads and Traffic Authority (RTA)
- Singleton Council;
- Utility service providers;
- Adjoining landowners and local community;
- The Aboriginal community.

This section documents consultation undertaken with the above stakeholders.

4.2 Community Consultation

Following the grant of EL 4918 and EL 5860 ACOL introduced a community consultation program to notify the community of development associated with the ACP. Elements of the community consultation program relating to the Bowmans Creek diversion project are discussed below.

4.2.1 ACP Community Consultative Committee

The grant of development approval for the ACP on 11 October 2002 by the Minister for Planning contained a condition of consent requiring the establishment of a Community Consultative Committee (CCC) relating to the construction and operation of the ACP. In accordance with condition 10.1 the CCC comprises two representatives of ACOL (typically the General Manager and the Environment and Community Relations Manager), one representative of Singleton Council and four community representatives. The CCC is currently chaired by Singleton Councillor Godfrey Adamthwaite.

The CCC generally meets on a quarterly basis. Since 2003 there have been more than 22 meetings. The CCC was established to make comments and recommendations on the preparation and implementation of environmental management plans and to monitor compliance with the conditions of consent for the approved ACP.

To allow for the effective functioning of the CCC, ACOL provides information on the progress of the ACP, monitoring results and the environmental performance of the mine and any other information requested by the Chairman of the CCC. ACOL when requested provides access for site inspections by the CCC.

The CCC was briefed on the proposed diversion of Bowmans Creek at its meeting held on 8 September 2009.

4.2.2 Newsletters

Since the commencement of exploration activities at the ACP, ACOL has prepared a series of 30 newsletters to date, demonstrating ACOLs ongoing commitment to keeping the community informed on mining and mining related activities associated with the ACP. The newsletters have covered various issues related to the ACP, including exploration activities, planning and environmental assessment progress and outcomes, status of construction and operation activities, environmental monitoring and environmental performance of the project. The local community have been informed of the Bowmans Creek diversion project by an ACOL newsletter.

4.2.3 Website and 1800 Telephone Line

ACOL has an established environmental hotline (1800 657 639) and website (www.ashtoncoal.com.au) that covers the existing ACP operations. This hotline and website have been used throughout the environmental assessment process to enable local residents and landowners, interested persons and key community groups to contact representatives of ACOL to discuss issues or aspects associated with the proposed project or to gain access to relevant publicly available information.

4.2.4 Future Community Consultation

ACOL will continue to advise the CCC, provide newsletters and "engage in one on one" discussions during and after the public exhibition of the EA report. Consultation will continue during the construction and operational phases of the project with all identified stakeholders.

4.3 Consultation with the Aboriginal Community

Community consultation with Aboriginal stakeholder groups was undertaken in accordance with the DECCW guidelines: *Interim Community Consultative Requirements for Applicants*. Letters of notification of the project were sent to the DECCW, NSW Native Title Services, Office of the Registrar Aboriginal Owners, Office of the Registrar of ALRA and Singleton Council.

Letters of invitation to register an interest in the project were sent to those stakeholders known to ACOL.

Public notices advising of the proposed modification and inviting registrations of interest from Aboriginal groups and individuals were published in the public notices sections of the Singleton Argus and Sydney Morning Herald newspapers on 11 September, 2009.

A total of 26 Aboriginal community groups and individuals have registered an interest in the project. Aboriginal heritage issues are further discussed in **Section 11** below.

4.4 Consultation with Singleton Council

A meeting with the Mayor of Singleton – Councillor Sue Moore and Singleton Council General Manager Mr S Greensill and ACOL representatives was held at Council's administrative offices on

7 September, 2009 to formally advise Council of the proposed modification for the diversion of Bowmans Creek.

4.5 Consultation with Adjoining Landowners.

4.5.1 Macquarie Generation

A meeting was held on 14 August 2009 between representatives of Macquarie Generation and ACOL. The Bowmans Creek diversion project and potential subsidence impacts upon Macquarie Generation infrastructure and land holding were discussed.

4.5.2 Ravensworth Underground Mine (RUM)

Two meetings (6 July and 16 October, 2009) have been held between representatives of RUM and ACOL to discuss the Bowmans Creek project. The initial meeting discussed the proposed diversions whilst the second meeting was in the format of a printed PowerPoint presentation. Issues raised in the later meeting were the potential impact of multi-seam mining (western most longwall) on RUM operations, timing of operations, possible impacts upon Brunkers Lane, Narama Dam and other Ravensworth operations infrastructure.

4.6 Consultation with Government Authorities

4.6.1 The Formation of the Director General's Requirements

Project application was made to the Department of Planning on 19 August 2009.

The Department of Planning consulted with the relevant government agencies to allow the Director General of Planning to adequate formulate the Director General's Requirements (DGRs), otherwise referred to as the Environmental Assessment Requirements. The DGRs were issued on 18 September 2009.

Table 1.1 in **Section 1.4** provides a summary of the DGR's including where they have been addressed in the EA report. Consultation with the government organisations and authorities has occurred to clarify and assist the proponent's understanding of agency requirements to enable the preparation of the EA report including the proponent's draft Statement of Commitments.

The proponent's Major Project Application, the DGR's and other key documents associated with the project are available on the Department of Planning website, which will be updated as the project moves to a new phase in the assessment process.

4.6.2 Bowmans Creek Diversion Consultation

A summary of the consultation log with relevant government agencies and ACOL in relation to the project is provided in **Table 4.1**.

Table 4.1: Consultation Log with Relevant Government Agencies

Stakeholder	Date Consulted	Description
Department of Industries and Investment - Fisheries. (Mr S Carter)	8 September, 2009	Telephone discussion
	17 September, 2009	Meeting in Sydney.
	25 September, 2009	Telephone discussion
	3 September, 2009	Telephone discussion
Department of Industries and Investment - Agriculture. (Ms G Briggs)	8 September, 2009	Telephone discussion
	10 September, 2009	Meeting at Tocal

Stakeholder	Date Consulted	Description
Department of Environment, Climate Change and Water (Mr M Bennett & Ms R Akhurst)	8 September 2009	Telephone discussion
	16 September, 2009	Meeting at ACOL
Mine Subsidence Board (Mr I Bullin)	8 September, 2009	Telephone discussion
	10 September, 2009	Meeting at ACOL
Dam Safety Committee (Mr D Hilyard, Mr B Ziegler and Ms H Middleton)	26 August, 2009	Meeting at ACOL.
Department of Industries and Investment - Minerals (Mr R Ramage & Mr G Summerhayes)	4 July, 2009	Meeting at ACOL.
Singleton Shire Council (Mayor S. Moore & Mr S Greensill)	7 September 2009	Meeting at Council Administration Building.
New South Wales Office of Water (Mr F Hancock, Mr M Miganelli & Mr J Williams), and Department of Industries and Investment - Minerals (Mr G Summerhayes)	13 August, 2009	Meeting in Newcastle.
New South Wales Office of Water (Mr F Hancock, & Mr J Williams)	30 September 2009	Meeting in Newcastle
Roads and Traffic Authority	28 September 2009	Meeting in Newcastle office of RTA

4.6.3 Issues Arising from Consultation with Government Authorities

A summary of the issues raised by the various government authorities in relation to the project is provided below.

DII – Fisheries: DII – Fisheries are opposed to the proposed diversion on the basis that Bowmans Creek is one of a few remaining Hunter catchment creeks with good upper catchment aquatic and fish habitat. DII Fisheries have concern regarding the on-going maintenance of the diversion after the cessation of mining and would consult with NOW.

DII – Agriculture: DII - Agriculture advised that they would consult with NOW and sought that the EA consider and address the retention of "pasture country", stock access points to cross the creek, flooding, riparian vegetation and impacts to the flood plains.

DII – Minerals: DII – Minerals requested that the EA report consider the impacts of the project upon Bowmans Creek and alluvium, ecology (especially the stand of River Red Gums) and what contingencies ACOL proposed**.**

DECCW: The DECCW representatives sought to understand how the proposed project interacts with the existing ACOL underground mine and proposed Longwall/Miniwall No. 9 project. Three significant issues were identified, these being:

(i) The impacts of the project (if any) upon the River Red Gums;

(ii) The quality of the alluvium and water within Bowmans Creek and its interconnection (DECCW advised that advice would be sought from NOW) and potential impacts from the project; and

(iii) What impacts the project would have upon Aboriginal heritage.

The design of the project and the commissioning of specialist studies by ACOL has sought to address these matters as reported within the EA document.

Mines Subsidence Board: The Mine Subsidence Board requested regular updates of ACOL induced subsidence from their underground operations and requested information on the final land form for the project.

Dam Safety Committee: The Dam Safety Committee has advised that it will not take an active interest in the project unless it impacts upon a prescribed dam.

The Narama Dam and the proposed Ravensworth Void Ash Dam are located or will be located within the Dam Safety Committee Notification Area.

The subsidence impact assessment prepared by SCT has considered the potential impact of the project upon this infrastructure.

Singleton Shire Council: Singleton Shire Council requested that ACOL keep them informed on the project.

NSW Office of Water: NOW was provided with a PowerPoint presentation of the project. Representatives of NOW sought responses to numerous issues raised following the presentations, including:

- the impact of the project upon Bowmans Creek and associated alluvium,
- water accounting and licensing,
- impact of local mines on groundwater and associated accounting of impacts,
- flooding and flows,
- geomorphology and scour protection,
- length of diversions,
- impact on River Red Gums,
- salinity and potential for saline discharges, and
- ecology.

These issues have been addressed in the groundwater impact assessment and the terrestrial and aquatic ecology assessment.

RTA: RTA requested that the EA report address construction traffic impacts upon the New England Highway and whether the project would impact the highway.

In the design of the project, ACOL has had regard to the issues raised by the government agencies during the consultation process. In order to ensure that the project is ecologically sound, ACOL engaged specialists to undertake an assessment of the project upon the environment, in addition to the issues raised by government agencies. This EA document addresses the issues raised by the government agencies. Please refer to **Section 1.4** above, which identifies where these matters have been addressed within the EA document.

5 ENVIRONMENTAL RISK ASSESSMENT

5.1 Risk Identification Process

In order to undertake a comprehensive environmental assessment of the Project, ACOL has undertaken a consultation process and prepared an environmental risk assessment. The consultation process involved discussions with various government agencies and critical assessment of key environmental issues by mine staff and specialist consultants at a meeting at the ACOL offices on 3 June 2009. The risk assessment assisted in identifying and prioritising potential environmental impacts associated with the Project so that key issues could be addressed and subjected to detailed assessment. Key issues were also provided by the DoP Director-General's requirements for the EA.

The risk assessment was undertaken using the Risk Management Guidelines Companion to AS/NZS 4360:2004 (Standards Australia, 2004). It provides the preliminary screening of potential environmental impacts to identify those impacts that have higher levels of risk and those impacts unlikely to result in significant risks to the environment. As such the risk assessment establishes the following:

- It provides an objective, informed and transparent basis for the identification of key issues, which are further examined in detail in the Environmental Assessment (EA);
- It provides an objective decision making tool for the identification of issues unlikely to result in significant risks to the environment and hence issues which are not further examined in detail in the EA;
- It enables the EA to focus on key issues relevant to the decision making process, rather than resulting in an EA that accords the same level of attention to key and non-key issues, with often key issues obscured; and
- It enables the EA to be a briefer and more succinct document without limiting its scientific credibility.

Risk assessment is the formalised means by which hazards and associated dangers are systematically identified, assessed and ranked according to perceived risk and managed by means of appropriate and effective controls.

Environmental Risk is the chance of something happening that will have an adverse impact upon the environment. The impact will vary in consequence from Catastrophic (a major event which could cause severe damage to the environment) through to Insignificant (no detrimental impact on the environment is measured or envisaged). The Environmental Risk Rating is measured in terms of consequence (severity) and likelihood (probability) of the event happening.

In accordance with AS/NZS 4360:2004 five levels of consequence have been taken into account:

1	Catastrophic	A major event which could cause severe or irreversible damage to the natural and/or human environment.
2	Major	An event which could have a substantial and permanent consequence to the natural and / or human environment.
3	Moderate	An event which could create substantial temporary or minor permanent damage to the natural and / or human environment.
4	Minor	An event which could have temporary and minor effects to the natural and / or human environment.
5	Insignificant	No detrimental impact on the natural and / or human environment is measured or envisaged.

The likelihood (or probability) of each impact occurring was rated according to the following qualitative measures.

A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Could occur
D	Unlikely	Could occur but not expected
E	Rare	Occurs only in exceptional circumstances

A risk matrix based on these qualitative measures of consequence and likelihood was then used to measure risk and enable risk prioritisation.

Likelihood		**Consequence**				
		Catastrophic	***Major***	***Moderate***	***Minor***	***Insignificant***
		1	2	3	4	5
Almost Certain	A	**VH**	**VH**	**H**	**H**	**M**
Likely	B	**VH**	**H**	**H**	**M**	**M**
Possible	C	**H**	**H**	**H**	**M**	**L**
Unlikely	D	**H**	**M**	**M**	**L**	**L**
Rare	E	**H**	**M**	**M**	**L**	**L**

No	Aspect	Potential Risks and Issues	Potential Risk			Proposed Action	Residual Risk		
			P	C	R		P	C	R
1.	Subsidence	Subsidence leads to direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking.	A	2	VH	Assess magnitude of subsidence impacts and possible mitigation measures.	B	4	M
		Surface runoff and floodwater collect in subsidence troughs.	A	2	VH	Drainage works and filling to maintain free draining landscape.	D	4	L
		Ecology of floodplain and creek channel changes as a result of subsidence.	B	2	VH	Assess ecological impacts and propose mitigation measures / offsets.	C	4	M
		Impact of subsidence on infrastructure.	C	3	H	Develop mine plan to minimise potential impacts on infrastructure. Repair or relocate infrastructure as necessary to maintain function.	D	4	L
2.	Groundwater	Drainage of alluvial aquifer into workings via cracking of Permian rocks.	A	2	VH	Account for effect of drainage of alluvial aquifer in assessing mine inflows.	D	5	L
		Saline Permian groundwater inflow to Bowmans Creek resulting in increased salinity in Hunter River.	C	3	H	Re assess flow direction resulting from long term piezometric heads in Permian aquifer.	D	4	L
		Loss of baseflow to Bowmans Creek.	C	3	H	Assess quantum of loss. Offset against surface water licence.	D	4	L
3.	Mine Water	Excessive groundwater flow rate into underground workings.	C	3	H	Ensure pumping facilities available to cater for predicted inflow rates.	D	4	L

No	Aspect	Potential Risks and Issues	Potential Risk			Proposed Action	Residual Risk		
			P	C	R		P	C	R
						Prepare contingency plans for sudden unexpected high inflow to underground workings.			
						Minimise potential for surface water ponding that could drain to groundwater.			
		Excess volume water from groundwater sources that cannot be used in site operations.	D	3	M	Assess impact of predicted groundwater to longwalls 5-8 on site water balance (note ample water storage available in void).	E	5	L
4.	Surface Water/ Geomorphology	Long term increase in Hunter River salinity caused by flow of saline Permian groundwater via direct hydraulic connection between the Bowmans Creek alluvium and the underground workings occurring through connective cracking.	C	3	H	Re-assess long term piezometric heads and salinity in Permian aquifer.	D	5	L
		Reduction in surface water flow in Bowmans Creek.	B	4	H	Provide low permeability barrier under the base of the diversion channels.	D	4	L
		Diversion channels unstable.	C	3	H	Design channels to mimic geomorphology of existing channels including bed load transport charactistics.	D	4	L
						Rehabilitate channels to standard that provides comparable bed and bank stability to that in the existing creek.			
						Stabilise key locations (bends and ends of riffles by means of rock bars).			
		Flood damage to diversion channels.	C	4	M	Ashton undertakes to restore damaged areas.	C	5	L

No	Aspect	Potential Risks and Issues	Potential Risk			Proposed Action	Residual Risk		
			P	C	R		P	C	R
		Avulsion of diversion channels over time.	C	2	H	Assess geomorphic stability of incised channel.	D	4	L
5.	Flooding	Hydraulic regime in diversions different to existing.	C	3	H	Design channels to mimic existing.	D	4	L
		Impact to other properties from changes in flooding behaviour of Bowmans Creek and Hunter River.	C	4	M	Assess effects of diversion channels on downstream flood levels, flow and velocity.	E	5	L
		Damage to RTA bridge in large floods.	C	2	H	Maintain comparable flood conditions at RTA bridge.	D	4	L
		Scour on floodplain as a result of increased land gradients on the sides of subsidence areas.	C	2	H	Fill subsidence areas to eliminate areas of potential scour. Restrict flood frequency of floodwater flowing into subsidence areas.	E	4	L
6.	Flora and Fauna	Vegetation clearing.	A	4	H	Diversion channel and block banks located to minimise vegetation clearing and maximise retention of existing habitat.	D	5	L
						Offset clearing with high standard diversified vegetation in the diversion channels.			
		Habitat loss.	A	4	H	Rehabilitate diversion channels to provide equivalent or better riparian and aquatic habitat than existing creek.	D	5	L
						Enhance habitat value of remaining sections of existing creek through exclusion of domestic stock, weed removal and selective revegetation.			

No	Aspect	Potential Risks and Issues	Potential Risk			Proposed Action	Residual Risk		
			P	C	R		P	C	R
		Impacts to threatened species, endangered populations, endangered ecological communities, migratory species.	D	4	L	Seek to establish, manage and enhance linkages with surrounding nature corridors and rehabilitate in accordance with the ACP Landscape Plan.	D	5	L
7.	Aquatic Ecology	Impacts to surface water quality.	C	3	H	Minimise risk of saline groundwater inflow to creek.	D	4	L
						Provide erosion and scour protection to constructed channel banks.	D	4	L
		Impacts to surface water quantity.	B	4	M	Design diversion channels to minimise losses, particularly in low flows (80^{th} – 100^{th} percentile range).	D	4	L
		Significant habitat loss.	C	3	H	Design diversions to provide comparable pool habitat to that in the existing creek. Incorporate large woody debris into diversion channels to enhance aquatic habitat.	D	4	L
		Fish passage compromised.	C	2	H	Design diversion channels to provide adequate opportunity for fish passage (pools and riffle).	D	4	L
8.	GDEs	Impacts to possible Groundwater Dependant Ecosystems (GDEs).	C	4	M	Assess any impacts of changes in groundwater regime on GDEs.	D	4	L
9.	Aboriginal Heritage	Loss of or impact to items of aboriginal heritage.	C	3	H	Update Aboriginal heritage assessment for longwalls 5-9 to account for creek diversions in accordance with the DECC guidelines. Manage construction to minimise potential impact to items of archaeological significance.	D	4	L

No	Aspect	Potential Risks and Issues	Potential Risk			Proposed Action	Residual Risk		
			P	C	R		P	C	R
10.	European Heritage	Impact to items of potential European heritage. (There are no heritage sites recorded within the project site).	D	4	L	Diversions primarily within flood plain with no known structures present. Review historical aerial to check for presence of structures.	E	5	L
11.	Air Quality	Degradation of air quality during construction.	C	3	H	Develop operational practices to reduce dust generation such as: (i) Minimise disturbance area at any one time; (ii) Trafficked areas to be watered; (iii) Undertake rehabilitation as soon as practicable.	D	4	L
		GHG emissions from construction machinery.	C	4	M	Haul road lengths are as short as practicable. All machinery/vehicles/equipment is maintained in good conditions.	C	5	L
12.	Noise	Degradation of acoustic amenity from construction.	C	3	H	All machinery/vehicles/equipment is maintained in good condition. Limit construction to daylight hours.	D	4	L
13.	Traffic and Transport	Safety and traffic flow disruptions to New England Highway users, construction contractors and materials deliveries.	D	3	M	Maximise re-use of materials within the site in order to minimise quantities of materials imported to site. Undertake traffic assessment to ensure safe intersection use.	D	4	L
14.	Visual	Disturbance of visual amenity.	C	3	H	Design diversion channels with "natural" alignment and variability of channel shape. Rehabilitate diversion channels with similar vegetation to that at time of European occupation.	D	4	L

No	Aspect	Potential Risks and Issues	Potential Risk			Proposed Action	Residual Risk		
			P	C	R		P	C	R
						Rehabilitate spoil stockpiles with pasture grasses to blend with existing floodplains. Allow natural regeneration of floodplain woodland.			
15.	Social and Economic	The loss of potential significant gain for local, regional, state and national economies, through royalties, taxes and potentially employment, if the project was not approved.	C	2	H	Assess the net benefit and associated risks of the proposed diversion versus the approved mining layout.	C	2	H
16.	Rehabilitation and Final Landform	Diversion channel alignment unnatural looking.	C	3	H	Channel form and variability designed to mimic characteristics of the existing channel. Landscape architect commissioned to prepare rehabilitation plans.	E	5	L
		Excess spoil stockpiles provide unnatural looking structure on the landscape.	C	3	H	Stockpiles will be used to partially fill subsidence troughs that will develop over time. Stockpiles will be un-noticeable following full subsidence.	D	5	L

5.2 Identification of Key Issues

The purpose of the Environmental Risk Assessment process was to identify key issues where the risk of environmental impact was considered higher. These risks were considered during the development of the project in order to incorporate appropriate mitigation strategies into the design and implementation of the project. With the implementation of the proposed actions the probability and severity of the issues raised will be reduced substantially.

The Director-General's Requirements for the EA, together with agency consultation (see **Section 4.6.3**) and the Environmental Risk Assessment process, identified the key issues for assessment as:

- **Subsidence**:
  - Impacts on the alluvial aquifer from direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking,
  - Treatment of subsidence troughs,
  - Measures to minimise impacts on infrastructure;
- **Groundwater**:
  - Hydrogeology and quality of the alluvial aquifer,
  - Groundwater interaction with Bowmans Creek during mining,
  - Post mining groundwater conditions;
- **Surface water and flooding:**
  - Maintenance of comparable hydraulic conditions after construction of diversions,
  - Potential impacts upstream and downstream,
  - Water accounting and licensing;
- **Geomorphology:**
  - Long term channel stability during floods,
  - Potential for channel avulsion;
- **Landscape restoration:**
  - Measures to mitigate loss of habitat in excised section of creek;
- **Riparian and aquatic ecology:**
  - Maintenance of fish passage,
  - Measures to mitigate loss of aquatic habitat in excised section of creek,
  - Measures to mitigate loss of riparian habitat in excised section of creek;
- **Aboriginal heritage:**
  - Measures to protect known Aboriginal archaeological sites,
  - Measures to minimise harm to Aboriginal artefacts or sites identified during works;
- **Construction impacts:**
  - Measures to minimise noise, air quality, traffic impacts.

All items identified as key issues were investigated in detail by specialist consultants with expertise in the assessment and management of these particular issues. The technical effort involved in each of the specialist reports reflected the significance of the issue to the project. Each consultant provided a range of recommended actions to avoid, manage or mitigate the potential impacts. These recommendations have been considered by ACOL in developing the project proposal.

Copies of the detailed assessment studies are provided as Appendices to this EA. Relevant sections of this EA provide a summary of each of the studies, with reference to the relevant Appendix where required for more detail.

6 SUBSIDENCE

6.1 Introduction

SCT Operations Pty Ltd (SCT) was commissioned to undertake a subsidence assessment describing the impacts expected from the proposed mining of Longwalls 5 to 8 in each of the four seams. The full subsidence assessment report is provided in **Appendix 4**.

Based on this assessment and the hydrogeological assessment of Bowmans Creek alluvium, ACOL now considers that longwall mining beneath the Bowmans Creek alluvium can be carried out in an environmentally acceptable manner. This includes allowing direct hydraulic connection between the underground workings and the undermined parts of the Bowmans Creek alluvium where full panel extraction occurs.

The mine design incorporates a number of key design features (shown in **Figure 2.4**) including:

- Full longwall panel extraction (210m wide) of coal beneath the parts of the excised sections of Bowmans Creek and Bowmans Creek alluvium (particularly LW6 and LW7);
- LW6 and LW7 will be divided into two sections (A and B respectively) in order to retain a section of creek that runs east-west which is commonly referred to as the "oxbow section" of Bowmans Creek;
- Partial extraction of coal with 'miniwalls' where mining is necessary under the functioning sections of the creek in order to minimise impacts on the creek and ensure no connective cracking;
- Protection of the Hunter River and its connected alluvial aquifer water source by offsetting the start line of LW5, LW6 and LW7 by at least 200m from the Hunter River alluvium; and
- Providing adequate offsets from key infrastructure, the highly significant aboriginal "Water hole" site and Ravensworth Underground Mine (RUM) to avoid or mitigate subsidence impacts.

This subsidence assessment assumes the application of the following mitigation measures:

- In accordance with its existing conditions of consent, ACOL will maintain a free draining landscape by progressively constructing drainage works or filling subsidence areas on the floodplain, with the exception of the excised sections of the creek channel. This will minimise the potential water inflow into the mine and minimise pooling of surface water.
- The mine plan minimises subsidence in areas of the proposed diversion channels and in areas of retained sections of Bowmans Creek including riparian areas. Notwithstanding, the design of the diversions incorporates a flexible impermeable membrane below the channel which will be capable of minimising leakage from the channels in the event of minor subsidence.
- Lower seam mine plans will be reviewed and modified in response to actual subsidence and geotechnical behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice - in particular with respect to major infrastructure, Bowmans Creek, aboriginal archaeology and RUM.

6.2 Assessment Methodology

Estimates of the subsidence have been prepared based on the current best understanding of multi-seam subsidence described by Li et al (2007) and monitoring results from subsidence that has occurred as a result of mining the Pikes Gully seam in LW1 to LW4.

A stacked geometry, whereby the longwall panels of each of the four seams are directly superimposed, has been the basis for the subsidence assessment. There is some potential for the geometries in the lower seams to be varied or panels offset which would reduce the subsidence impacts on the surface. The stacked arrangement represents the worst case scenario, allowing ACOL to carry out mining studies on alternative layouts and seek approval through the SMP process following approval of the requested modification.

6.3 Subsidence Predictions

The predicted subsidence associated with mining of the Pikes Gully seam in LW5 to LW8 is shown on **Figure 6.1** while predictions for lower seams are contained in **Appendix 4**. Maximum subsidence impacts (subsidence over the centre of each longwall panel, maximum tilt and maximum strain) are expected to increase incrementally with each seam mined as shown in **Table 6.1** below.

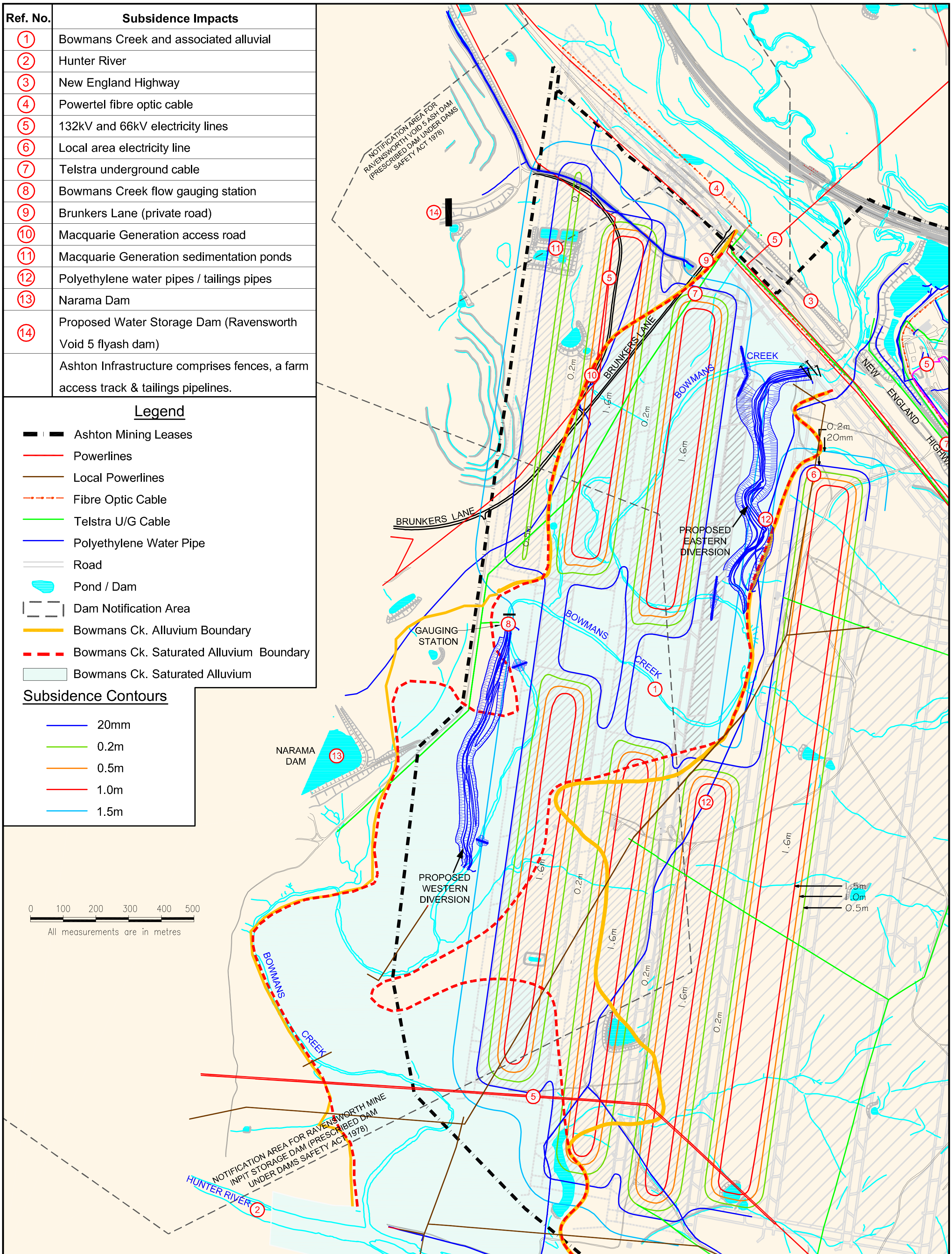
Table 6.1: Estimated Maximum Subsidence Impacts

Seam	Maximum Subsidence (m)	Maximum Tilt (mm/m)	Maximum Strain (mm/m)
Pikes Gully	1.6	70	30
Upper Liddell	3.7	150	70
Upper Lower Liddell	5.8	240	110
Lower Barrett	8.3	350	160

The maximum total subsidence below the alignment of the retained functioning east-west section of Bowmans Creek is likely to be sensitive to the overburden bridging characteristics across the narrow miniwall panels directly below the creek alignment. If the overburden bridging characteristics expected for a single seam are replicated in the lower seams, maximum subsidence below this section of Bowmans Creek is expected to be generally less than 0.4-0.5m when all the seams have been mined.

There has been a steady increase in angle of draw with depth of mining in LW1 to LW4 of the Pikes Gully seam. The angle of draw is expected to be generally of the order of 26.5° once mining in the Pikes Gully seam is complete. There is potential for the cumulative angle of draw to the deeper seams to increase above 26.5° as a result of the higher levels of subsidence associated with multi-seam extraction. If the longwall panels in the lower seams are offset, the angle of draw for each additional seam will be controlled by the outermost panel in any of the previous seams and not necessarily by the panel currently being mined.

Ref. No.	Subsidence Impacts
1	Bowmans Creek and associated alluvial
2	Hunter River
3	New England Highway
4	Powertel fibre optic cable
5	132kV and 66kV electricity lines
6	Local area electricity line
7	Telstra underground cable
8	Bowmans Creek flow gauging station
9	Brunkers Lane (private road)
10	Macquarie Generation access road
11	Macquarie Generation sedimentation ponds
12	Polyethylene water pipes / tailings pipes
13	Narama Dam
14	Proposed Water Storage Dam (Ravensworth Void 5 flyash dam)
	Ashton Infrastructure comprises fences, a farm access track & tailings pipelines.



Bowmans Creek Diversion Project

Figure 6.1
Predicted Subsidence Contours at Completion of Mining of Pikes Gully Seam

AshtonCoal

ACOL FILE: A-4063.dwg

6.4 Subsidence Impacts

Ground disturbance caused by the combined subsidence from four seams is expected to lead to the following potential impacts:

- The creation of subsidence troughs in which surface runoff and floodwater could pond and where the landscape could become significantly distorted with the potential for cracks up to 1m wide occurring and where vertical steps of several meters could develop;
- Cracking of the coal measures to the extent that there is connective cracking between the Bowmans Creek alluvium and the workings;
- Significantly impact any surface infrastructure located directly over the longwall panels, including:
  - Power lines traversing the surface above the mining area are likely to lose ground clearance;
  - Building structures (primarily owned by ACOL within the affected area) are not expected to remain serviceable and will need to be relocated or demolished;
  - Unsealed access roads are unlikely to remain serviceable during the period they are actively mined under by the second and subsequent seams. However once subsidence is complete, they can be re-established by regrading without undue difficulty;
  - The sealed section of Brunkers Lane is likely to require significant remedial work to maintain it in a serviceable condition; and
  - Buried water pipes and Telstra lines are not expected to remain serviceable. These will be relocated as necessary.
- Ravensworth Underground Mine (RUM) owned by Xstrata is planning a multi-seam underground longwall operation that shares a lease boundary with the ACOL lease. There is unlikely to be any significant interaction between the two mines for mining operations in the Pikes Gully seam. As deeper seams are mined, there is some potential, depending on the final geometries adopted, for loss of confinement to occur in the barrier pillar in overlying seams to cause pillar instability and loss of integrity of the barrier. Ashton Underground Mine is located up dip of RUM, so there is some potential for mine water that may pond in Ashton to flow through the barrier into RUM either during lower seam operations at Ashton or post mining and
- The Aboriginal archaeological sites may be impacted due to subsidence and cracking of the surface. There is the potential for the project to impact upon subsurface deposits.

These potential impacts have been assessed and evaluated, and the necessary monitoring, management and contingency actions have been incorporated into the project proposal.

6.5 Subsidence Mitigation and Management

Subsidence will occur progressively with mining of each successive seam. Impacts will be addressed, generally as part of the SMP process. ACOL will put in place management plans and consult with the owners of surface infrastructure so that impacts are either avoided or appropriately mitigated. The multi-seam nature of the ACOL and RUM operations allows impacts and contingencies to be monitored, interpreted and resultant actions included in the mine plans prior to extraction of each descending seam.

ACOL will review and modify mine plans in response to actual subsidence behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice. This will allow impacts to be addressed in the mine plan on an ongoing basis. Impacts may vary as there is a possibility that strains and tilts may vary from predictions as a result of the interaction and reworking of the fractured overburden strata above each panel. Monitoring of subsidence over LW1 to LW4 in the lower seams as each seam is mined will allow more accurate predictions of subsidence parameters above LW5 to LW8. This will inform development of subsequent mine planning.

ACOL are currently undertaking a mining study to assess the mining geometry of the Upper Liddell seam. Further review of the pillar geometry to ensure stability will be based on numerical modelling and monitoring of pillars for LW1 to LW4 following mining in the lower seams. On the basis of ongoing monitoring and numerical modelling of multi-seam operations, ACOL will also refine the multi-seam panel geometry of the miniwalls below the retained functioning section of Bowmans Creek to ensure long term overburden bridging below the creek.

The protection barriers provided to infrastructure outside the mining area, (Narama Dam, the New England Highway and bridge over Bowmans Creek, buried fibre optic cable, and power transmission lines) are expected to be sufficient, but ongoing review will occur based on monitoring experience. The actual magnitude of subsidence movement outside the area will be confirmed by monitoring in earlier panels and adjustment made to the mine plan for lower seams in order to avoid impact on these facilities.

In accordance with its existing conditions of consent ACOL proposes to maintain a free draining landscape by progressively constructing drainage works or filling subsidence areas on the floodplain, with the exception of the excised sections of the creek channel. This will minimise the potential water inflow into the mine and minimise pooling of surface water. The potential for inflow to the groundwater system and the mine as a result of subsidence has been taken into account and is addressed in the *Groundwater Impact Assessment Report* prepared by Aquaterra (**Appendix 5**) which is discussed in **Section 7** below.

The proposed diversion channels are located in areas where subsidence is predicted to be minimal. Notwithstanding, the design incorporates a flexible impermeable membrane below the channel which will minimise leakage from the channels in the event of minor subsidence. The effect of subsidence has also been considered and taken into account in assessing the flood regime that will prevail once the diversion channels have been constructed and subsidence has occurred on the floodplain (see **Section 8** and **Appendix 6**).

The physical and hydrological impacts of the proposal on the terrestrial and aquatic ecosystems has been considered and taken into account (see **Section 10** and **Appendix 9**).

Incremental remedial activities are likely to limit the width of cracks visible at any given time and soften the distortions, such as stepping, associated with large vertical subsidence. Incremental remediation will also reduce the ingress of water, injury to livestock and wildlife and entrapment of small animals.

The majority of the surface area that will be affected by mining subsidence is owned by ACOL. Buildings will be demolished or repaired depending on the degree of damage. Subsidence impacts will not affect adjoining privately owned land. Internal roads will be repaired or relocated as necessary to provide access for:

- General land management and environmental monitoring;
- Maintenance of mine surface infrastructure such a ventilation facilities; and
- Access to the adjoining dairy farm (Property 130).

Potential subsidence impacts associated with Aboriginal archaeological sites have been considered and are addressed in a separate *Aboriginal Archaeological Assessment* prepared by Insite Heritage (**Section 10** and **Appendix 11**). Impacts will be mitigated by ongoing work, including a salvage program of terrace deposits that will be confined to the area to be impacted. The methodology will be developed in consultation with the stakeholders. Consultation and reporting will be undertaken with the Aboriginal community regarding actual impact in comparison to the assessed impacts. Sections of the excised creek that are partly drained could be assessed for additional grinding grooves sites. The Water Holes site is well outside the predicted extent of subsidence (>200m) and is not expected to be impacted.

ACOL currently carries out monitoring of subsidence as specified in the development consent and the Subsidence Management Plans (SMP) Monitoring is reported to a range of stake holders as required – including DII, DoP, NOW, RTA, DSC, MSB, AATP, Energy Australia and landholders.

Several methods are used to report to stakeholders. These include: Preparation of a Subsidence Management Plan for groups of LW blocks (ie the LW/MW 5-9 SMP), Risk Assessments, End of Panel Reports, AEMR, MOP and Specialist Reports on specific locations, e.g., Narama Dam.

The SMP process outlines key monitoring protocols and processes for managing subsidence impacts which have been are followed by Ashton. These include:

1. **Ground Monitoring**:-Reports of surveys of approved Cross Lines and Longitudinal Lines plus survey of specific infrastructure.

2. **Infrastructure Monitoring and Management**: Specific SMPs have been prepared for the following surface infrastructure/features. Specific infrastructure identified in the documentation that supported the approval of the SMP for "Longwalls 5-6 and Miniwalls 7-8 only" include:
   - Private roads;
   - New England Highway;
   - Electricity transmission lines;
   - Telecommunications;
   - Fences and gates; and
   - Surface water storages;

3. **Public Safety**: Specific SMPs have been prepared for public safety.

4. **Geological Mapping** to determine structures in miniwalls that may affect caving behaviour.

5. **Environmental Management Plans** are addressed in the site management plans. As required by Section 3.6 of the development consent a range of plans have been prepared and approved. **Section 2.2.2** provides details of the environmental management regime for the ACP.

The same monitoring and management protocols will be followed in relation to subsidence resulting from the longwalls that are the subject of this proposed modification.

6.6 Subsidence Commitments

In relation to subsidence, ACOL will make the following commitments:

1. ACOL will review and modify mine plans in response to actual subsidence and geotechnical behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice.
2. The Southern limits of LW5, LW6 and LW7 will be offset at least 200m from the Hunter River alluvium.

3. ACOL will continue to monitor and manage subsidence as approved within the SMP process. Particular actions that will be include in the SMP process are:
   - A continued strategy of monitoring of subsidence over Longwalls 1 to 4 in the lower seams as each seam is mined will allow more accurate predictions of subsidence parameters above Longwalls 5 to 8. (Per Condition 3.27).
   - Complete End of Panel Reports with particular reference to subsidence.
   - ACOL will refine the multi-seam panel geometry below Bowmans Creek to ensure long term overburden bridging below the creek if ongoing monitoring and numerical modelling of multi-seam operations indicates that this is necessary.
   - ACOL will consult with Ravensworth Underground Mine to assess geotechnical and groundwater interactions and to determine monitoring criteria.
4. Filling of subsidence troughs and reshaping of the subsided landform will be undertaken as necessary to create a free-draining landscape and obviate the potential for pooling of water on the surface. This approach is expected to reduce the potential for surface pooling and inflow into the mine.
5. Additionally subsidence impacts will be managed to continue compliance with the following development consent conditions:
   - Condition 3.16: No tunnelling or mining shall occur directly underneath the piers or abutments of Bowmans Creek Bridge. The RTA must approve access tunnel layouts in the vicinity of the Bridge.
   - Condition 3.17: The angle of draw for the mine subsidence after removal of the coal is to be kept outside of the New England Highway Road Reserve.

6.7 Conclusions

Subsidence will occur progressively with each successive seam. Predictions of the magnitude of subsidence and the associated tilts and strains have been prepared using the best currently available science. Nevertheless, ongoing monitoring will be undertaken in order to permit refinement of the mine plans for the lower seams, which will be subject to the current subsidence management plan approval process.

The impacts of subsidence associated with the proposal are understood and the impacts have been assessed in the various specialist reports and are able to be managed.

7 GROUNDWATER

7.1 Introduction

Extensive groundwater investigations and ongoing routine monitoring in relation to the Ashton Coal Project has been undertaken by Aquaterra (which incorporated the practice of Peter Dundon & Associates in 2008). Based on data from these investigations and monitoring, Aquaterra has prepared a detailed groundwater impact assessment for the Ashton mining operations. A copy of the Aquaterra report forms **Appendix 5.**

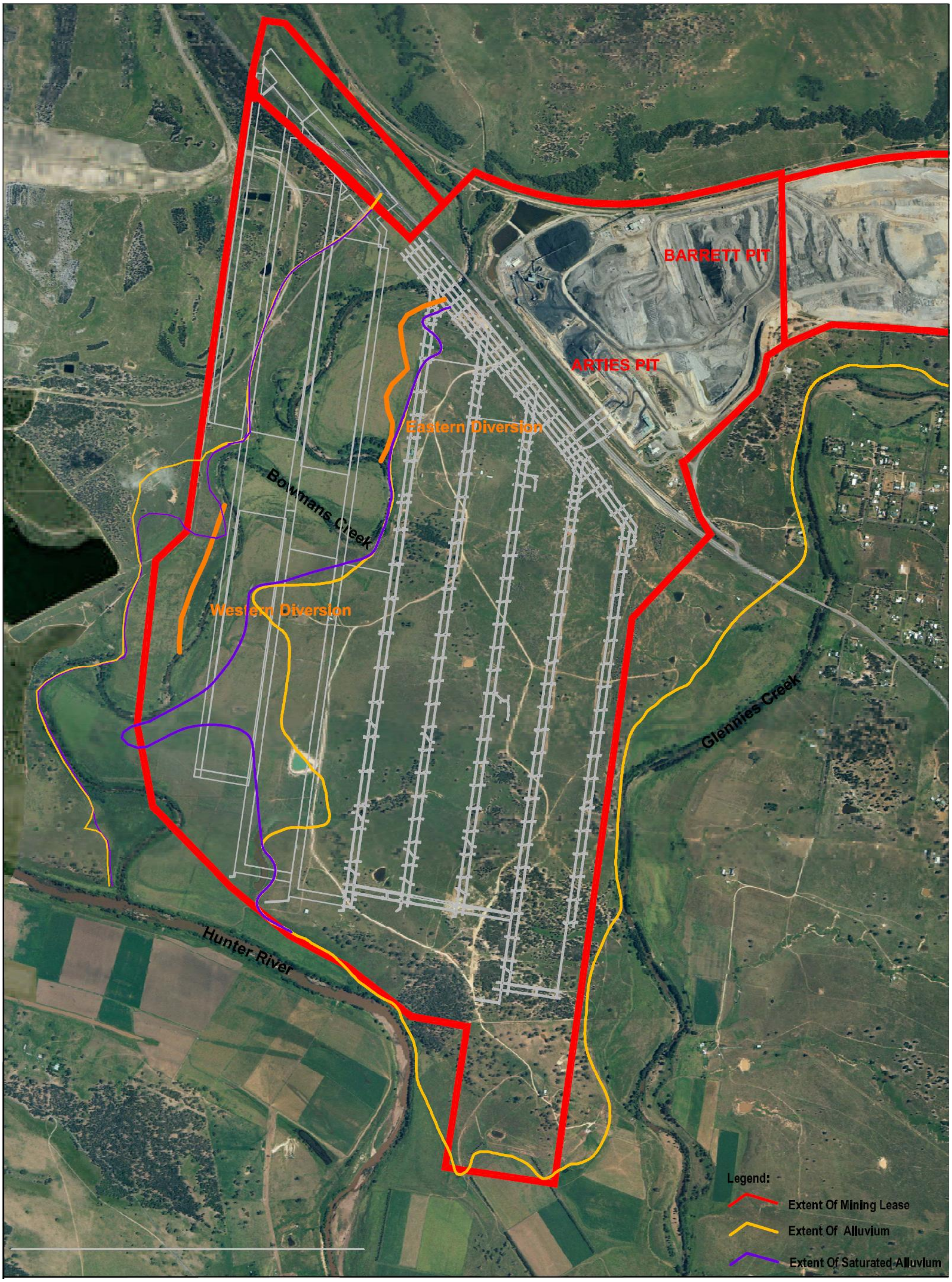
This section of the Environmental Assessment report includes a summary of the hydrogeological environment, and an assessment of potential impacts of the Ashton underground mine and proposed Bowmans Creek diversion on that environment. All other mines in the area, including the ongoing longwall mining in the adjacent Ravensworth Underground Mine, current open cut mining in the Ashton North East Open Cut and Narama Open Cut, and the proposed future development of the Ashton South East Open Cut, have been included in the evaluation of the baseline environment and provide the context for evaluation of the impact assessment of the proposed mining and creek diversion activities that are the subject of this Environmental Assessment.

For the Ashton underground mine associated with the Bowmans Creek diversion, it is proposed that longwall mining will be carried out within all four seams as proposed in the 2001 EIS, namely the Pikes Gully, Upper Liddell, Upper Lower Liddell and the Lower Barrett seams (abbreviated as the PG, ULD, ULLD and LB seams). The mine layout that has been used within this current groundwater assessment is shown in **Figure 7.1**. For the purposes of this assessment it has been assumed that all of these longwall panels will be 'stacked' (i.e. they lie directly beneath each other in each of the four seams). This represents a worst case in terms of subsidence and mining impacts (see **Section 6**), which results in a worst case assessment of groundwater impacts.

The investigations and analyses described in this section are particularly aimed at evaluating the baseline status of the Bowmans Creek alluvium, and the impacts that the diversion and connective cracking caused by longwall mining may have on the hydrogeology of the creek/alluvium system. This includes impacts on creek baseflows, alluvial water levels and water quality, both during mining and following post mining recovery. The extent of the Bowmans Creek alluvium in relation to the proposed project is shown in **Figure 7.1**.

The modelling that has been used in this assessment includes the main longwall panels and associated roadways. The small miniwall panels described in the project proposal have not been included in the groundwater modelling, as they lie within the impact footprint of the main longwall panels and the subsidence specialist reports predict that caving above the miniwall panels 'bridges' well below the alluvium (see **Section 6**). Therefore, miniwalls do not have a significant influence on the groundwater modelling.

The groundwater impact assessment includes a post-mining recovery period of 100 years. It was considered prudent also to assess the effect that an unanticipated early end to mining due to either economic, technical or consent constraints, might have on groundwater impacts. Accordingly, the groundwater recovery assessment includes a situation in which mining ceased after the Upper Liddell seam.



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Bowmans Creek
Diversion Project

Figure 7.1
Proposed Mine Layout and
Bowmans Creek Diversions

The groundwater assessment includes an evaluation of the impacts of the whole of the Ashton underground project, including the effects on Glennies Creek, the Hunter River and their associated alluvium where appropriate. Impacts on those water bodies would occur as a result of the existing approvals for the underground mine, irrespective of whether the proposed modification is approved or not.

The evaluation of groundwater takes into account the large amounts of monitoring data and improved modelling capability that has been gained since the 2001 EIS. This has provided a significantly greater understanding of the hydrogeological system and the potential impacts of the proposal. It has also provided a reliable database from which to draw data for selection of appropriate parameters for the groundwater model and calibration of the model. Accordingly, the current assessment of potential groundwater impacts has significantly greater certainty than the original EIS assessment.

7.2 Groundwater Investigations

Because the development at Ashton has been subject to a full EIS (HLA, 2001) and Subsidence Management Plans (SMPs) for the development of LW1 to LW4 and Longwalls/Miniwalls 5-9 (LW/MW5-9) in the Pikes Gully seam, there have been extensive previous groundwater investigations and monitoring borehole installations around the site. The majority of the information contained in the *Groundwater Impact Assessment* report (**Appendix 5**) is based on the data gathered from those previous studies, and from the ongoing monitoring programme together with detailed groundwater modelling based on the data gathered.

Groundwater studies were undertaken during the period 2000 to 2001 to support the EIS for approval to develop the Ashton coal project (HLA, 2001). Investigations were then undertaken during 2005 and 2006 to provide additional information in support of the underground mining, and specifically in support of the SMP for Pikes Gully seam LW1 to LW4 (Peter Dundon and Associates, 2006). This was followed during September and October 2007 by focussed investigations in and around the Bowmans Creek floodplain in order to delineate the extent of the saturated alluvium and determine the nature and properties of the alluvial aquifer system associated with Bowmans Creek (Aquaterra, 2008a). In late 2008, a report was prepared on the assessment of groundwater impacts to support the SMP application for Pikes Gully seam LW/MW5-9 (Aquaterra, 2008b). Further investigations were undertaken in 2008 and early 2009 around the Glennies Creek area on the eastern side of the Ashton Coal Project (ACP) site to support the EA for the Ashton South East Open Cut (SEOC) mining proposal (Aquaterra, 2009). Those investigations concentrated on the alluvium and colluvium on the eastern side of Glennies Creek, but also included multi-level vibrating wire piezometer installations into the underlying Permian strata.

The previous site investigations have resulted in the completion of an extensive network of investigation boreholes that have supported the detailed understanding of the local geology and hydrogeology. Where appropriate, groundwater monitoring bores have been installed as part of this drilling programme.

For the purposes of this project, a further two new standpipe piezometers were installed, and an existing exploration drillhole (WML248) was completed as a multi-level vibrating wire piezometer bore. This was done in order to provide additional information on the hydraulic characteristics of the Upper Liddell seam in the zone between the eastern side of the underground mine and the subcrop of the seam beneath the Glennies Creek floodplain, and to provide additional monitoring points in the strata below the Pikes Gully seam.

A total of 100 piezometers have now been installed across the project area. This includes 81 standpipe piezometers, 16 multi-level vibrating wire piezometers and three test bores drilled as part of the SEOC investigations. Water quality sampling has been carried out as part of the drilling investigations and piezometer installation programme.

As well as the water level monitoring and quality samples gathered during drilling investigations, a *Groundwater Management Plan* (GWMP) has been in place since 2005, which includes monthly monitoring of groundwater levels and quarterly water quality sampling for EC, TSS, TDS and pH at each piezometer. A range of other water quality parameters are monitored annually. Further details of monitoring are contained in **Appendix 5**.

Hydraulic testing involving slug tests and constant rate pumping tests has been carried out for the EIS, SMP, Bowmans Creek and SEOC investigations. The results of this testing have formed the basis of the assessment of hydraulic parameters for the alluvium and hard rock strata. Details of measured permeability are contained in **Appendix 5**.

Surface water quality for Bowmans Creek and Glennies Creek has been monitored monthly since 2000 for pH, EC and TSS. Samples are taken at five sites on Bowmans Creek, four sites on the Hunter River, and three sites on Glennies Creek (see **Figure 8.6**). In addition to this, there is a DWE monitoring station on Bowmans Creek above the underground mine area (Foy Brook 210130), which has provided continuous monitoring information up to at least August 2008. Whilst there have been some reliability issues with this monitor, it does provide useful data on the EC values within the creek during periods of high and low flow.

7.3 Existing Hydrogeological Environment

7.3.1 Geology

The study area is located within the Hunter Coalfield of the Sydney Basin. The Permian aged coal reserves within the Ashton Coal Project mining lease are mostly within the Foybrook Formation of the Vane Sub-Group (Hebden to Lemington seams), with limited occurrence of the Bayswater seam which is the basal unit of the Jerry's Plains Sub-Group. Both sub-groups are part of the Whittingham Coal Measures, the basal coal-bearing sequence of the Singleton Supergroup. Regional surface geology is shown on **Figure 7.2** and a representative geological cross section is shown on **Figure 7.3**. The target coal seams are separated by interburden sediments which comprise sandstone, siltstone, conglomerate, mudstone, and shale, as well as occasional minor coal seams. The interburdens between the target seams vary in thickness between 7m and 63m although in the proposed underground mining area the interburdens are generally of the order of 25-45m.

The main regional geological structures in the area are the Bayswater Syncline, the axis of which is located to the west of the ACP in the vicinity of the Ravensworth and Narama mines; the Camberwell Anticline, which passes to the east, through Camberwell village and the Camberwell open cut; and, further to the east, the Glennies Creek Syncline. The axes of these structures run from N to S and NNW to SSE respectively. No major faults or other significant structures or igneous intrusions (dykes or sills) are known to occur in the mining area, although minor dykes and small scale structures such as rolls or folds in the seams may be encountered in the mine.

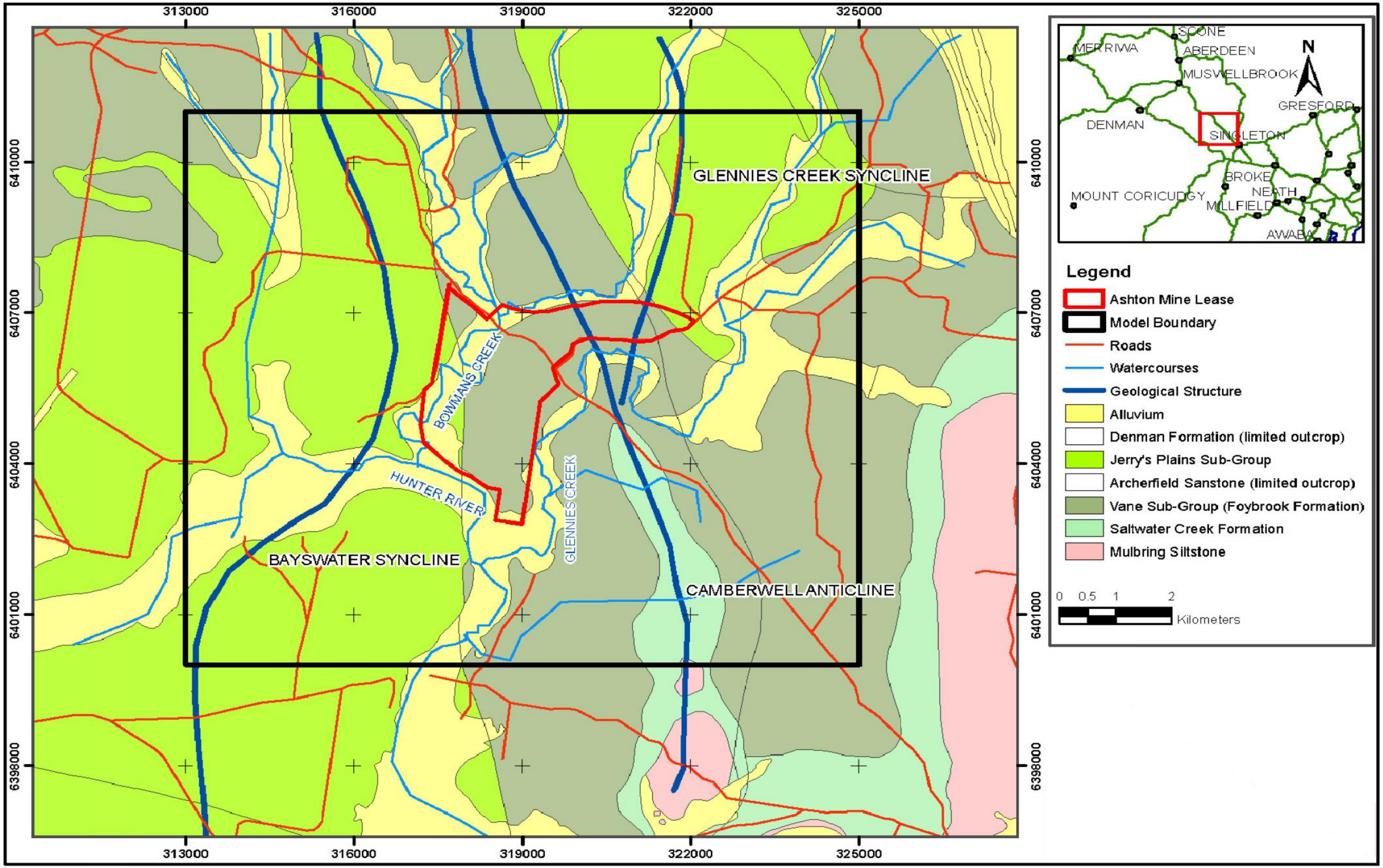

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Figure 7.2:
Regional Geology

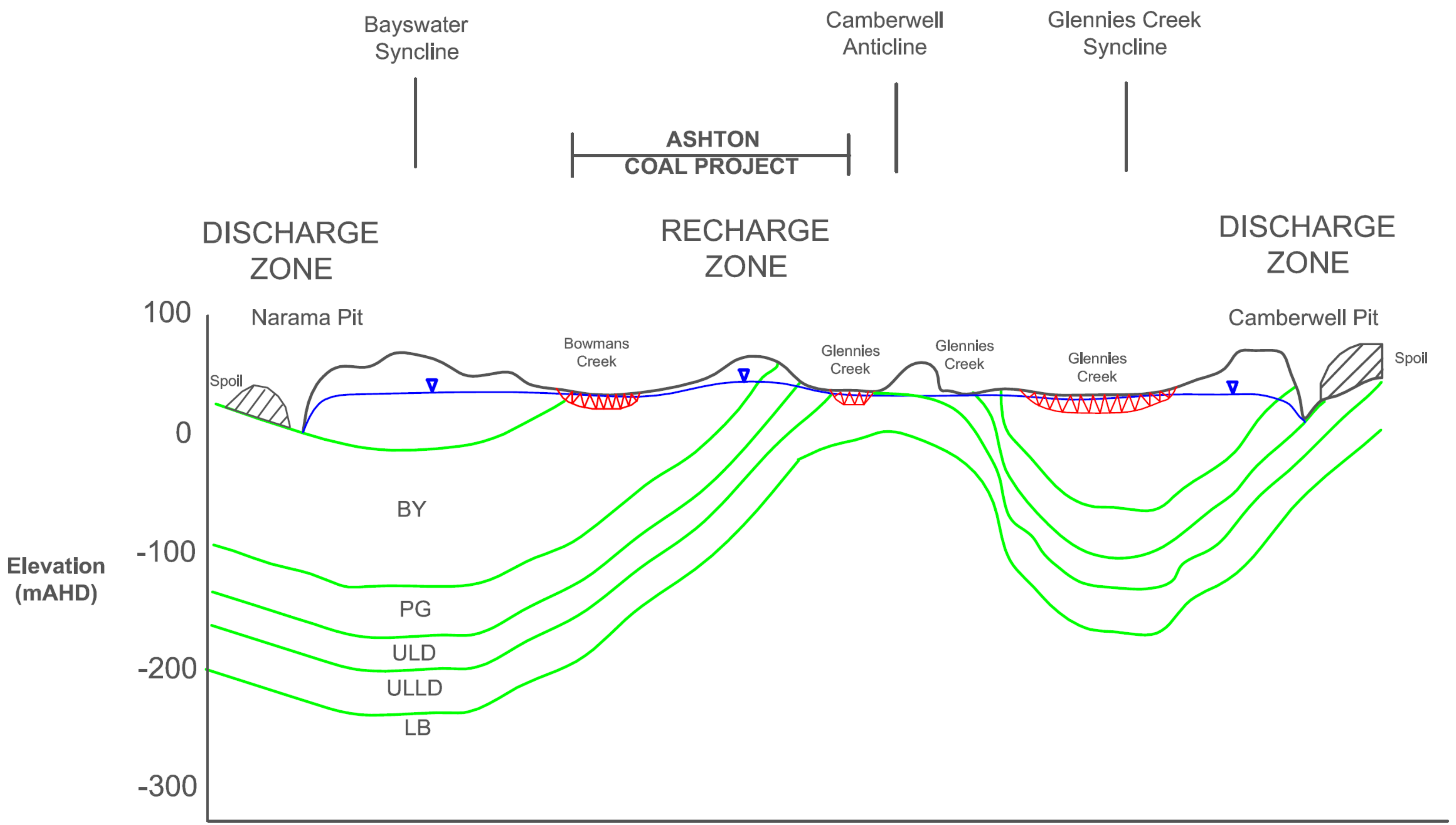

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Figure 7.3:
Representative Geological Cross Section

The Pikes Gully seam outcrops/subcrops in the eastern part of the ACP area and is up to about 200m deep (around -140m AHD) in the south west. The Lower Barrett seam, which is the deepest seam planned for underground mining at Ashton, occurs at depths ranging from 40m to more than 300m below ground (0 to -240m AHD).

Within the project area, alluvium occurs in association with the Hunter River and its tributaries Bowmans Creek and Glennies Creek. Investigation drilling of the Bowmans Creek alluvium indicated up to about 15 metres of sandy silts, silts and silty clays, with occasional horizons of silty sands and gravels, and a maximum saturated thickness of around 4.5m. Investigation drilling of the Glennies Creek floodplain and regolith has indicated up to about 8-10m of sandy silts, silts and silty clays, generally overlying coarse sandy gravels, with a maximum saturated thickness of about 4m. The Hunter River alluvium comprises clay and silty clay, with gravel horizons, and is more permeable than the Bowmans Creek alluvium, and extends to greater depth. There is a distinct interface between the polymictic Bowmans Creek alluvium and the cleaner Hunter River alluvium, with the latter extending less than 100m from the Hunter River in the ACP area.

7.3.2 Hydrogeology

The climate of the region is temperate with hot summers and cool winters. Overall there is an excess of evaporation over rainfall in all months, although rainfall and potential evaporation are close to being in balance in the winter months (June and July).

The ACP area includes three major water courses that interact with alluvial groundwater. The Hunter River lies to the south of the underground mine area, Glennies Creek flows to the east of the mine area and Bowmans Creek flows across the western part of the mine area.

Two distinct aquifer systems occur within or near the ACP area:

- A fractured rock aquifer system in the coal measures, with groundwater flow mainly in the coal seams; and
- A shallow granular aquifer system in the unconsolidated sediments of the alluvium associated with Bowmans Creek, Glennies Creek and Hunter River.

The coal measures are highly laminar sedimentary rocks, which means that the majority of the permeability is parallel to bedding, and there is very little hydraulic connectivity between layers. There is also only limited hydraulic connection between alluvial deposits and shallow weathered Permian sediments. This is evidenced by distinctly different groundwater levels, differences in groundwater quality, and differing responses to recharge or mining activity.

The presence of fine silts and clays within the cobbles and sands of the Bowmans Creek alluvium and the presence of clay layers have a strong influence on its hydraulic nature. Permeability is relatively low and monitoring results show little hydraulic connectivity with the underlying Permian strata. The Glennies Creek alluvium is similar in nature, although it appears that paleo mechanisms have served to 'clean' the sand and gravel layers in some places, resulting in localised areas of high hydraulic conductivity. The Hunter River alluvium contains relatively thick layers of cleaner sands and gravels and has been shown to have a relatively high horizontal permeability. In all cases, vertical permeability is generally low and discontinuous due to the presence of silt and clay layers within the alluvial sequence.

The overall groundwater flow regime in the pre-mining condition is controlled by recharge and discharge mechanisms. For the shallow alluvium, recharge occurs dominantly by downward percolation of rainfall, and discharge occurs mainly by lateral seepage to the river/creeks through the relatively more permeable alluvial layers. For the Permian layers, the sub-cropping coal seams are recharged by rainfall infiltrating the seams at sub-crop. Low mobility of groundwater within the strata at depth means that groundwater heads in the Permian are, in turn, largely controlled by the physical elevation of these recharge areas. Pre-mining, the Permian aquifer generally had higher potentiometric heads than the alluvium, and in some low-lying areas heads were above ground level. This resulted in observed upflows from the Permian to the alluvium in some areas in the pre-mining condition.

Elevated salinity is found within much of the coal measures aquifer system. This ranges from around 6,000 µS/cm EC (electrical conductivity) to more than 11,000 µS/cm EC within some of the less permeable Permian overburden layers. Some samples taken from shallower horizons near subcrop can be much less saline, down to 1,100 µS/cm within the Pikes Gully close to subcrop. This reflects the proximity of the subcrop areas to rainfall recharge. Samples taken from the colluvium on the flanks of the hills are also generally saline, with values recorded between 8,000 and 17,000 µS/cm EC.

The low hydraulic conductivity of the Bowmans Creek alluvium means that moderately saline conditions (up to 6,400 µS/cm) are encountered within much of the Bowmans Creek alluvium. Salinity within the Glennies Creek alluvium is generally moderate to low, particularly in the more permeable connected alluvium that contains a higher rate of through flow from surface recharge. In these areas the salinity is generally below 2,000 µS/cm EC. Higher ECs (up to 6,000 µS/cm) have been recorded in some parts of the less permeable, more 'stagnant' alluvium or colluvium that is not connected with the current stream system.

The 2001 EIS contained a number of key conclusions about the groundwater associated with Bowmans Creek that are no longer considered to be valid, based on the current understanding of the groundwater environment as described above. These include:

- Previously it was thought that Bowmans Creek was highly connected to its alluvium, and that there was a high rate of groundwater through-flow within the alluvial materials. Core logging and hydraulic testing from 17 boreholes (Aquaterra, 2008 – see **Figure 7.10** for locations) has shown that, unlike the Hunter River and Glennies Creek alluvium, the hydraulic conductivity of the Bowmans Creek alluvium is relatively low (around 0.5 m/d on average), and the connection with the creek is limited. This is because of a high occurrence of silts and clays within the alluvium matrix, and the absence of layers of 'clean' sands or gravels.
- Similarly, it was thought that the Bowmans Creek alluvium was a 'high quality' resource, with good water quality. The Bowmans Creek investigation programme (Aquaterra, 2008), which involved sampling from the bores referred to above over a number of years, showed that relatively low recharge rates caused by low permeability, and a lack of connectivity with the creek, have resulted in generally poor water quality within the alluvium. Measured salinities are often high, with recorded values of up to 6,400 µS/cm EC. The alluvial groundwater resource is also limited in quantity, with current assessments showing there is around 344ML of groundwater within the alluvium in the reach between the New England Highway and the Hunter River. Baseflow contributions to Bowmans Creek from the alluvium in this reach are similarly limited, only providing about 0.03 ML/d of flow to the creek. This is less than 10% of the 95th percentile low flow (0.5 ML/day) in Bowmans Creek.
- It was concluded in the 2001 EIS that under natural pre-mining conditions there was a downward flow of low salinity alluvial groundwater to the more saline Permian coal measures beneath, and that post-mining there would be a net upward flow of saline groundwater to the alluvium. It is now understood that the water quality in the Bowmans Creek alluvium is sometimes poor because in the pre-mining condition, groundwater levels in the underlying Permian were generally above alluvium groundwater levels. This results in upward leakage of saline groundwater from the Permian aquifer in some areas. The current groundwater assessment has also shown that for the current mining proposal, post-mining there will be no upward flow of saline water within the mine area, as discussed below.

7.4 Assessment of Potential Impacts

7.4.1 Assessment Process

In order to assess the impacts that the proposed longwall mining of the four seams in conjunction with the diversion of Bowmans Creek could have on the hydrogeological environment, a MODFLOW-SURFACT groundwater model was constructed to represent the operational and post mining recovery stages of the project. This model was adapted from the original model used in the 2001 EIS, but has been significantly updated and improved. The updated model contains realistic representations of other mines in the area, in particular the Ravensworth Underground Mine, the Narama Open Cut and the Ashton North East Open Cut (NEOC), as well as the proposed South East Open Cut (SEOC).

The model was first calibrated against interpreted 'steady state' pre-mining conditions, and was then calibrated in 'transient' mode against measured mine inflows and changes to groundwater heads during the first few years of open cut mining and the mining of Pikes Gully seam LW1 to LW3. This groundwater model was then used to predict the potential impacts of the proposed underground mine on groundwater levels in the alluvium and Permian, and potential impacts on 'baseflows' in the Hunter River, Bowmans Creek and Glennies Creek (ie impacts on the component of streamflow derived by seepage discharges from the alluvium or Permian aquifers). The influence of other mines was allowed for in the analysis and has been referred to where appropriate.

There are a number of physical hydrogeological effects that are expected to occur as a result of the proposed longwall mining project, which were allowed for using specific modelling approaches. These included:

- Simulation of groundwater de-watering caused by both open cut and underground mining;
- Changes to the hydraulic properties of overburden material caused by the caving and subsidence above longwall panels. This included changes to permeability during mining (which was included progressively in the modelling in accordance with the mine plan schedule), and changes to permeability and storage in the post mining recovery period. Values used for changes in permeability were based on latest industry research and groundwater observations/model calibration at the existing ACP site. Values used for changes in storage were calculated based on subsidence predictions and industry standard rock mass bulking characteristics;
- Changes to the hydraulic properties in open cut mines with the progressive backfilling with waste rock;
- Changes to the hydrogeology of Bowmans Creek due to the creation of the diversion channels;
- Changes to the geometry and hydraulic nature of the Bowmans Creek alluvium due to the creation of subsidence zones and surface cracking above LW6 and LW7. For the Bowmans Creek alluvium, it was assumed that significant increases in vertical hydraulic connectivity between the alluvium and the underlying Permian strata will occur within the subsidence zones above LW6 and LW7 once mining reaches the Upper Liddell seam. Evidence from this area shows that clays in the regolith or alluvium are generally sufficiently mobile and have sealing properties that will prevent or significantly reduce vertical leakage through cracks associated with subsidence from a single seam. This has been shown in farm dams above LW1 to LW3, where surface subsidence fractures can be seen leading into and beyond the dam, but no leakage or cracking is visible in the wetted area, and water was retained in the dams. The Bowmans Creek alluvium has been shown to have low permeability and contain clay layers that are likely to act in a similar fashion to this regolith material. However, it is considered that large amounts of subsidence will eventually cause significant disturbance in the tensile areas around the perimeter of the subsidence areas that will result in enhanced vertical connectivity around the margins of subsidence zones.

Inclusion of these effects as an integral part of the model represents a significant improvement over the modelling approach used for the 2001 EIS. In addition the model used for this assessment has the benefit of significantly more data with which to establish model parameters and calibrate the model. Accordingly, the assessment of potential groundwater impacts has significantly greater certainty than the original EIS assessment.

The impacts of the proposed mining have been assessed, together with a 100 year post-mining recovery period. As discussed previously, it was considered prudent also to assess the effect that an unanticipated early end to mining due to either economic, technical or consent constraints, might have on groundwater impacts. Due to the staged nature of mining within the four seams and the progressive nature of the impacts experienced, the mining impact assessment and the post mine recovery has been undertaken at two defined stages of mining; Stage 1 after mining of the upper two seams, (ie the Pikes Gully and Upper Liddell seams) and Stage 2 after mining all four seams. The results are presented in detail in **Appendix 5**, and are summarised in the following sections.

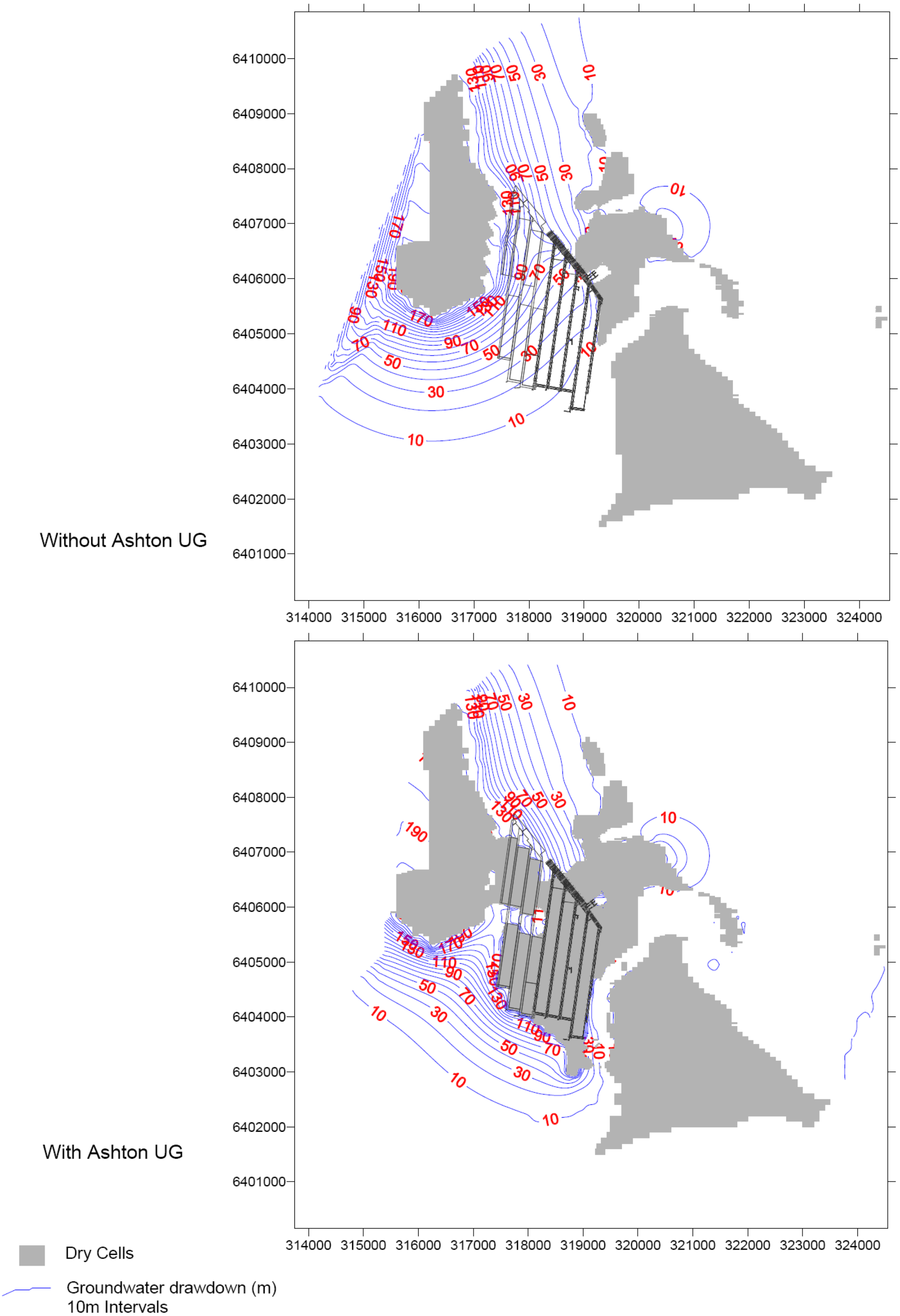
7.4.2 Impacts on Groundwater Levels and Inflows During Mining Operations

Predicted drawdowns in the Pikes Gully seam at the end of the mining in the Upper Liddell seam and the Lower Barrett seam are shown in **Figure 7.4** and **Figure 7.5**. These figures contain predicted groundwater drawdowns 'with' and 'without' the Ashton underground mine (i.e. impacts from all mines in the area compared with a base case that includes impacts from other mines, but not the Ashton underground mine). These figures show that the target coal seams and overburden within the mine footprint are predicted to be essentially de-watered during mining.

Outside of the mine footprint, the main impact from the Ashton underground mine on potentiometric pressures within Permian strata occurs to the south and south east of the mine, where drawdowns of 10m or more could occur up to 2km from the mine for the full four seam mining project. Impacts to the north, west and north east are minimal, due to the influence of other mines to the west and the fact that the areas to the north and north east are up-dip of the Ashton mine. Following mining only to the Upper Liddell seam impacts on the Permian are smaller, with the 10m drawdown contours extending about 1.5km from the mine area.

Predicted drawdowns in the alluvium and surface regolith are shown in **Figure 7.6** and **Figure 7.7**. The model results show that the impacts of the proposed four-seam Ashton underground mine on the Bowmans Creek alluvium are limited to the area south of the New England Highway and north of the Hunter River. The alluvium that is affected, between highway and the Hunter River, is predicted to be largely de-watered by the end of mining activities, as a direct result of the proposed Ashton mine. By the end of mining, saturated alluvium only remains in the southern end of this reach, between the Hunter River and the proposed Bowmans Creek western diversion, and in a small area of alluvium around the section of creek that is left in place between the two diversions. These areas remain saturated because they are locations where the existing poor vertical hydraulic connectivity between the alluvium and underlying Permian coal measures remains intact. Maximum drawdowns in these remnant saturated areas vary from around 0.5m to 2m.

Predicted impacts on alluvial groundwater levels on the eastern side of Glennies Creek are in the order of 0.1m or less by the end of mining. There is relatively little alluvium on the western side of Glennies Creek in the area closest to the underground mine, where drawdowns of up to 0.4m are predicted. The Ashton underground is predicted to cause some depressurisation of the Permian strata below the Hunter River alluvium, but predicted impacts on alluvial water levels are minimal (less than 0.1m). It should be noted that impacts on the Hunter River and Glennies Creek are generally related to the approved underground mining in the Permian, and are not specifically as a result of the proposed diversion or longwall layout associated with the Bowmans Creek diversion project.



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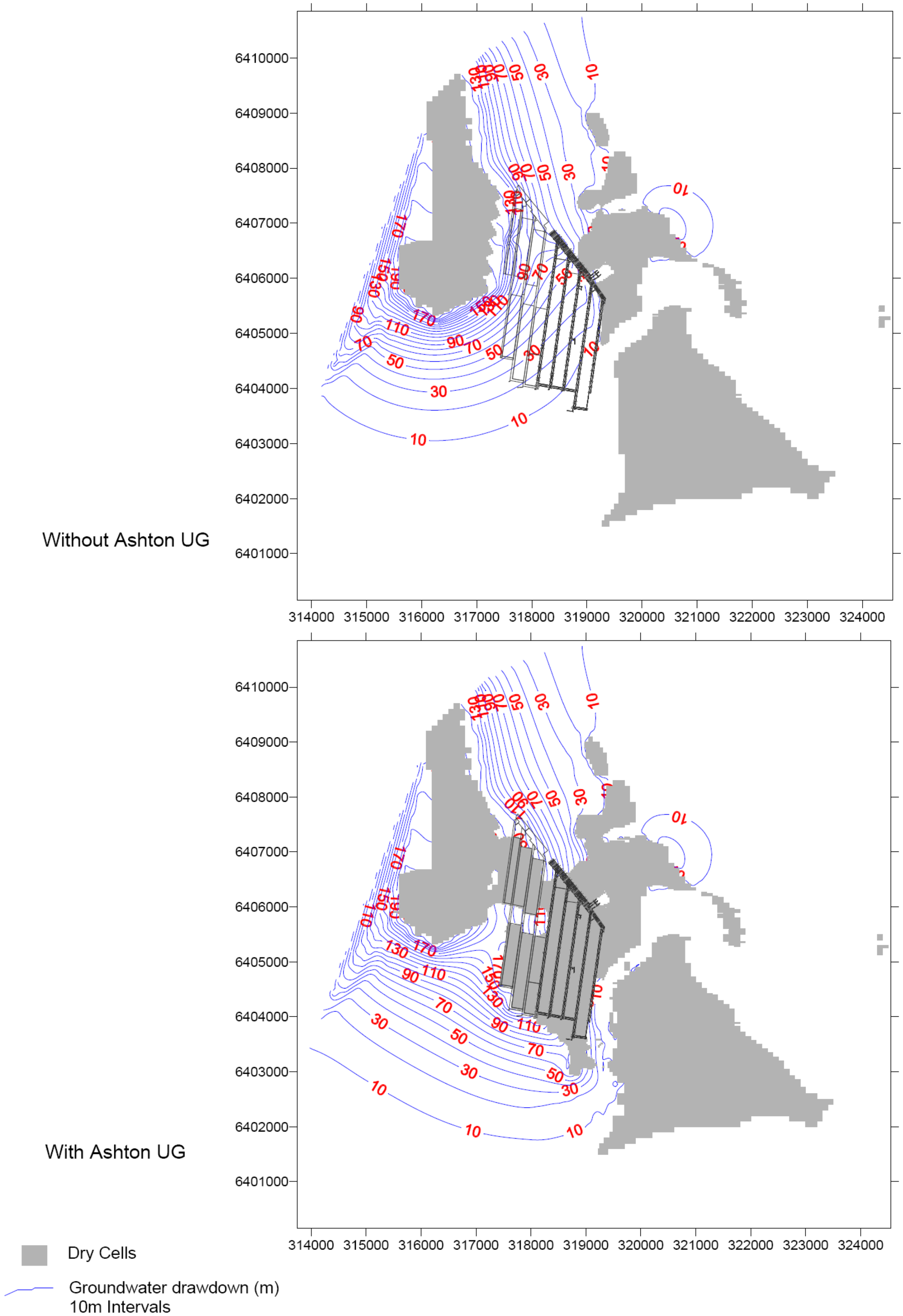
Bowmans Creek
Diversion Project

Figure 7.4
Predicted Groundwater Drawdowns in the Pikes Gully Seam at the End of Upper Liddell Seam Mining



Bowmans Creek
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Figure7.5
Predicted Groundwater Drawdowns in the Pikes Gully Seam at the End of Lower Barrett Seam Mining

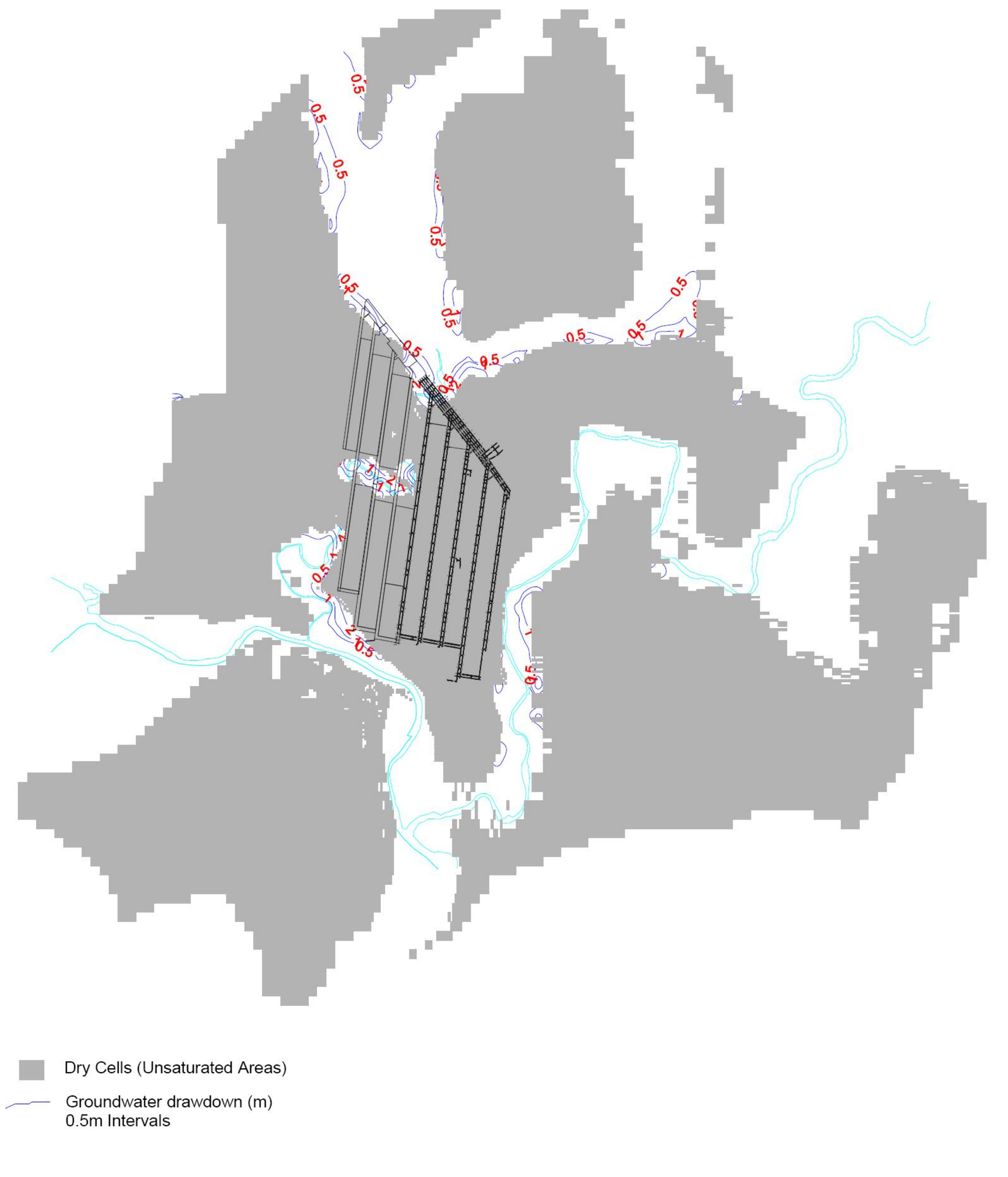

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Figure 7.6
Predicted Groundwater Drawdowns in the Alluvium
at the end of Upper Liddell Seam Mining

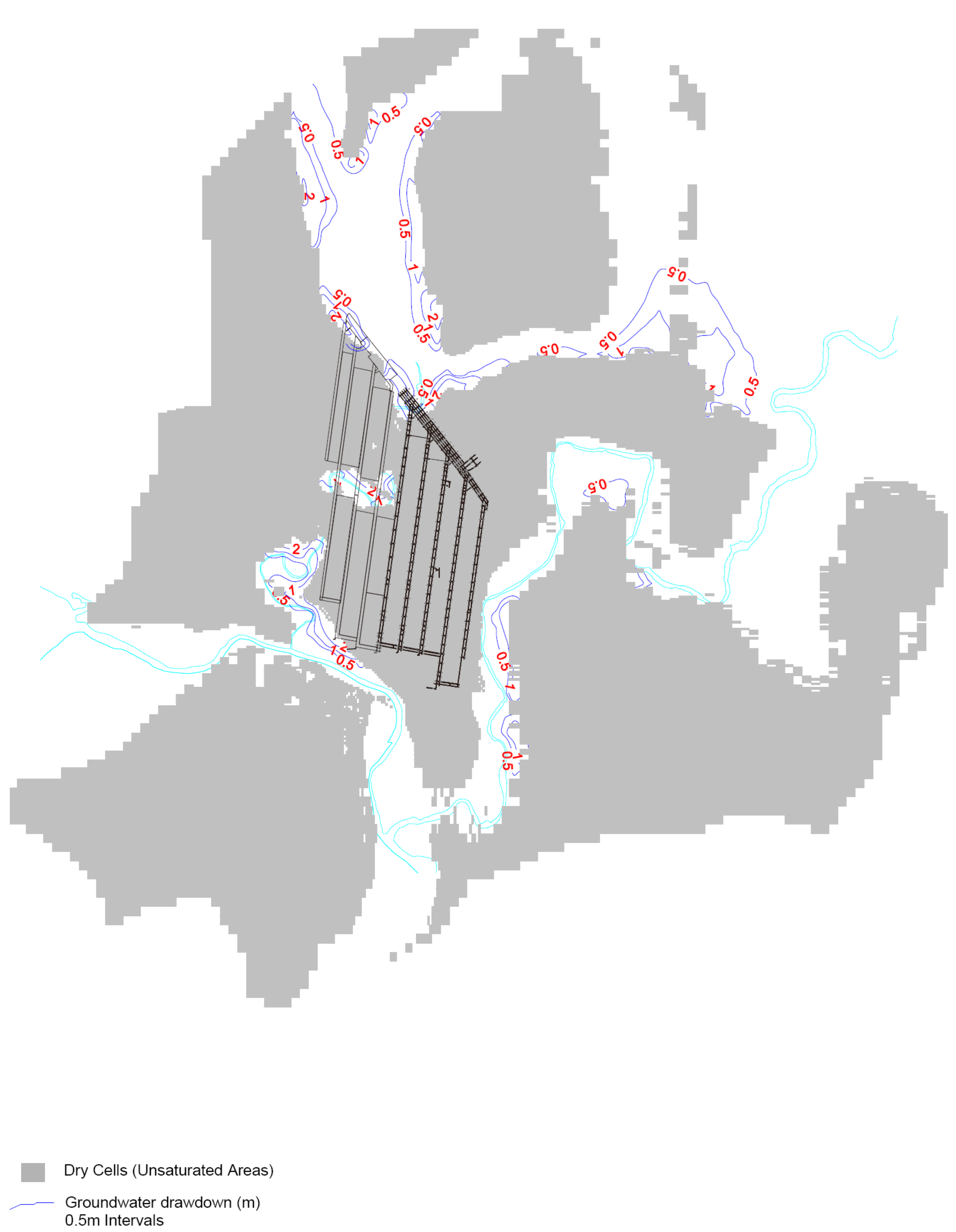

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Figure 7.7
Predicted Groundwater Drawdowns in the Alluvium at the end of Lower Barrett Seam Mining

Following mining only to the end of the Upper Liddell seam predicted impacts on alluvium and baseflows are marginally lower than those presented above. For Bowmans Creek, the area of de-watered alluvium would be similar. Impacts on the remnant saturated alluvium in the southern end of the reach would be slightly smaller, with most of the area experiencing drawdowns of less than 0.5m. For the Hunter River and Glennies Creek there would be slightly less impact on alluvium water levels, but these are marginal for the full four seam project in any case.

Inflows to the proposed underground mine have also been predicted using the updated groundwater model. Mine inflow rates during operations are predicted to reach an initial peak of around 1.4 ML/d during the start of the mining of the Upper Liddell seam. This is followed by a slight reduction, before flow rates rise again once mining of the Upper Lower Liddell seam starts. Maximum inflows of just over 1.6 ML/d are predicted to occur near the start of the Lower Barrett seam mining. There is some uncertainty over the timing and amount of surface waters that might enter the mine due to runoff recharge to the disturbed subsidence areas in the Bowmans Creek floodplain, although these have a relatively minor impact (approximately 0.1 ML/d after mining in the Upper Liddell seam reaches the Bowmans Creek floodplain).

Overall, predicted impacts during the mining phase are generally lower than the 2001 EIS predictions, both in terms of baseflow losses from the three river/creek systems, and in terms of alluvium groundwater level impacts. Mine inflow rates are also lower during the early part of mining, although inflows towards the end of mining are similar to the 2001 EIS prediction. However the majority of this is from the dewatering of the Permian coal measures.

7.4.3 Impacts on Surface Waters During Mining Operations

During mining operations, the impacts on groundwater levels described in the previous section are expected to result in the following maximum impacts on groundwater baseflows to Bowmans Creek, Glennies Creek and the Hunter River:

- Bowmans Creek is predicted to change from a position where, on average, it ‘gains’ groundwater from the alluvium and Permian in the affected reach, to a position where it loses water to the alluvium and/or Permian. The overall impact is a loss of around 0.10 ML/d up to the end of mining the Upper Liddell seam increasing to 0.13 ML/d at the end of mining of the Lower Barrett seam. The proposed placement of an impermeable lining under the diversion channels will significantly mitigate the losses that would otherwise occur. Attention should also be drawn to the fact that if the Ashton mining beneath the Bowmans Creek alluvium were not to take place and the diversions were not constructed, the impact from other mines would result in a similar total impact on Bowmans Creek baseflows in any case.
- Flow in Glennies Creek is predicted to reduce by around 0.22 ML/d after mining of the Upper Liddell seam and 0.23 ML/d after the mining of the Lower Barrett seam due to the Ashton underground mine.
- Flow in the Hunter River is predicted to reduce by around 0.05 ML/d after mining of the Upper Liddell seam and 0.06 ML/d after mining of the Lower Barrett seam due to the Ashton underground mine.

Impacts on Glennies Creek are associated with mining in the LW1 area, and most of this predicted impact has already occurred as a result of the mining of LW1 in the Pikes Gulley seam. Similarly, the impacts on the Hunter River are caused by general lowering of groundwater levels in the Permian due to underground mining, and are not specifically associated with the Bowmans Creek diversion or mining of longwall panels beneath the Bowmans Creek alluvium. All of these impacts are small in relation to the pre-mining baseflows of the affected rivers, particularly the Hunter River and Glennies Creek. The impacts on Bowmans Creek and the Hunter River generally increase steadily during the life of the underground mine.

These baseflow impacts are all smaller than those predicted in the 2001 EIS. This is due to the appropriate inclusion of the Bowmans Creek diversion within the predictive modelling, and a better understanding of the relationship between the alluvium and the underlying Permian strata.

7.4.4 Impacts on Groundwater Levels Following Post Mining Recovery

For the post mining recovery phase, the groundwater model was also used to examine potential impacts. This included allowances for the impacts from other mines in the area. Two post mining recovery runs were evaluated:

- 100 years of recovery after mining to the end of the Lower Barrett seam (i.e. the full, four-seam project). For this run, it was assumed that mining at the Ravensworth Underground Mine (RUM) stopped at the same time as the Ashton underground mine, even though at current mining rates, RUM would not have reached the Lower Barrett seam by the time Ashton is scheduled to have completed mining. This was done to ensure clear visibility of the maximum post mining recovery impacts from the Ashton underground mine.
- 100 years of recovery after mining to the end of the mining of the Upper Liddell seam (i.e. recovery if mining stops after only two seams). For this run, the RUM was run operationally for the first 9 years of the recovery run, in order to ensure consistency between the two sets of results.

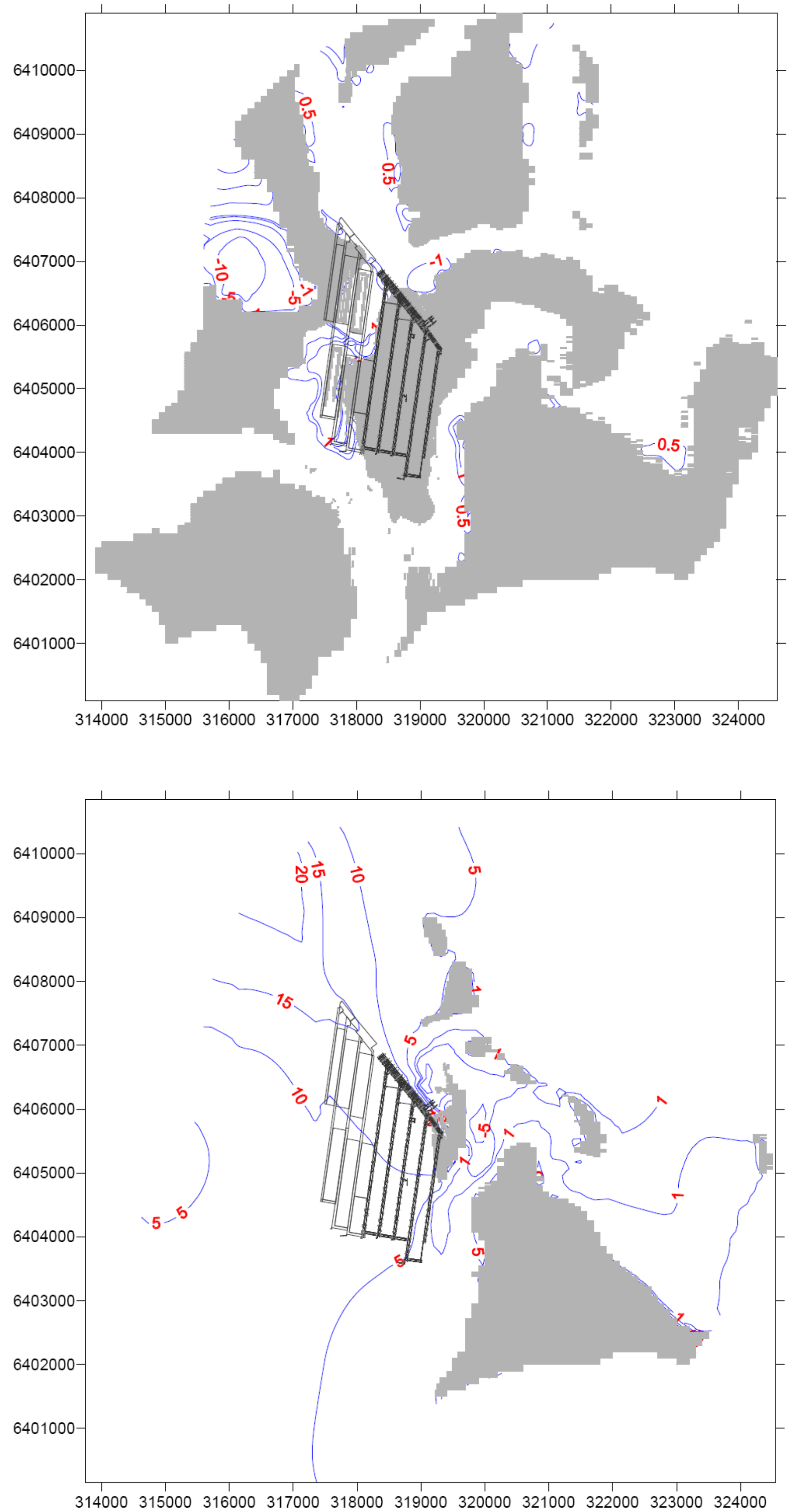
During the post mining period, the groundwater within the mine workings and caved overburden will be highly connected. Post recovery groundwater levels within the workings and caved overburden will reach a dynamic equilibrium, where inflows from the surface and other strata balance outflows from the mine area. Conservative allowances were made within the modelling to allow for runoff recharge to the backfilled subsidence areas on the Bowmans Creek floodplain, and for the occasional flood inundation of the old creek channel above LW6B.

These changes result in some long term impacts to water levels within the Permian strata. Residual drawdowns, comparing final, post recovery groundwater levels against pre-mining steady state conditions in the Pikes Gully seam, are shown in **Figure 7.8** and **Figure 7.9**. Following recovery from the proposed mining project, drawdowns of up to 15m are seen within the Pikes Gully seam in the mine area, extending to the south and south west in response to the 'flattening' of piezometric heads in the Ashton and Ravensworth underground mine areas. A similar response is seen following recovery if mining were to cease after the Upper Liddell seam, although potentiometric heads around the mine workings would be slightly higher, and residual drawdowns would therefore be slightly lower.

Predicted residual drawdowns in the alluvium and surface regolith are shown in **Figure 7.8** and **Figure 7.9**. This shows that the changes in the hydrogeological regime within the Permian do not significantly affect the alluvium and there is negligible residual drawdown in the Hunter River or Glennies Creek alluvium from either project. Small sections of the Bowmans Creek alluvium will remain dewatered, generally those areas around the perimeter of subsidence zones, where a high degree of vertical connectivity will remain between the alluvium and the underlying Permian. Predicted residual drawdowns in the remainder of the Bowmans Creek alluvium are generally small (<1m).

Alluvium

Pikes Gully Seam



Dry Cells

Drawdowns (m)

(Note: negative values indicate heads at higher in the post mining than the pro-mining condition)

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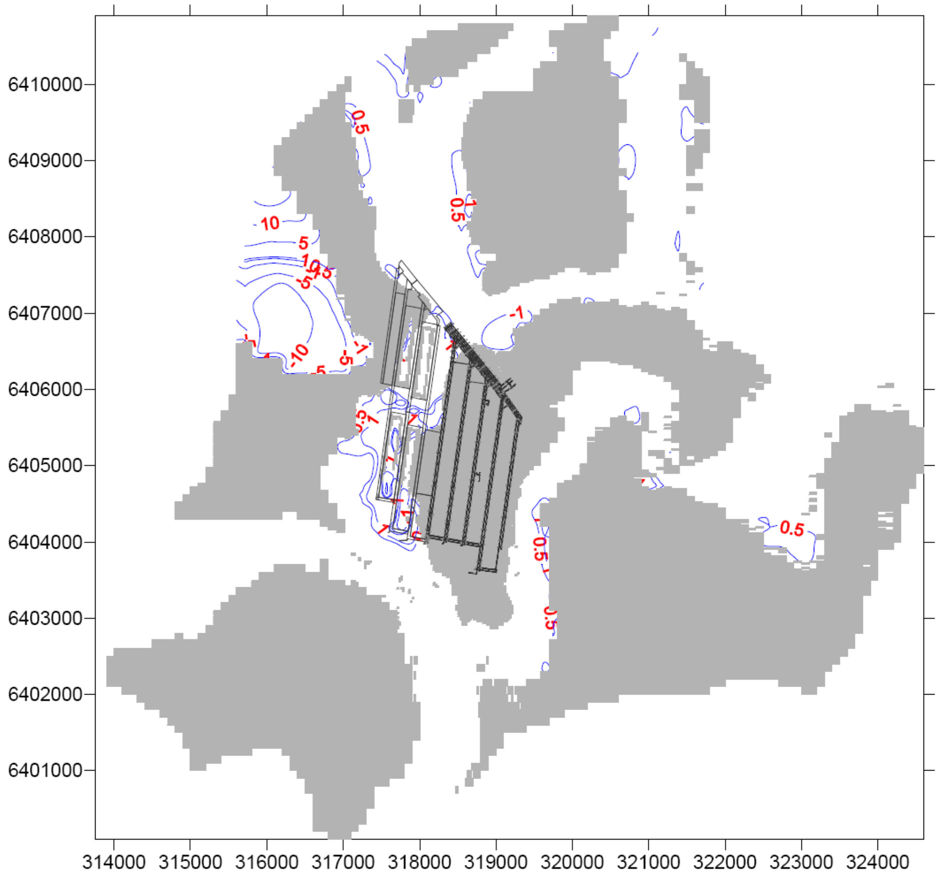
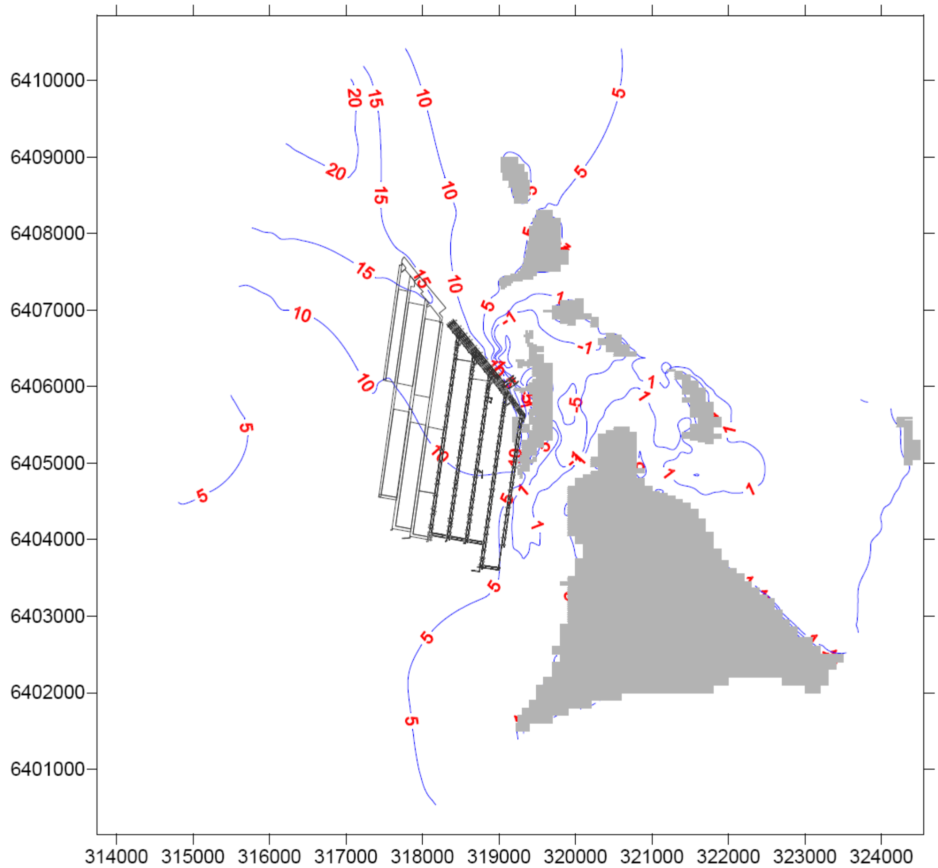
Figure 7.8
Residual Drawdowns in the Alluvium (Layer 1) and Pikes Gully Seam for the Upper Liddell Seam Recovery Run

Alluvium



Pikes Gully Seam



Dry Cells

Drawdowns (m)

(Note: negative values indicate heads at higher in the post mining than the pro-mining condition)

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Bowmans Creek
Diversion Project

Figure 7.9
Residual Drawdowns in the Alluvium (Layer 1)
and Pikes Gully Seam for the
Lower Barrett Seam Recovery Run

7.4.5 Impacts on Groundwater Quality Following Post Mining Recovery

The only potential impact to groundwater quality will come from the risk that changes in the post mining hydrogeological environment could cause saline waters within the mine workings and caved overburden to leak upwards to the Bowmans Creek alluvium through the connective cacking that occurs above the abandoned longwall panels. However, detailed analysis of the post mining recovery modelling shows that the dynamic equilibrium that groundwater heads reach within the mine workings and caved Permian overburden are lower than the water table that establishes within the Bowmans Creek alluvium. There will therefore be no upward movement of water from the mine workings to the alluvium, and hence no risk of saline flow. Indeed, the modelling shows that groundwater heads in the Permian will be slightly lower than in the pre-mining condition, and that upward flow from the Permian to the alluvium will no longer occur. Groundwater quality within the Bowmans Creek alluvium should therefore be better than in the pre-mining condition.

7.4.6 Impacts on Surface Waters Following Post Mining Recovery

The lower groundwater levels in the Permian and the changes to the hydrogeology of the Bowmans Creek alluvium do mean that there will be a slight reduction in post mining recovery baseflows when compared with the pre-mining baseline condition, as follows:

- For Bowmans Creek, the changes to the hydrogeological regime and the construction of the diversions mean that baseflows will be slightly lower than the pre-mining condition. The reduction would be around 0.06 ML/d from the full proposed project, or 0.056 ML/d if mining did not proceed past the Upper Liddell seam.
- Baseflows to the Hunter River will return to near baseline conditions, and will be only around 0.015 ML/d less following recovery. If mining were to cease early after the Upper Liddell seam, post-mining baseflows would be around 0.012 ML/d less than pre-mining.
- Baseflows in Glennies Creek are predicted to be around 0.055 ML/d lower following post mining recovery than they were in the baseline condition. This is mainly caused by the fact that post-mining equilibrium groundwater heads in the Pikes Gully seam will be lower than pre-mining levels, so there will still be some ongoing leakage from Glennies Creek alluvium to the mine workings on the eastern side of LW1. These are modelled values, which do not allow for the reduction in permeability that has been seen within the monitored flows from the Glennies Creek alluvium to the mine workings since mining first started. This is thought to be probably caused by progressive clogging of cleats and fissures in the coal seam within that region, and in the long term it is expected that the permeability would reduce even further. This means that the modelled impact on Glennies Creek baseflow is likely to be over-stated, and actual post mining recovery baseflow impacts are likely to be less than 0.03 ML/d.

As discussed previously, the impacts on Glennies Creek occur due to the mining of LW1, and the impacts on the Hunter River are caused by general lowering of Permian groundwater levels around the abandoned Ashton and Ravensworth mines. These are not therefore directly associated with the diversion of Bowmans Creek or the mining of longwall panels beneath the Bowmans Creek alluvium.

These post recovery baseflows are marginally less than the 2001 EIS predictions, which predicted minor increases in baseflow for all three rivers following post mining recovery. However in total this presents a more positive situation then the 2001 EIS because there will be no post-mining upward flow of saline Permian groundwater. Alluvium water quality should therefore be better than in the pre-mining condition, and water quality within Bowmans Creek, and hence the Hunter River, should also improve, particularly during drought periods. This is a significant difference from the 2001 EIS, which predicted increases in salinity in Bowmans Creek and the Hunter River following post mining recovery.

The NSW Office of Water (NOW) has indicated its concern over the potential loss of 'buffering capacity' of the Bowmans Creek alluvium as a result of mining. This essentially refers to the ability of the intermediate salinity water contained within the Bowmans Creek alluvium to act as a buffer between the creek and the upwelling, saline, Permian groundwater during drought periods. It is thought that the presence of the less saline water within the alluvium delays the encroachment of the saline Permian groundwater and hence reduces the rate of increase of salinity within the creek during drought periods. However, the modelled recovery hydrographs conclusively show that groundwater recovery will occur first within the Bowmans Creek alluvium, before potentiometric heads within the mine workings come close to surface level. This, combined with the lack of upward flow from the Permian to the alluvium, means that impacts on 'buffering capacity' are not an issue for the recovery phase.

7.4.7 Potential Impacts on Groundwater Dependent Ecosystems and Other Groundwater Users

Because impacts on river flows and groundwater levels within the Hunter River, Glennies Creek and their associated alluvium are so small, both during mining and in the post mining condition, it is very unlikely that there would be any impact on GDEs associated with those water courses. For Bowmans Creek, there will be a slight decrease in baseflows due to losses from the non-diverted sections of the creek, but these are limited to 0.13 ML/d or less. The ecological investigations described in **Section 10** show that there are no GDEs within those parts of the alluvium that are predicted to be dewatered during mining activities. Two stands of River Red Gum have been recorded, but these are further south, next to the creek between the southern end of the western diversion and the Hunter River. Impacts on alluvial groundwater levels in this area are predicted to be less than 0.5m, not sufficient to affect the river red gums.

As the Ashton underground mine does not significantly affect alluvium groundwater levels to the north of the New England Highway, or on the south side of the Hunter River, there will be no impacts on registered groundwater bores. Likewise, predicted maximum drawdowns in Glennies Creek alluvium of less than 0.1m around Camberwell village mean that there will be no impacts on the registered well there, even if it is still operational.

7.4.8 Baseflow Losses

The groundwater modelling indicates that prior to any mining, Bowmans Creek between the New England Highway bridge and the Hunter River gained about 0.03 ML/day (10 ML/year) from its alluvial aquifer. As a result of mining undertaken to date at adjoining mines as well as the ACP, the baseflow gain to Bowmans Creek is estimated to have reduced slightly to about 8.5 ML/year in 2009. The modelling indicates that by the end of mining in about 2024, this section of the creek will lose about 0.11 ML/day (39 ML/year) but that, as alluvial groundwater levels recover following completion of mining, the loss will reduce progressively and reach a 'steady state' of approximately 0.03 ML/day (11 ML/year) 60 years after the end of mining. (It should be noted that the predicted loss of baseflow from this reach of Bowmans Creek would occur as a result of impacts from surrounding mines, even if no underground mining had occurred at Ashton.)

In addition to mitigating the loss of water from the creek by providing an impermeable layer under the bed of the diverted sections of channel, ACOL proposes to offset the remaining loss of baseflow as follows:

- ACOL will offset, under existing Water Access Licences, 47.5 ML per annum to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek for the duration of underground mining. (The figure of 47.5 ML/year comprises the difference between the current gain of 8.5 ML/year and the loss of 39 ML/year at the end of mining.)
- At the conclusion of mining in the ACP underground operations, ACOL will permanently surrender existing Water Access Licences with a share component of 20 ML to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek.

(The figure of 20 ML/year is based on the difference between the current gain of 8.5 ML/year and the loss of 11 ML/year after recovery of groundwater levels in the Bowmans Creek alluvium, a net loss from current conditions of 19.5 ML/year, which has been rounded up to 20 ML/year).

7.5 Monitoring and Management

7.5.1 Existing Monitoring and Management.

There is an extensive network of existing piezometers within the Ashton mine site, which are monitored through the use of automatic loggers downloaded on a monthly basis. These are used to support the site *Groundwater Management Plan* (GMP). This currently has the following objectives and performance outcomes:

Objectives	Performance Outcomes
To maintain the quality of groundwater in the vicinity of Ashton Coal Project. To minimise impacts of the development on the alluvial aquifers associated with Bowmans Creek, Glennies Creek and the Hunter River. To ensure that any changes to the groundwater regime are monitored. To ensure that contingency plans are in place should monitoring detect variations from the predicted groundwater regime. No adverse impacts on groundwater supplies of surrounding landholders.	A groundwater monitoring program is developed and implemented. All groundwater extraction is licensed. Impacts on groundwater systems are within predictions. Results of monitoring are reported in AEMR.

In total there are 69 boreholes (standpipes and vibrating wire piezometers) that are used to monitor water quality and water levels on a monthly or quarterly basis (see **Figure 7.10**). In addition, the current level of mine inflows to the tailgate of LW1 in the Pikes Gulley are measured to determine the approximate rate of inflow from the Glennies Creek alluvium to the underground mine. Some of the boreholes referred to above have been specifically installed to measure the level response to mining in the LW1 tailgate area.

The results from this monitoring are compared against a Trigger Action Response Plan (TARP) to determine whether inflows, water levels or water quality readings are outside of the range anticipated in the original EIS or updated SMP assessments.

The TARP has been designed to allow reference to risks of impact from mining to environmental aspects identified within the mining area and surrounds. These are both predicted and unpredicted and include:

- Groundwater level;
- Groundwater quality;
- Hydraulic connection to Glennies Creek, Bowmans Creek and the Hunter River;
- Groundwater dependant ecosystems;
- Groundwater users (Private Bores);
- Cumulative Impacts.

This provides a comprehensive framework for monitoring groundwater related impacts from the Ashton mine, and has resulted in an ongoing, detailed understanding of the relationship between the mine and the hydrogeological environment. Contingency measures within the TARP are designed to ensure the timely and adequate management of impacts outside of predicted levels. This initially involves investigation by a suitably qualified hydrogeologist, followed by development of a site mitigation/action plan to the satisfaction of DoP, in consultation with the landowner, DPI and NOW.

7.5.2 Proposed Monitoring and Contingency Management.

Proposed monitoring and management requirements are fully described in **Appendix 5**. The extensive network and existing *Groundwater Management Plan* for the ACP include most of the monitoring and management measures that will be required for the Bowmans Creek diversion project, although this will be extended to include:

- Monitoring of water extracted from the mine will extend to the lower seams as these are mined, and inflows from the area closest to Glennies Creek will be monitored separately, if practicable. Once Bowmans Creek has been undermined, then inflows to that section of the mine will be recorded separately, if practicable.
- Operational monitoring will be implemented in relation to the Bowmans Creek floodplain around LW6A and LW6B, in order to assess and mitigate the operational risk posed by potential connective cracking between the underground mine and the surface water environment above the floodplain alluvium. Additional monitoring boreholes will be installed in the alluvium and Pikes Gully overburden to the southwest of LW6A and to the east of LW6B (see **Figure 7.10**). These will be monitored on a routine monthly basis with weekly monitoring over the period when mining is taking place in the seam in the immediate vicinity of the bore. If connective cracking is detected, then the construction involving raising of block banks to their final level may be implemented ahead of schedule, as discussed in **Section 12**.
- One additional borehole will be installed on the south side of the mining area (to the south of LW2) to provide monitoring down to the Lower Barrett seam in this area. This will allow the relationship between the Lower Barrett seam and overlying Permian seams to be monitored.
- Subsidence monitoring of Bowmans Creek alluvium will be undertaken across one or more of the longwalls within the Bowmans Creek alluvium to ensure that monitored results are the same as or less than the predictions.
- The TARP within the existing *Groundwater Management Plan* will be extended to include the additional water quality and level monitoring obtained from the additional boreholes described above.

7.6 Commitments

The main commitments in relation to the management of groundwater of relevance to this assessment are:

1. ACOL will offset, under existing Water Access Licences, 47.5 ML per annum to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek for the duration of underground mining
2. At the conclusion of mining in the ACP underground operations, ACOL will permanently surrender existing Water Access Licences with a share component of 20 ML to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek.
3. ACOL will account for water extracted from the underground workings under bore licences issued or required in accordance with the 2002 development consent and the *Water Act 1912*

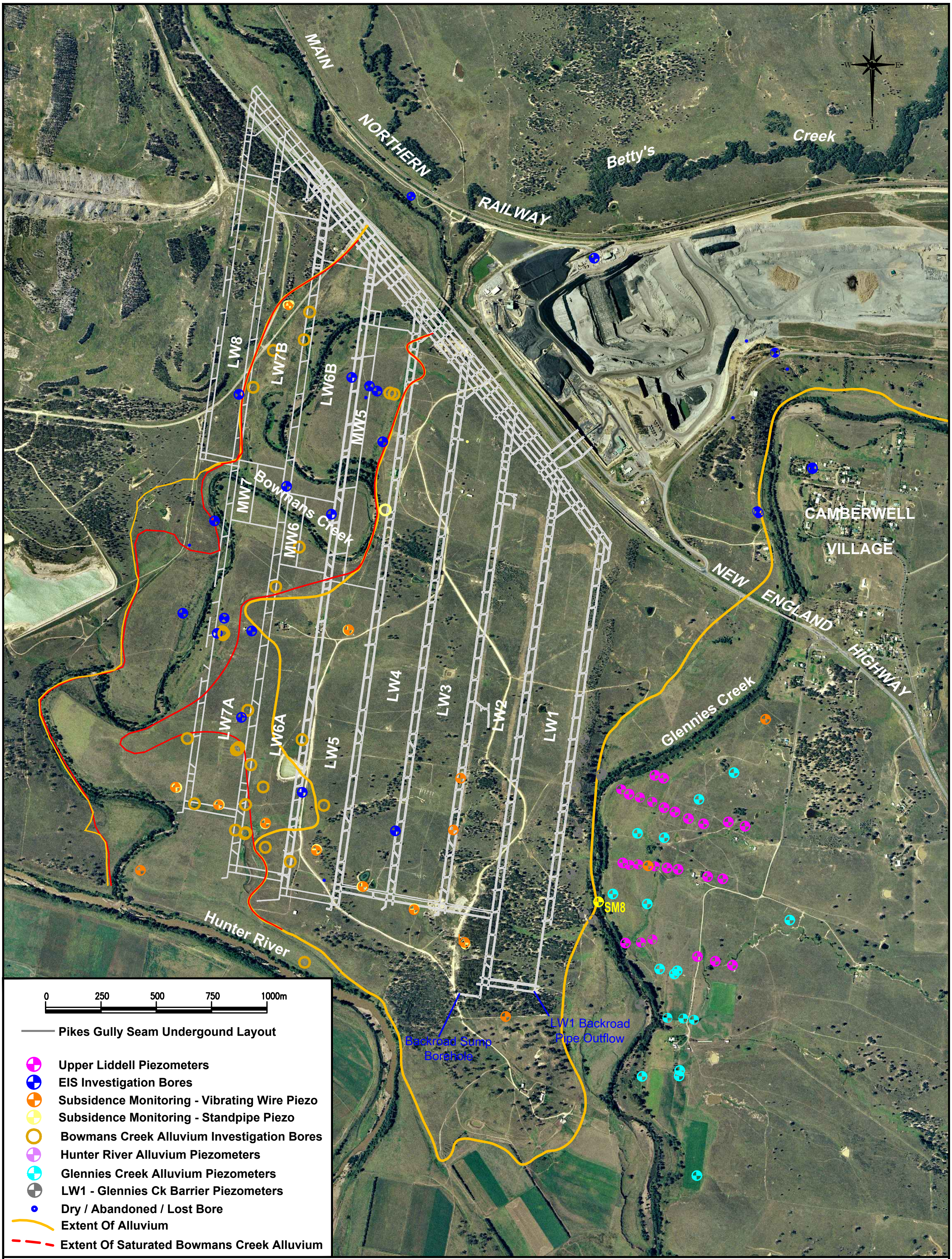
4. Subsidence troughs formed within the Bowmans Creek floodplain will be progressively filled as mining progresses.
5. An impermeable barrier will be placed beneath the Bowmans Creek diversions to minimise connectivity with the surrounding alluvium in those areas.
6. Three additional nested groundwater monitoring points 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; and
   - 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 detect any drainage of the alluvium.
7. An additional monitoring bore will be installed to the south of LW2 to provide monitoring down to the Lower Barrett seam.
8. The current groundwater monitoring network will be maintained and expanded to monitoring of water extracted from the mine workings as the lower seams are mined.
9. Monitoring of the volume of water extracted from the mine workings will be undertaken for the life of mine.
10. Volumes and qualities of individual sources of groundwater inflows will be undertaken where separation is possible.
11. Operational monitoring and response plans will be implemented in relation to the Bowmans Creek floodplain around Longwall 6A and 6B.
12. The ACOL *Groundwater Trigger Action Response Plan* will be reviewed and extended to include monitoring of the lower seam inflows as they are mined.

7.7 Conclusions

The commitment to the construction of the diversion channels and the progressive backfilling of subsidence troughs within the Bowmans Creek floodplain will minimise the impact associated with direct hydraulic connection between the Bowmans Creek alluvium and the underground workings through connective cracking. Overall this assessment shows that predicted impacts on the groundwater environment during the operational mining phase are generally lower than the 2001 EIS predictions, both in terms of baseflow losses and in terms of alluvium groundwater level impacts. Mine inflow rates are also lower during the early part of mining, although inflows towards the end of mining are similar to the 2001 EIS predictions. This change in 'profile' results from the fact that the current assessment allows for connective cracking to the Bowmans Creek alluvium during the mining of the lower seams. Impacts on GDEs and other groundwater users are not expected to be significant.

The improved hydrogeological assessment and modelling carried out for this report shows that dynamic equilibrium will be reached in the post mining recovery phase between the inflows to, and outflows from, the mine area that will effectively dictate groundwater levels within the mine and caved overburden. This will change the hydrogeological environment in comparison to the pre-mining condition, but unlike the 2001 EIS assessment, it is clear that there will be no risk to alluvium or river/creek water quality from these changes. Impacts on alluvial water levels will be generally negligible, except in some parts of the Bowmans Creek alluvium near the creek diversions. These areas are well away from any GDEs. Because of the changes to the hydrogeological environment, there are expected to be some long term losses to baseflow in rivers and creeks around the mine. However, these are limited to less than and 0.06 ML/d for Bowmans Creek, 0.015 ML/d for the Hunter River and 0.03ML/d for Glennies Creek.



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Bowmans Creek Diversion Project

Figure 7.10
Existing Groundwater Monitoring Locations

ACOL FILE: A-4061.dwg

8 SURFACE HYDROLOGY AND WATER MANAGEMENT

8.1 Introduction

The proposed modification would allow the diversion of two sections of the reach of Bowmans Creek located between the New England Highway and the Hunter River. The proposed diversions will be capable of accommodating the full range of flow conditions that affect the creek including:

- Conveying low flows with minimal or no loss;
- Conveying peak flood flows in a manner that is not subject to significant increase in the potential for scour than in the existing creek;
- Causing no significant change in upstream or downstream flood conditions.

Flow conditions in this reach of Bowmans Creek are affected by both runoff from the Bowmans Creek catchment a well as the Hunter River. Typically, the peak flow in Bowmans Creek occurs about 24 hours before the peak of the Hunter River flood at this location. However, while peak flood levels in Bowmans Creek will occur in combination with a significant flood in the Hunter, peak flow velocities, and the attendant potential to cause scouring of the creek will occur under conditions in which the Hunter River is at a low level when a flood occurs in Bowmans Creek.

In view of these considerations, specialist studies have been undertaken by Fluvial Systems (**Appendix 7**) and Hyder Consulting (**Appendix 6**) to establish the hydrology of Bowmans Creek including:

- The probability associated with a range of low and flood flows;
- The flow conditions, including the distribution of flow between the channel and floodplain under existing conditions, and the associated flow velocities;
- Flow conditions that would occur once the proposed diversion channels had been constructed.

The outcomes of these studies are described in this section, while **Section 9** provides a detailed analysis of the geomorphology of the existing creek and includes a comparison of the potential for scour in the existing creek and in the proposed diversions.

In order to direct flow into the diversion channels it will be necessary to construct block banks in the existing channels near the upstream end of each diversion channel. Block banks will also be constructed at the downstream end to prevent backwater flooding of the excised reaches of creek. The existing creek channel has sufficient conveyance capacity to carry about 5 year average recurrence interval (ARI) flood before flow overtops the banks onto the floodplain. Accordingly, the practical limit for the capacity of the diversion channels, and the height of the associated block banks is about a 5 year ARI flood. In larger floods, flow can be expected to overtop the block banks and enter the excised portions of the creek. Whilst such floods can be expected to occur once every 5 years on average, the actual sequence of such floods and their duration is a factor in the assessment of the volume of surface water available for drainage to the groundwater system once mining has finished. Accordingly, the hydrologic assessment includes an analysis of the timing and duration of floods that have exceeded the 5 year ARI flow over the period of record.

Climate change and its impact on rainfall and streamflow is a topic that receives considerable attention but remains an imprecise science. Whilst climate change may reduce the overall yield of the Bowmans Creek catchment or may lead to an increase in peak flow, such conditions would equally affect both the existing creek and the proposed diversions. The key consideration is the ability of the proposed diversions to handle a range of different flows in a manner that is comparable to the existing creek. If future climate change leads to a 20 year ARI flow occurring once every 15 years, the creek system will adapt to the new regime. For this project, the key issue is that the diversion channels should have comparable hydraulic and geomorphic characteristics and similar resilience to the existing channel.

8.2 Existing Conditions

8.2.1 Bowmans Creek Hydrology

Bowmans Creek, (officially known as Foy Brook by the Office of Water), rises in the foothills of the Mount Royal Range about 50km north-west of Singleton. The creek generally flows in a southerly direction until it joins the Hunter River about 56km from the headwaters. At its junction with the Hunter River, Bowmans Creek is a third order stream according to the Strahler system. The reach of relevance to this report comprises the final 6km of the creek between the New England Highway and the Hunter River.

At its junction with the Hunter River, Bowmans Creek has a total catchment area of 265km^2 of which about 8km^2 are located downstream of the New England Highway. A gauging station comprising a concrete weir and telemetered water level recorder is located within the area of relevance to this report approximately mid-way between the New England Highway and the Hunter River. This gauging station, known as Foy Brook, downstream of Bowmans Creek Bridge (Station 210130) has been operated since 1993 by the Office of Water and its predecessors.

The catchment is predominantly cleared rural pasture land although it includes the Ravensworth State Forest which is located in the central section of the catchment and covers approximately 5% of the total catchment area. In the low lying downstream areas of the catchment mining activities have altered land surfaces and impacted on Bowmans Creek and its associated tributaries and floodplains.

Bowmans Creek has flow data available from two gauges. The upstream gauge at Ravensworth (210042), which has a catchment area of 170 km^2, operated from 1956 to 1999. This gauge had a relatively high proportion of years with complete records while the record from the gauge downstream of Bowmans Creek Bridge (210130), which commenced in October 1993, has a high proportion of missing values. Analysis of peak daily discharge records for the period of coincident records shows that the daily peak discharge at Ravensworth is closely correlated with the daily peak discharge at downstream Bowmans Creek Bridge. This correlation has been used to extend the shorter and incomplete record from downstream of Bowmans Creek Bridge for purposes of flood flow estimation.

Two methods were used to generate flood frequency estimates for the site at downstream Bowmans Creek Bridge on the basis of the record from Ravensworth. The first method was to factor the flood frequency curve established for Ravensworth using the correlation relationship. The second method was to first factor the flow data from Ravensworth, and combine this series (1957 to 1998) with that from downstream Bowmans Creek Bridge (1994 to 2008). Where the two series overlapped (1994 to 1998), the downstream Bowmans Creek Bridge data were used, unless data were missing in which case Ravensworth data were used. A flood frequency curve was then established for this extended time series (1957 to 2008) from which the data in **Table 8.1** were derived.

Other values of discharge for various ARI have been reported in previous studies of Bowmans Creek (Patterson Britton, 2001; ERM, 2006). As set out in **Appendix 6** there are serious doubts about the reliability of the predictions of magnitudes of floods of given ARIs based on RAFTS model output and the Probabilistic Rational Method used in previous studies. Events of the size indicated by these methods do not appear with the expected frequency in the gauged record.

Table 8.1: Magnitude of Floods for a Range of ARI for the Gauge Downstream of Bowmans Creek Bridge.

Flood (ARI)	Flow (m^3/s)
0.25	9.8
0.33	13
0.5	25
1.0	62
1.25	75
2	99
5	152
10	219
20	324
30	400
50	517
75	629
100	721

As noted earlier, the flow record downstream of Bowmans Creek Bridge has a high proportion of missing data (12%). Notwithstanding the limitations of this record for purposes of defining the flood regime, the record provides the equivalent of 13.8 years of daily record (collected over a period of 15.7 calendar years) and provides a reasonable dataset from which to assess the flow duration regime for the creek, particularly the mid to low flow regime. **Figure 8.1** shows the flow duration curves for the full record and for the data for December only (3% missing data). Key statistics from this data are summarised in **Table 8.2**.

Table 8.2: Flow Duration Statistics for the Gauge Downstream of Bowmans Creek Bridge.
(Based on historic record: 1993 - 2009)

Percentile	Flow (ML/day)	
	Total Record	December
50%	2.6	3.8
60%	2.1	3.0
70%	1.8	2.0
80%	1.5	1.7
90%	0.9	0.9
95%	0.5	0.2

The data in **Figure 8.1** and **Table 8.2** indicate that the 80th percentile flow for December of 1.7 ML/day is slightly above the 80th percentile flow for the entire record (1.5 ML/day).

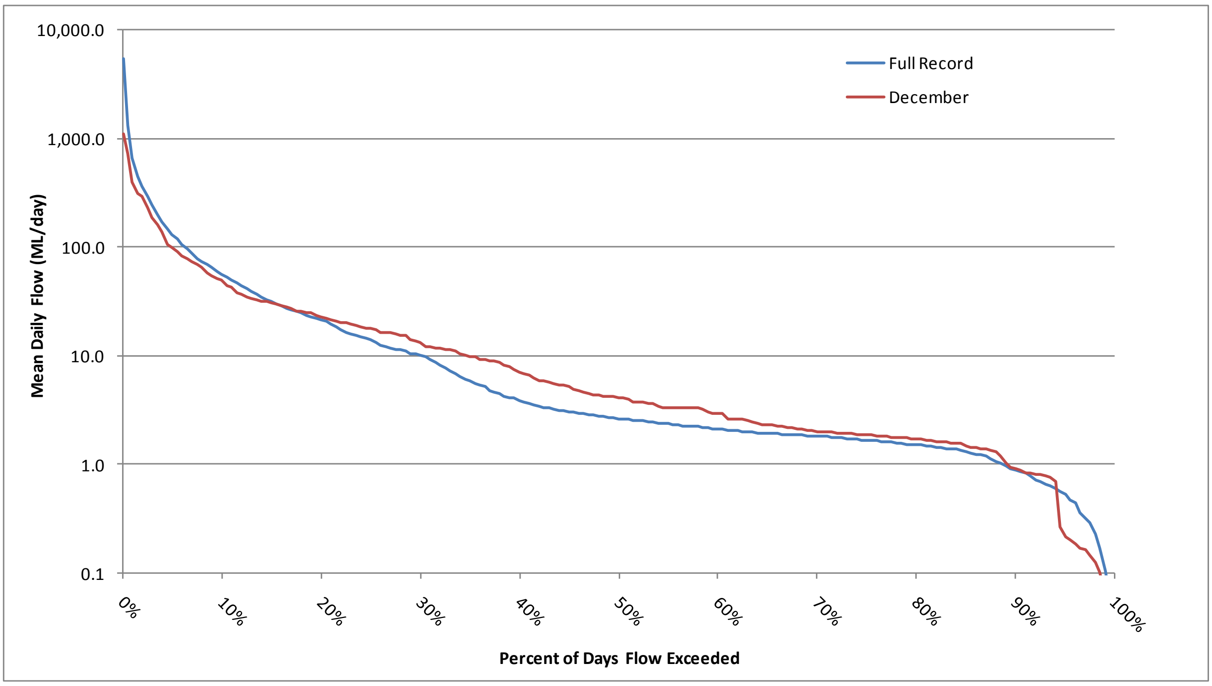

Figure 8.1:
Flow Duration Curves for the Gauge Downstream of Bowmans Creek Bridge

8.2.2 Influence of the Hunter River on Flooding of Bowmans Creek

The lower 6km of Bowmans Creek is known to be within the range of influence of the Hunter River, but this has not previously been quantified. The main problem is that the levels in the Hunter River near Bowmans Creek are not known to Australian Height Datum (AHD). The two Hunter River gauges (one just upstream of Bowmans Creek and one just downstream) in the vicinity are not tied to AHD and their record is relatively short (from 1993).

The two Hunter River gauges closest to Bowmans Creek that have stage data tied to AHD are Liddell (25km upstream) and Singleton (38 km downstream). An analysis of the river gradient between these gauges indicates a relatively narrow range of river gradient for a range of flow regimes. While it is recognised that local channel morphology and hydraulics mean that the water surface is not likely to be even along this 63km reach of river, as a first approximation, the slope of the river surface can be used to estimate the peak flood level in the Hunter River at Bowmans Creek junction, for the length of common record at Liddell and Singleton. The full (longer) Singleton record can be used by using a single (mean) value of river gradient for days when Liddell data are not available.

Flood frequency analysis for Singleton gauge, and then converting the discharges to predicted stage height at Bowmans Creek junction, (based on assumed river gradient), revealed that the Hunter River is not often at an elevation that has significant impacts on the hydraulics of Bowmans Creek (**Figure 8.2**). For example, the downstream end of the proposed Eastern Diversion is at about 59mAHD, which is reached on average once every 5 years, and the bed at the upstream end of the proposed Eastern Diversion is reached on average once every 10 years. The high-level Bowmans Creek floodplain is significantly inundated at about 64-65m AHD, and this is a very rare event to be caused by the Hunter River alone. These data were also analysed on an event (spells) basis. This revealed that there were relatively few events on record when the Eastern Diversion would be inundated by the Hunter River (bed of the lower end inundated 57 days in 93 years, median spell duration 2 days). The Western Diversion channel would be influenced by the Hunter River more frequently but for a relatively small proportion of the time (bed of the lower end inundated 342 days in 93 years, median spell duration 3 days).

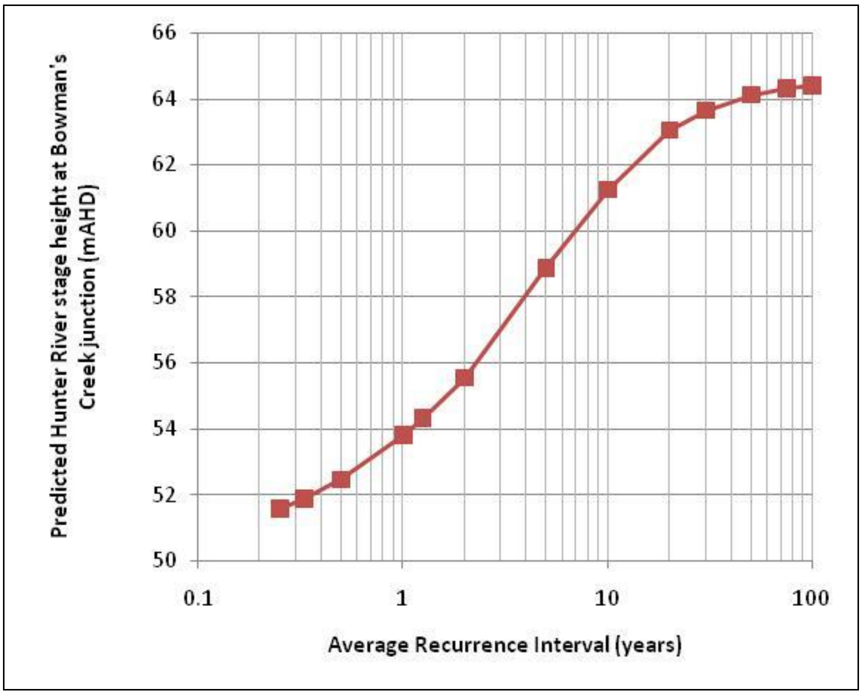

Figure 8.2:
Flood Frequency Curve for Singleton Converted to Stage Height at Bowmans Creek Junction
(Data from 1913 to 2005)

The analysis indicates that for the Eastern Diversion channel, most of the time, flood events in Bowmans Creek would act independently of the Hunter River. Although the Western Diversion would occasionally be affected by backwater from the Hunter River, most of the time, storm event flows in Bowmans Creek would be independent of the Hunter River.

Under conditions of very large Hunter River floods, Bowmans Creek will be inundated by Hunter River water. However, Bowmans Creek typically peaks one day before the Hunter River, so the Creek will still experience the hydraulic conditions imposed by high flows in Bowmans Creek itself.

8.2.3 Frequency and Duration of 5 Year ARI Flows

As noted in **Section 8.1** the practical limit to the height of the upstream block banks is level corresponding to a 5 year ARI flood. The block banks are designed to allow events greater in magnitude than about a 5 year ARI flood (152 m^3/s from **Table 8.1**) to spill into the existing Bowmans Creek channel. For purposes of understanding the likely sequence of such floods, based on the historic records, a peak daily discharge series was generated. This is described in detail in **Appendix 6**.

Over the 54 year long modelled period, there were 15 spells that would have been likely to have created spill over the block banks into the existing sections of channel. **Figure 8.3** shows the duration in days and the time of occurrence of these events and indicates that the series is represented by relatively long periods between events (7-8 years) interspersed with several events in close succession. Most of these events would have been large enough and of sufficiently long duration to fill the excised sections of the existing channel (after allowing for predicted subsidence).

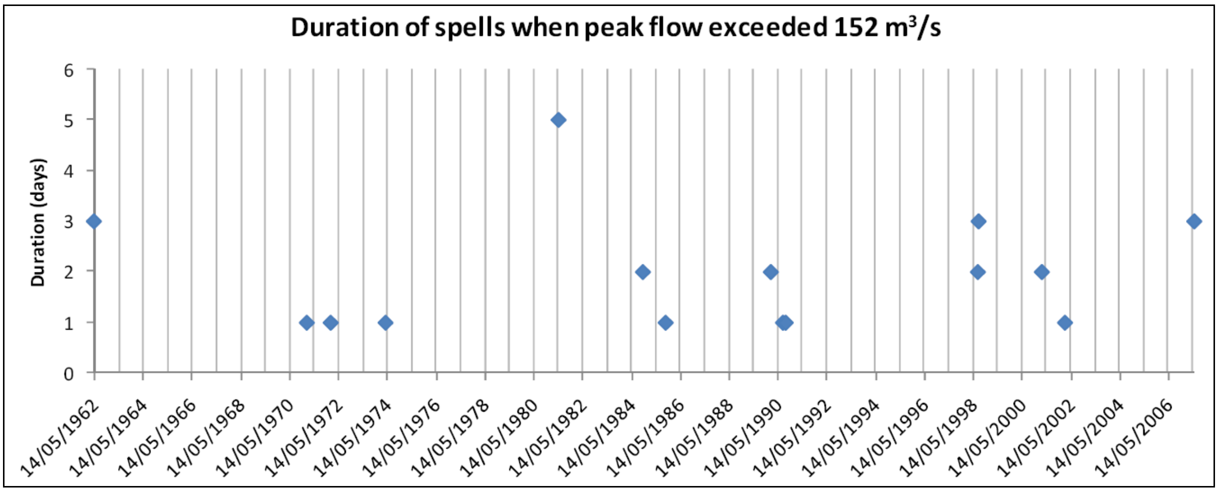

Figure 8.3:
Duration of Spells Exceeding the 5 Year ARI Event

8.2.4 Flood Regime in Bowmans Creek

A detailed assessment of the flow distribution, hydraulic conditions and flood levels within the channels (existing and constructed diversions) has been carried out by Hyder Consulting using a two dimensional hydrodynamic model (TUFLOW). The full *Flood Study* report is provided in **Appendix 6**.

TUFLOW is a computer model that provides two-dimensional and one- dimensional solutions of the free-surface flow equations that simulate flood and tidal wave propagation. Two dimensional modelling was adopted for this work so as to take account of the hydrodynamic behaviour of the meandering channel system and its interaction with the overbank floodplain.

The TUFLOW model extends from just upstream of the New England Highway downstream to the confluence of Bowmans Creek with the Hunter River. For this study the channel and floodplain topography and hydraulic roughness characteristics for the TUFLO model were derived from:

- A digital terrain model based on aerial laser survey provided by Ashton Coal. This has been used to represent the general floodplain with a 5m model grid.
- Thirty five ground survey sections across Bowmans Creek provided by Ashton Coal.
- Site inspection during the course of this study to determine waterway and floodplain roughness characteristics.

For purposes of assessing flood conditions the flood hydrographs for various magnitude floods were generated using a rainfall:runoff model (RAFTS) that was "calibrated" to give approximately the same the peak flows for a nominated ARI as those determined by the flood frequency analysis (**Section 8.2**). Rainfall runoff modelling of the Bowmans Creek catchment indicated that 12 hour to 18 hour storm durations result in maximum runoff through the lower end of the catchment and at the confluence with the Hunter River.

A recent surface water assessment on the neighbouring Glennies Creek (‘*Ashton Coal South East Open Cut Project Surface Water Assessment’*, 3 July 2009) supports the assessment in **Section 8.2.2** that flooding on the Hunter River is likely to occur relatively independently to that of the Bowmans Creek catchment. Due to this independence and because Hunter River flooding would tend to mask flow regime changes on Bowmans Creek resulting from the proposed diversions (e.g.

flood levels and extents, velocities, etc.), the assessment of flow conditions primarily focused on Bowmans Creek flow regimes with low level Hunter River levels.

Appendix 6 presents figures showing the flow regime for the existing channel and floodplain between the New England Highway and the Hunter River for 1 year, 5 year, 20 year and 100 year ARI floods. For purposes of illustrating the key features of the flow regime, the figures for the 5 year and 100 year ARI floods are reproduced in **Figure 8.4** and **Figure 8.5**

The key features of the flow regime in Bowmans Creek when Hunter River water levels are low are:

- Flows are generally contained within the bank along Bowmans Creek in the 1 year ARI event, with only minor breakouts occurring locally at several upstream 'remnant meanders' in a 5 year ARI flood (**Figure 8.4)**. Major breakout flows extending through overbank areas occur in events greater than the 20 year ARI. Up to the 100 year ARI event (**Figure 8.5**) such breakout flows are most significant in the 1km length of floodplain immediately downstream of the New England Highway bridge, with depths of up to 2m on the floodplain. Flow velocities on the floodplain are significantly lower than in the channel.
- Velocities within the Bowmans Creek main channel generally vary from about 1.5 m/s to 2.0 m/s in the 1 year ARI event, except at the upstream of the site through the New England Highway bridge where velocities are shown to be greater than 2.0 m/s. In a 100 year ARI flood the main channel velocities generally vary from about 2.6 m/s to 3.8 m/s, although the velocity through the Highway bridge is greater than 4.2 m/s. Such high velocities through the bridge waterway are consistent with observed scouring that occurred as a result of the June 2007 flood event which had an ARI of about 37 years.

A figure showing the effect of a 100 year ARI flood in the Hunter River coincident with the 1 year ARI flood in Bowmans Creek flows is also included in **Appendix 6**. This condition indicates a drowning out of the Bowmans Creek system by the Hunter River flood level, with associated velocity decreases along the Bowmans Creek channel. The analysis indicates that under these conditions the Hunter River influence extends upstream almost to the New England Highway, but does not influence the flow regime through the bridge waterway.

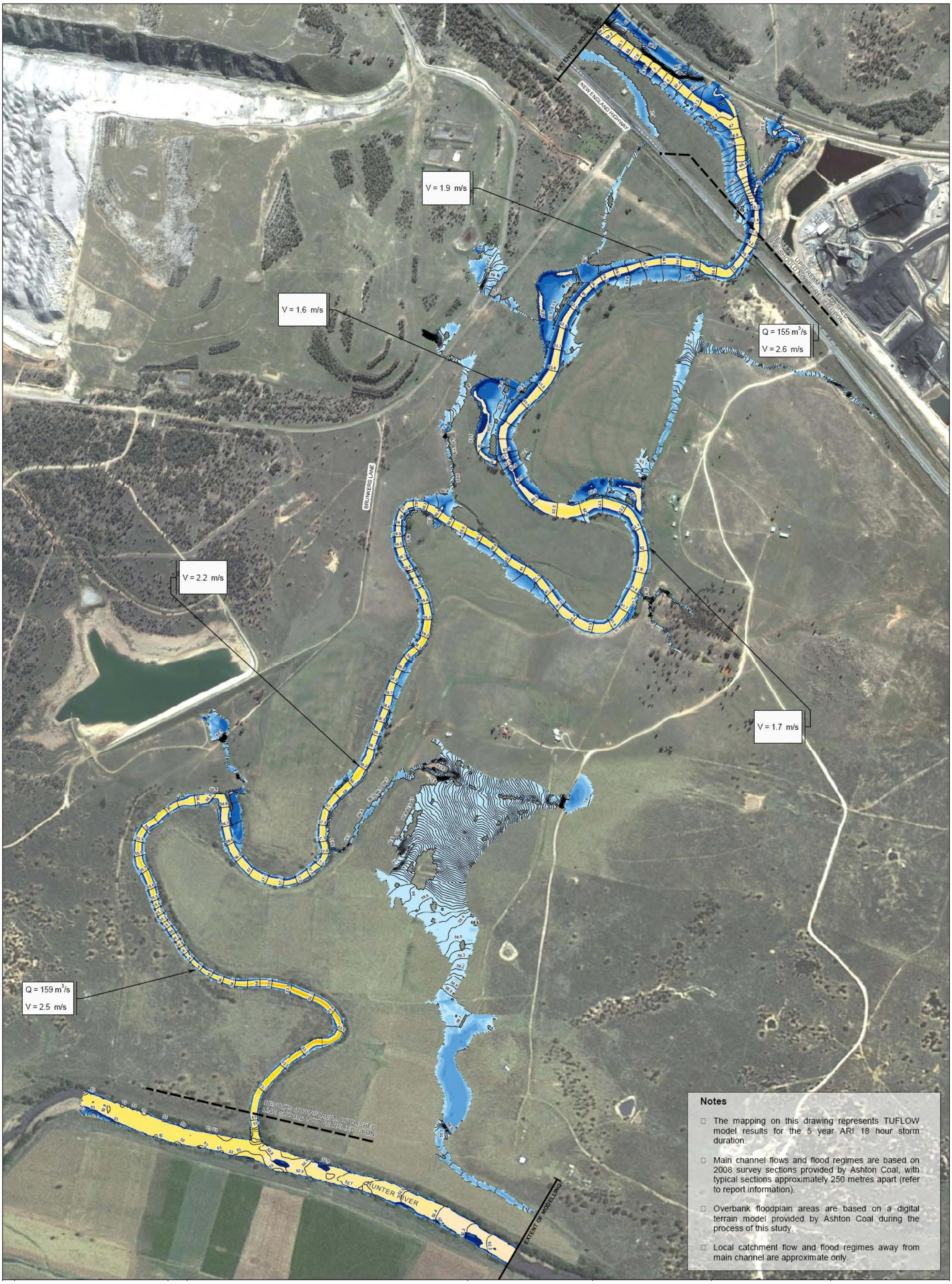

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Figure 8.4:
Flow Conditions in Bowmans Creek in a 5 Year ARI Flood
(Source: Hyder Consulting)

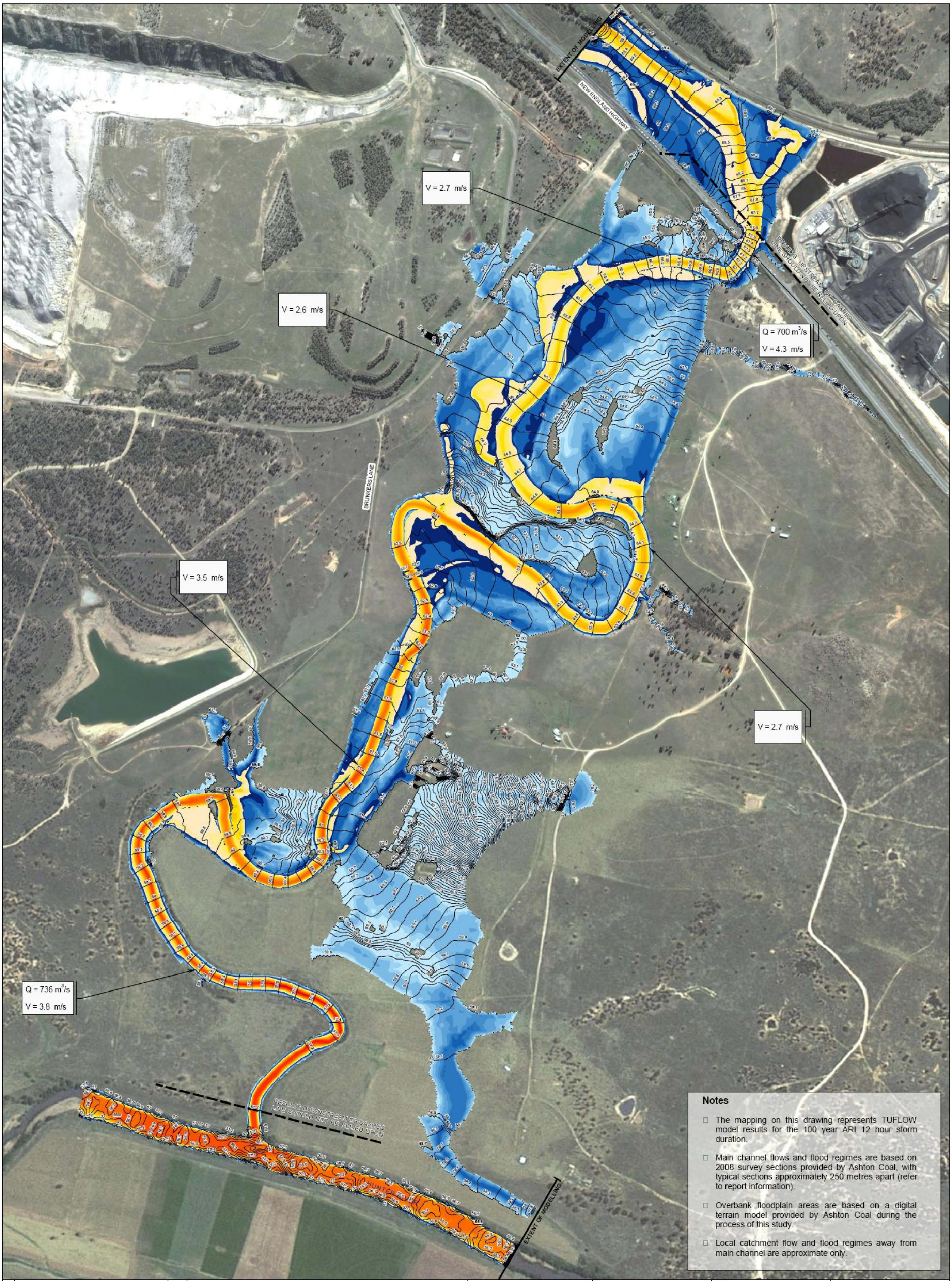

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Figure 8.5:
Flow Conditions in Bowmans Creek
in a 100 Year ARI Flood
(Source: Hyder Consulting)

8.2.5 Surface Water Quality

There are a number of water quality monitoring stations (see **Figure 8.6**) on Bowmans Creek and its local tributary Bettys Creek, most of which have been sampled since September 2004:

Details of the water quality monitoring from the sites listed above are provided in **Appendix 9** and key water quality parameters are summarised in **Table 8.3**. Over the five years of sampling, the two up-stream SM1 and SM2 were predominantly dry and only had sufficient water for sampling following the June 2007 flood. An additional Bowmans Creek site (SM4A) was established in March 2007 to aid in determining the cause/source of the water quality anomalies at Site SM4 (see below). The upstream Bowmans Creek site SM3 was sampled over the complete sampling period, but was dry over the period 13 March to 7 June 2007.

Table 8.3: Summary Water Quality Statistics for Bowmans Creek

Statistic	Bowman Upstream	Bowman / Betty Confluence	Rock Pool	Weir Pool	Bowman / Hunter Confluence	Hunter Upstream	Hunter Downstream
Site >	SM 3	SM3A`	SM 4	SM 5	SM 6	SM 9	SM 10
Alkalinity (mg/L CaCO3)							
Samples	38	12	42	42	42	42	42
Min	102	106	97	105	107	131	112
Max	383	344	1,590	363	371	358	356
Mean	301	251	683	291	241	218	221
Total Suspended Solids (TSS mg/L)							
Samples	38	12	42	42	42	42	42
Min	2	2	2	2	2	1	2
Max	160	103	278	31	36	204	160
Mean	23	24	49	11	15	26	26
Acidity (pH)							
Samples	39	13	43	43	43	42	42
Min	6.9	7.5	7.4	6.9	6.9	7.8	7.9
Max	7.9	7.9	9.1	8.1	8.3	8.5	8.5
Mean	7.5	7.7	8.0	7.7	8.0	8.1	8.2
Conductivity (µS/cm)							
Samples	39	12	43	43	42	42	42
Min	421	434	428	432	453	304	319
Max	1,750	1,980	14,400	2,040	1,850	1,270	1,290
Mean	1,375	1,263	4,574	1,486	1,001	740	767
Total Dissolved Solids (TDS mg/L)							
Samples	38	12	42	42	42	42	42
Min	294	300	286	296	308	236	255
Max	976	1,130	8,820	1,160	1,080	658	672
Mean	818	734	2,833	870	539	385	401

The main features of surface water quality in Bowmans Creek are:

- A similar pattern of variation over time for all parameters at all sites except SM4 which has significantly higher mean values for all parameters than other site;
- A slight trend for increasing pH further downstream;
- An pattern of salinity (represented by electrical conductivity and total dissolved salts) that is not consistent with Bowmans creek being a 'gaining' creek along its full length. Because the groundwater is generally more saline than the creek, groundwater contribution to baseflow

would tend to increase the salinity of the creek at downstream locations. In this instance the main anomaly is SM4 which has elevated salinity, particularly at times of low or minimal flow.

- Suspended solids concentrations that show significant variations over time which is indicative of sediment laden runoff from upstream.

Appendix 8 contains a detailed analysis of the differences in water quality exhibited at SM4 compared to other sites and concludes that the water quality at Site SM4 is directly related to creek flow rate. When flows are low, EC, alkalinity and TDS values at SM4 increase and when flow is very low or stopped, values peak.

8.2.6 Water Extraction

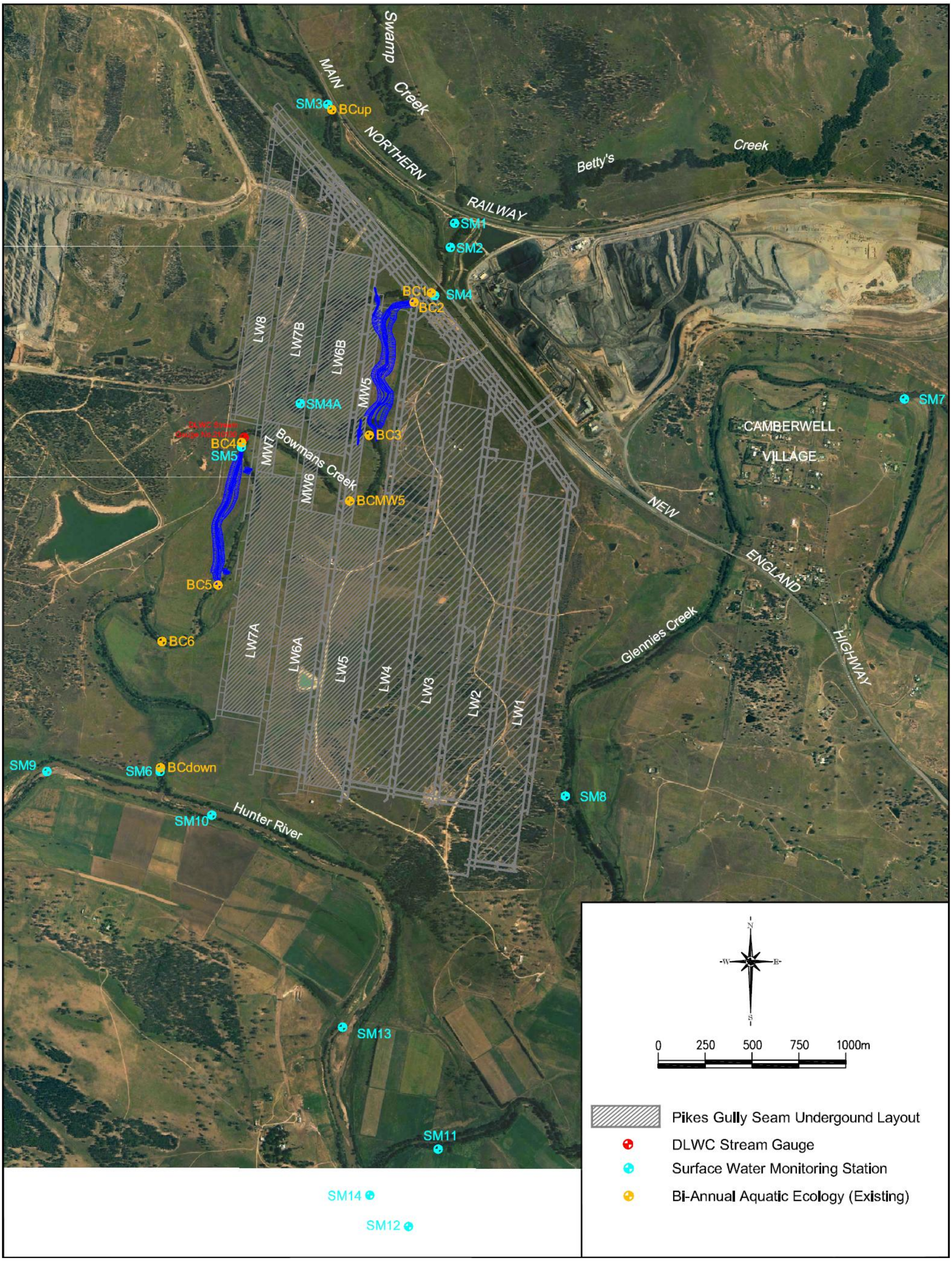
ACOL has a number of water access licences that total 360 ML/annum. Water is extracted from Bowmans Creek in accordance with the licence conditions to supplement the supply for operation of the CHPP derived from surface runoff into the open cut and water pumped from the underground mine.

8.3 Assessment of Project Impacts

Bowmans Creek exhibits wide variations in flow that are typical of creeks and rivers in eastern Australia. The cross sections of the diversion channels are 'carbon copies' of the adjoining sections of the existing creek with minor adjustments of bed levels. Accordingly, the proposed diversion channels will provide similar conveyance capacity to the existing creek channels. The similarity in conveyance capacity, combined with the provision of sequences of pools and riffles that mimic the existing creek will ensure that similar geomorphic and ecological processes, including fish passage, can occur in the proposed diversions.

The proposed construction of the diversion channels and undermining of the Bowmans Creek alluvium have the potential to have the following impacts on the flow regime in Bowmans Creek and site water management:

- The bank full capacity of the constructed diversion channels will remain similar to that of the existing creek (about 5 year ARI flood). The construction of the diversion channels will, however, alter the flood regime once flows exceed about a 5 year ARI flood by distributing the flow between the existing and new channels. This has the potential to lead to an increase in flow velocity upstream.
- As a result of subsidence there will be an increase in floodwater storage on the floodplain. This has the potential to reduce peak discharge to the Hunter River.
- As a result of drainage of the alluvium, the creek will change from a 'gaining' to a 'losing' creek.
- Connective cracking will increase inflow to the underground workings. This additional water will be pumped into the mine water management system and will contribute to the overall water balance of the ACP operation.



Bowmans Creek
Diversion Project

Figure 8.6
Existing Surface Water Quality and
Stream Health Monitoring Locations

8.3.1 Flood Regime

For purposes of assessing the hydraulic performance of the proposed diversion channels and the effect of floodplain subsidence, the TUFLOW model of the existing conditions in Bowmans Creek was adjusted to include the geometry of the proposed Eastern and Western diversions (as indicated in **Figure 2.6** and **Figure 2.7**) and the predicted subsidence profiles following mining of the Lower Barrett seam. As a prelude to this, in order to develop a channel design that provided appropriate hydraulic and geomorphic conditions, the TUFLOW model was used to test a number of alternative channel designs and block bank levels before selecting the preferred final design.

In addition to the two lengths of proposed diversion channels, the revised TUFLOW model also included:

- Four block banks on the existing creek alignment to contain main channel flows within the proposed diversions. These block banks were set at a level approximately the same as the existing adjoining floodplain, which corresponds approximately to the 5 year ARI flood level;
- Local narrowing (representing equivalent existing channel waterway area) near the upstream end of the Eastern Diversion channel. This was introduced in conjunction with an extended overbank section of block bank in order to limit upstream velocities to approximately those under existing conditions;
- A local diversion bund, approximately 30m length and up to 0.4m high to represent blockage of a minor floodplain flowpath (within one of the central main creek meanders just upstream of the flow gauging station) in order to constrain floodplain flow into an area of subsidence near the north-east corner of LW7A; and
- Predicted land surface subsidence as a result of the future underground mining works prior to filling for purposes of creating a free draining landscape.

The resulting flood regime conditions are discussed below, and figures showing the flow regime for 1 year, 5 year, 20 year and 100 year ARIs (with low Hunter River flood levels), and a 100 year Hunter Flood coincident with a 1 year ARI flood in Bowmans Creek flood are included in **Appendix 6**. Copies of the figures showing flow conditions in a 5 year ARI flood and a 100 year ARI flood are reproduced as **Figure 8.7** and **Figure 8.8**.

Modelling of flood conditions with the diversions channels in place indicates that they perform in a similar hydraulic manner to the existing creek and would generally contain Bowmans Creek flows within the banks up to approximately the 5 year ARI event, with flood levels and velocities similar to existing conditions. (An analysis of shear stresses associated with different flood flows in the diversion channels is reported in **Section 9.4**).

In a 100 year flood, the combined conveyance capacity of the Eastern Diversion channel and flow over the block bank into the existing channel is greater than under existing conditions. This leads to the potential to increase flow velocities under the New England Highway bridge. This possibility has been recognised and the design of the Eastern Diversion channel has been adjusted to minimise this effect. The analysis in **Appendix 6** indicates that, in the 'worst case' conditions of a 100 year flood in Bowmans Creek occurring when the Hunter River water level remained low, there would be a small increase in flow velocity under the New England Highway bridge (from 4.2 to 4.5 m/s). Given that scouring has already been observed at this location in 2007, it is not considered that the predicted increase in flow velocity represents a significant increase in risk of scour compared to existing conditions.

Figure 8.7 shows the effect of a 5 year ARI flow which would not overtop the block banks and flood into the excised sections of the channel. The figure shows that, in the absence of filling to create a free drainage landscape, the subsidence zones would collect local tributary flows in frequent small events. **Figure 8.8** shows that in larger events flow would enter the excised sections of the existing creek and adjoining subsided zones. In such events, the increase in floodplain storage will result in the attenuation of the peak flows entering the Hunter River. Although small in terms of the total flow in the Hunter River, this attenuation indicates that the project would have no adverse downstream flood impacts. In both cases however this reduction will be offset by drainage works and partial filling of the subsidence areas to establish a free-draining land form. Notwithstanding the proposed filling to create a free draining, there will still be some increase in floodplain storage which will lead to a reduction in peak flow from Bowmans Creek into the Hunter River. The attenuation of the flood peak at the Hunter River will, if anything, have the beneficial effect of reducing the flood peak in the Hunter River. This effect will, however, be so small as to be negligible.

8.3.2 Conveyance of Low Flows

Low flows are particularly important for the maintenance of ecological function within the creek and to minimise potential impacts on downstream water users in the Hunter River. Groundwater modelling (**Appendix 5**) indicates that Bowmans Creek between the New England Highway and the Hunter River is a 'gaining' creek with the groundwater system currently contributing a very small quantity (about 8.5 ML/year) to baseflow in the creek out of a total flow of about 12,000 ML/year.

A predicted effect of longwall mining under sections of the Bowmans Creek alluvium, particularly following mining of the Upper Liddell seam, is that subsidence will cause direct hydraulic connection between the Bowmans Creek alluvium and the underground workings due to connective cracking, providing a pathway for the alluvial groundwater system to drain into the mine workings. While this rate of water loss will be governed by the hydraulic properties of the alluvium, the groundwater modelling (**Appendix 5**) predicts that by completion of mining to the Lower Barrett seam more than 70% of the Bowmans Creek alluvial groundwater (estimated 250 ML) will have drained into the Permian hard rocks.

The loss of the alluvial groundwater leads to the potential for the creek to lose baseflow rather than gain. Accordingly, the design of the diversion channels incorporates a geosynthetic clay liner to prevent losses from the diversion channels. As shown in **Figure 2.9**, the liner will extend 500mm above the permanent ponding level in the pools and 500mm above the riffles. This will ensure that all flows less than about a 6 month ARI flow will not suffer loss to the groundwater system.

There will, however, be some increased loss of water from those sections of the existing creek that will remain as functional conveyance elements of the system under normal flow conditions. This will occur because of the predicted dewatering of the alluvial aquifer. The rate of loss of water from the creek will be largely governed by the hydraulic properties of the alluvium. This has been quantified by means of the groundwater model (**Section 7**) which indicates that over the period of mining the average annual loss of baseflow from Bowmans Creek will be about 10.7 ML/year (less than 0.1% of the average annual flow, or 2% of the 80th percentile low flow). This loss is considered insignificant. As noted in **Section 7.4.3**, the groundwater modelling also indicates that baseflow losses by the end of mining are likely to be about the same as would occur as a result of the influence of other mines in the area without ACP underground mining.

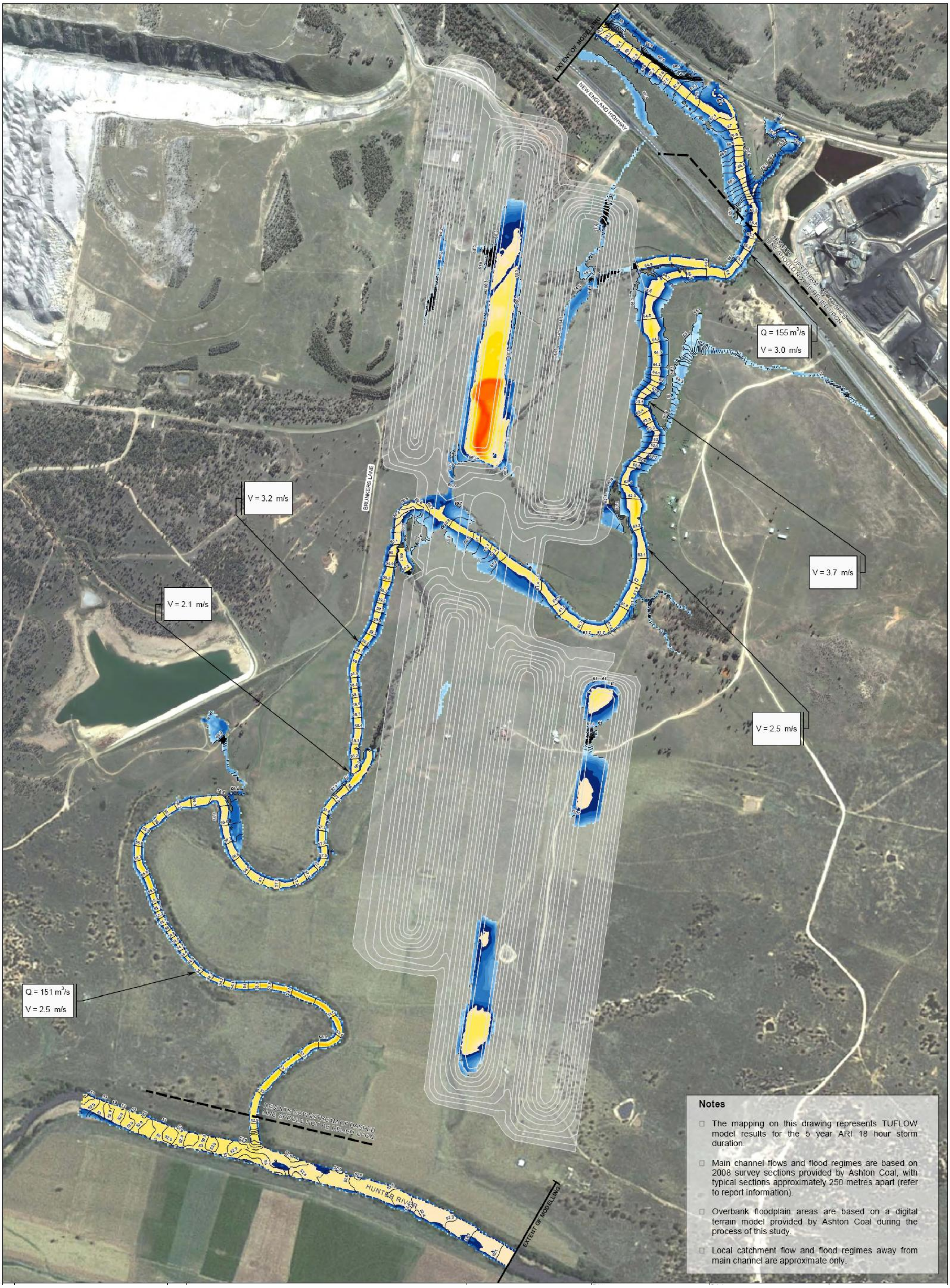


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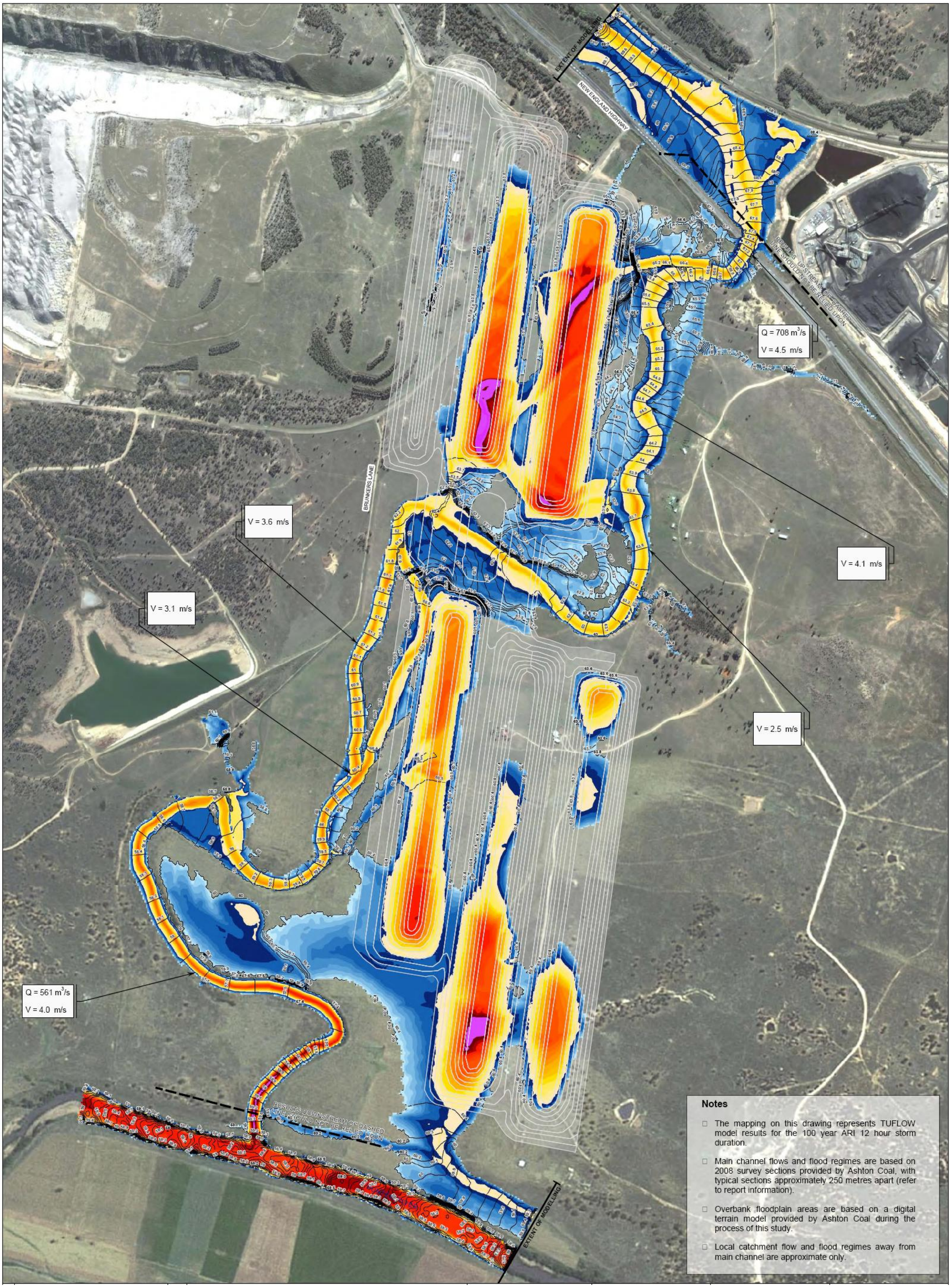
Figure 8.7:
Flow Conditions in Bowmans Creek in a 5 Year ARI Flood with Diversions
(Source: Hyder Consulting)



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Diversion Project

Figure 8.8:
Flow Conditions in Bowmans Creek
in a 100 Year ARI Flood with Diversions

(Source: Hyder Consulting)

8.3.3 Site Water Balance

A water balance analysis for the whole of the ACP including the underground workings associated with the proposal described in this Environmental Assessment has been undertaken by WorleyParsons. A copy of the water balance assessment report is provided in **Appendix 8**.

WorleyParsons has developed a comprehensive water balance model of the whole ACP water management system. This model was used as part of the Environmental Assessment for the proposed South East Open Cut (SEOC), which is currently under consideration by the NSW Department of Planning. This water balance model was revised to incorporate the additional inflow from the underground operation as predicted by the groundwater modelling described in **Section 7** above. As the SEOC project has not yet been approved, the water balance assessment considered future scenarios that took account of predicted groundwater inflows to the underground mining, with and without the SEOC.

Groundwater modelling predicts the average daily inflows (from all longwall panels) will range from 1.2 ML/day in 2014 to 1.6 ML/day in 2021. The water balance undertaken for the SEOC indicated that the ACP operation would face water shortages during low rainfall periods. The predicted additional inflow to the underground workings would, therefore, moderately reduce the frequency and severity of these water shortages. However, water shortages in excess of 1ML/day are predicted during dry periods, when the SEOC is operational. Following the closure of the SEOC, the probability of water shortages is significantly reduced due to the reduced water demands for dust suppression and coal processing.

During wet periods, when higher rainfall leads to increased surface runoff volumes, controlled water sources such as licensed extraction and water sharing from the Glennies Creek Underground mine could be reduced to maintain a balance between water inflows and demands. The water balance modelling predicts that only minimal use of the controlled sources would be required during wet years. Importantly, the ability to control inflows from licensed sources will provide sufficient the flexibility to maintain a balance between inflows and demands during wet periods.

The water balance model excluding the SEOC project predicted reasonably steady results over the life of the project. This is because the only variation in the model input and output parameters was variations of up to 0.4 ML/day in predicted inflows into the underground workings over the life of the mine.

The existing ACP *Surface Water Management Plan* provides emergency storage in both the proposed SEOC pit and the remnant Barrett Pit. During major rainfall events, such as a 100 year ARI design storm, excess water would be pumped into these emergency storages to prevent mine water overflows occurring. The predicted volumes of runoff during historic major storms range from 280 to 520ML. It can be seen that the predicted increased inflow rates from the underground operations are insignificant compared to the volumes of surface runoff predicted during major rainfall events. As such, the predicted inflows to the underground mine would not adversely affect the capacity of the surface water management system to retain mine water runoff during major rainfall events.

8.3.4 Surface Water Quality

Construction of the diversion channels has the potential to increase suspended sediment concentrations immediately after flow is first directed through the channels. The potential for this to occur will be minimised through the following proposed mitigation actions:

- The bed of the channels will be constructed using coarse cobble material selected from the channel excavation. The cobble materials, as found in the existing channel, have very little fine sediment that would be available for transport from the bed of the channel.

- Extensive use will be made of durable erosion control matting on the gravel and cobble bars at a slightly higher elevation that the low flow channel. The purpose of this matting will be to protect these adjacent bars in the event of a flood soon after completion of construction and initial rehabilitation.
- The risk of significant suspended sediment being generated in the event of a flood will be further mitigated by the proposed construction of a temporary block bank (overtopped in about a 6 month ARI flood) that will remain in place until just prior to mining of the Upper Liddell seam unless groundwater monitoring indicates that the alluvial groundwater is draining into the Permian rocks, or loss of surface flows from the existing stream is identified, in which case the permanent block banks will be installed immediately.
- The drainage of the alluvial aquifer will create conditions in which the saline contribution from the groundwater will no longer occur. Accordingly, the average salinity of Bowmans Creek is expected to reduce slightly.
- The elimination of saline groundwater inflow to the creek is expected to be particularly beneficial in reducing the elevated salinity that has been observed in the pool immediately downstream of the Highway. At this location the salinity reached over 14,000 µS/cm during the drought in 2006.

8.3.5 Impacts on Surface Water Users

There are no surface water users who take water from Bowmans Creek downstream of the area of the proposed project. In addition, as set out in **Section 2.7**, the proposed installation of a geosynthetic clay liner under the low flow channel will lead to negligible loss of water from the diversion channels themselves.

8.4 Monitoring and Management

8.4.1 Existing Monitoring

Flow and salinity monitoring is undertaken by the NSW Office of Water at a weir located approximately mid way between the New England Highway and the Hunter River. Flow and salinity records from the gauging station are regularly accessed by ACOL as a reference for flow conditions at the time of water quality sampling and ecological monitoring.

Water quality is monitored monthly at the locations shown on **Figure 8.6**. Monitoring includes pH, EC, total dissolved salts, total suspended sediment alkalinity and oil & grease.

8.4.2 Proposed Monitoring and Management

No changes are proposed to the existing surface water management arrangements described above.

The predicted loss of baseflow as a result of dewatering the alluvial aquifer is so small that it is not practical to establish a monitoring regime that could detect any change.

8.5 Commitments

ACOL offers the following commitments in relation to surface water management:

1. The diversion channels will be constructed in accordance with the civil and landscape designs (**Plan Sets 2 and 3**) including the placement of an impermeable geosynthetic clay liner under to bed to eliminate baseflow losses from the constructed channels.
2. ACOL will continue to the existing surface water quality monitoring program.

3. Water level monitoring will be undertaken in two pools immediately above LW6B as part of the routine monthly monitoring program. While mining is occurring in LW6B, water levels will be monitored weekly.
4. ACOL will surrender a portion of its water access licence to offset the assessed loss of base flow in Bowmans Creek.

8.6 Conclusion

The proposed mitigation actions that form an integral part of this proposal are expected to lead to a situation in which the project has no significant impact on the flood regime or the surface water flow to the Hunter River.

9 GEOMORPHOLOGY

9.1 Introduction

This section of the report provides a summary of the fluvial geomorphic characteristics of Bowmans Creek, a description of the approach adopted to the design of the proposed diversion channels and an assessment of the long term geomorphic stability of the proposed diversions. Full details of the investigations and assessments are provided in the *Flood Hydrology and Geomorphology* assessment prepared by Fluvial Systems (**Appendix 7**).

The geomorphology of Bowmans Creek is relevant to the proposal for two main reasons. The first is that the geomorphic form is the physical template that provides ecological habitat. The second is that sediment transport processes govern channel stability. The view adopted here is that a degree of channel instability is ecologically favourable (Florsheim et al., 2008), and that channel form variability is likely to have ecological significance. Given these premises, the philosophy adopted for the design of the physical form of the two diversions proposed for Bowmans Creek was that the diversion channels should have the same range of physical forms, bed material, and stability characteristics as the existing channel, i.e. they should aim to mimic the existing channel as closely as possible.

The section of Bowmans Creek that is relevant to this project has been the subject of previous geomorphic investigations (Patterson Britton & Partners, 2001; ERM, 2006, Maunsell Australia, 2008). This work included a detailed cross section survey by Pegasus Technical at 51 locations in 2006 that was repeated at the same locations in 2008 following the flood in June 2007.

Bowmans Creek is an incised channel. Downstream of the New England Highway, the degree of incision increases towards the junction with the Hunter River. This would be expected wherever a smaller tributary joints a larger river, as the tributary has to cut through the floodplain formed by the larger river. However, it appears that Bowmans Creek incised beyond this level following incision of the Hunter River, which probably began in association with a large flood in 1949. The evidence for relatively recent incision is that the creek is incised at the upstream end (partially spilling onto the terrace at the 1 in 20 year ARI event), where the Hunter River influence is minor, and the incised channel is relatively narrow, with inset benches (incipient active floodplain surfaces). Thus, it appears likely that following incision of the Hunter River, Bowmans Creek incised (by upstream nickpoint migration) in response to the lowered base level. Since that time the channel has been geomorphologically active within the incised corridor, widening the corridor, redistributing bed material, and building and destroying bars, benches and banks.

The geomorphology of Bowmans Creek has been characterised using five methods that are outlined below and described in further detail in **Appendix 8**:

- Examination of 51 transects and several thalweg long profiles surveyed by Pegasus Technical in 2008;
- Field measurement of channel width and depth undertaken for this project;
- Field measurement of bed particle size undertaken for this project;
- Assessment of bed stability and bank stability based on HEC-RAS (1-D hydraulic model) predicted bed shear stress and velocity (i.e. hydraulics); and
- Assessment of modelled bed scour potential.

9.2 Existing Environment

9.2.1 2008 Survey Data

Detailed surveys of 51 cross sections of Bowmans Creek were undertaken by Pegasus Surveys in 2006 and 2008. For purposes of this project, the 2008 channel survey data has been taken to represent "existing" conditions and shows a distinctive downstream pattern (**Figure 9.1**). The elevation of the floodplain terrace was highly variable, which reflects the variable topography of the terrace, plus limitations in the data due to variable transect length. It appears that from around chainage 2,500m downstream, the terrace is relatively level, as here it is under the dominant control of the Hunter River. Upstream of this area the floodplain terrace slopes down from the highway towards the Hunter River, indicating that it was largely formed by Bowmans Creek.

The bed of Bowmans Creek appears to steepen in grade from about chainage 2,500m, as it cuts through the Hunter River floodplain to reach the Hunter River bed level at the junction (**Figure 9.1**). The creek is more incised in this area, with valley walls of up to 11m high.

The low flow channel bank top level was variable, but generally followed a downstream grade similar to the water surface and the thalweg (**Figure 9.1**).

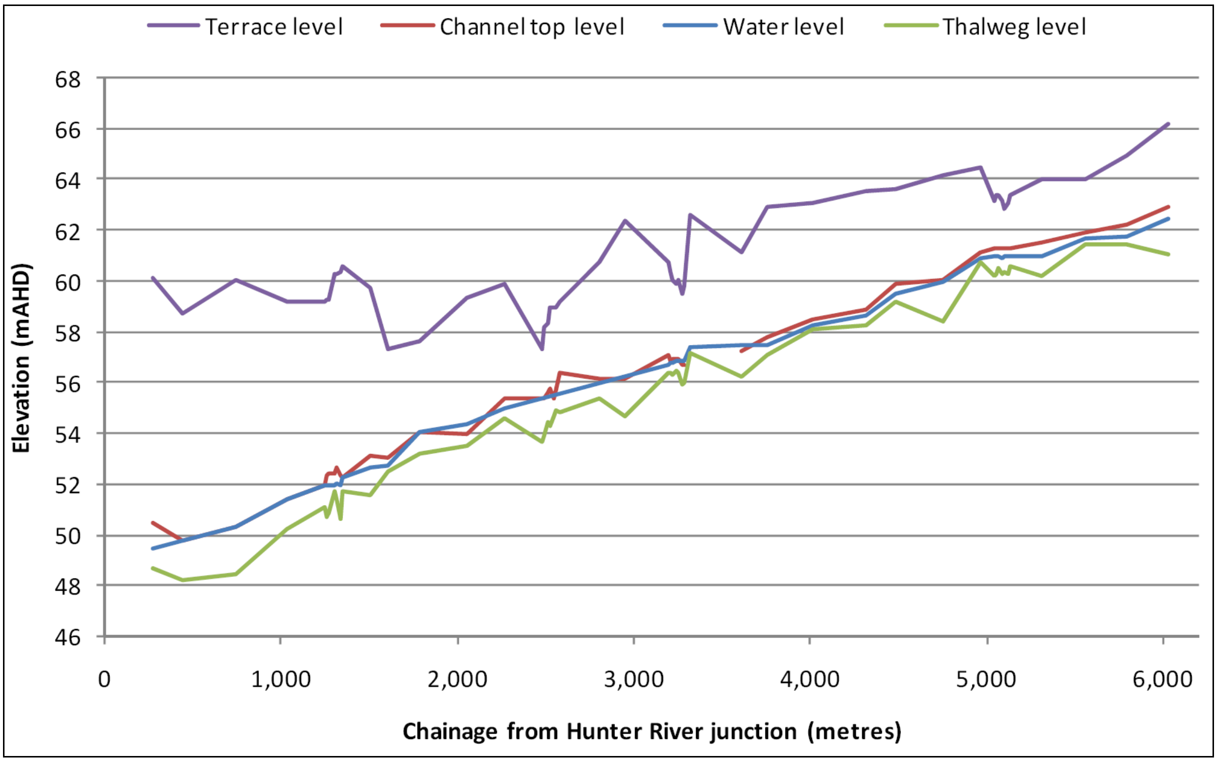


Figure 9.1:
Downstream Pattern of Morphology of Bowmans Creek
(Water level is on days of survey in 2008)

9.2.2 Field Measurement of Low Flow Channel Width and Depth

On 29/07/2009 a survey was undertaken in Bowmans Creek, to measure the water depth (at thalweg) and width of the low flow channel. A total of 29 measurements were taken along the reach corresponding to the Western Diversion, and 34 measurements along the reach corresponding to the Eastern Diversion. Mean flow for the day was 0.25 m^3/s (21.8 ML/d), which was equivalent to the flow exceeded 20% of the time for all months for the available record. For July, this flow was equivalent to the flow exceeded 28% of the time (i.e. 72 percentile flow, or a higher than average baseflow). The purpose of this survey was to characterise the variability in the form of the low flow channel. These data (**Figure 9.2** and **Figure 9.3**) generally corresponded with the values interpreted from the 2008 cross-section survey data, although direct comparison was not possible, as the measurement points were not coincident.

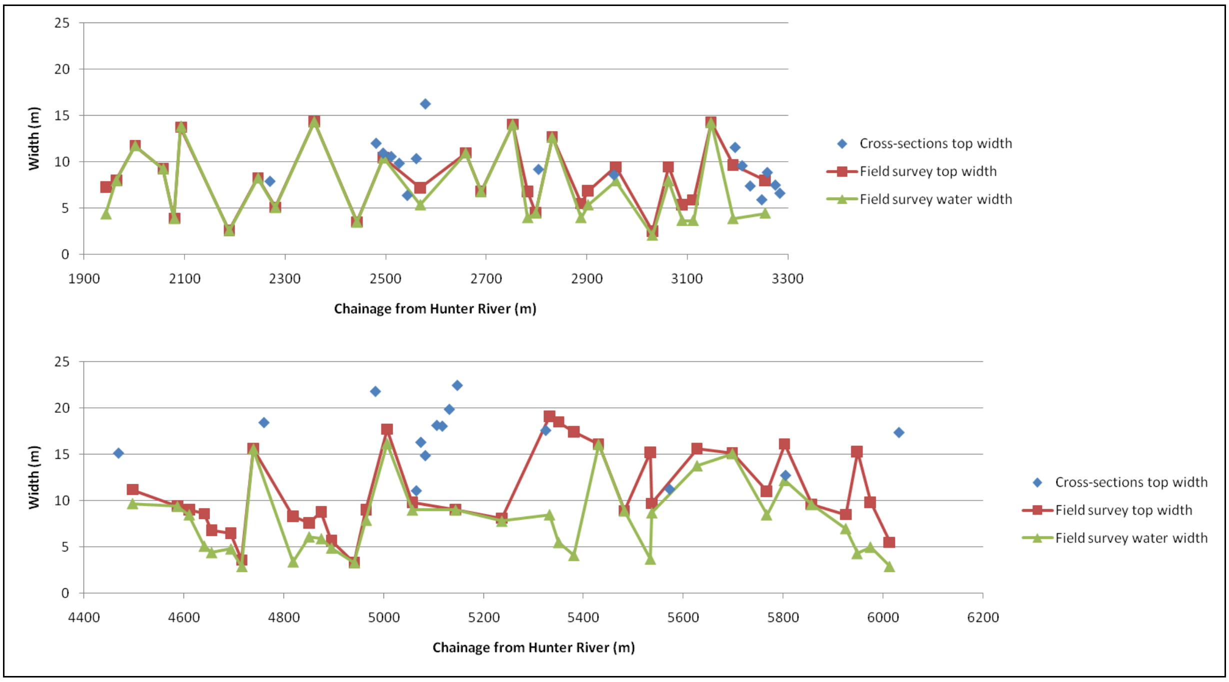


Figure 9.2:
Downstream Pattern of Width of Low Flow Channel in Bowmans Creek

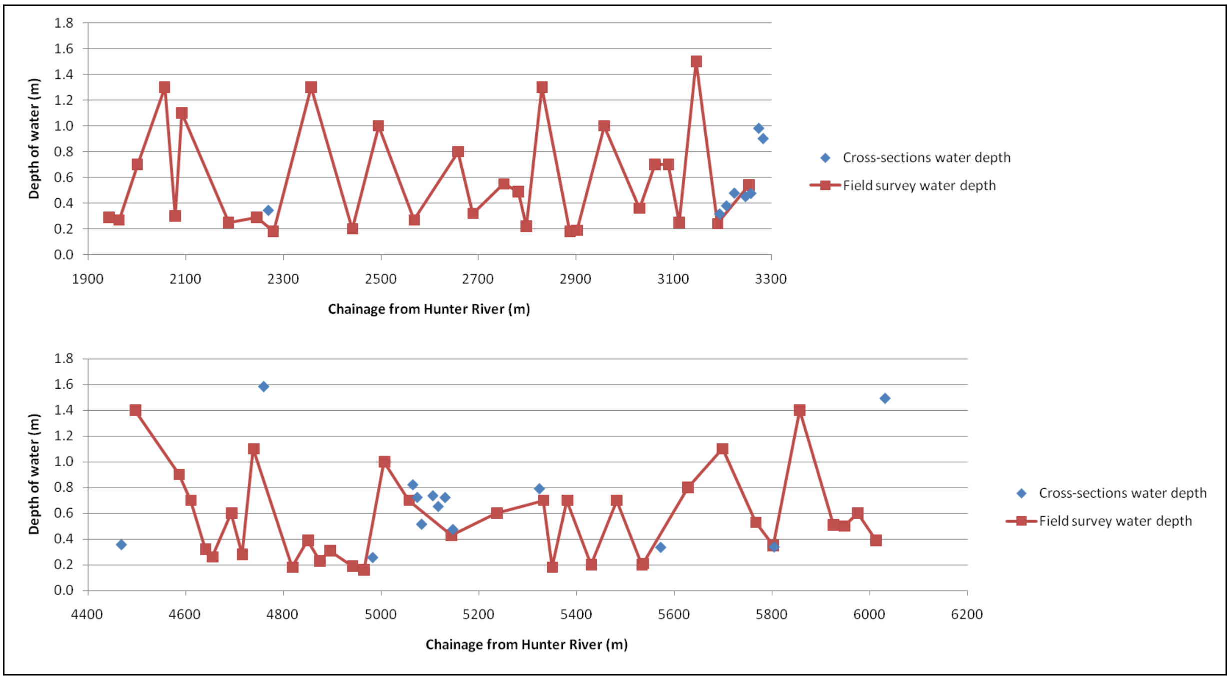


Figure 9.3:
Downstream Pattern of Depth of Water in Low Flow Channel in Bowmans Creek

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 diversions were characterised in terms of mean and standard deviation (**Table 9.1** and **Table 9.2**). These data form a basis for the design of the diversion channels. The data indicated that the upper (Eastern) section of creek corridor is broader and less incised than the lower (Western) section.

Table 9.1: 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 9.2: 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

9.2.3 Field Measurement of Bed Particle Size

Bed particle size was measured at 10 locations on Bowmans Creek using the Wolman Pebble Count technique, measuring the B-axis dimension of 100 particles selected at random from the surface of riffle crests. The data were converted to distributions of percent finer by weight (in phi classes), corrected for bias in sampling using the method of Leopold (1970). The riffles at chainages 1,120 m and 1,948 m were significantly coarser than at the other sites, but the other sites had similar particle size distributions. The median particle diameter was very coarse gravel, but cobble-sized material down to fine gravel and coarse sand was present at all sites.

9.2.4 Assessment of Shear Stress and Bed Stability

For purposes of deriving bed shear stress estimates, a HEC-RAS model was set up using the same surveyed cross sections that were used in the TUFLOW model (described in **Section 8** and **Appendix 6**) and minor adjustments made to the roughness parameters in order to make the water surface profile in the two models consistent. The index of stability used here was the ratio of actual bed shear stress to the critical shear stress for initiation of movement (a ratio higher than 1 means that some particles can move). The analysis of potential particle mobility for exposed bed material on the sides of the channel indicated a low likelihood of bed material mobility in the existing channel for the 1 year ARI event, but higher floods had the potential to scour these areas. For the 1 year ARI event the shear stress in the central channel area was above the threshold for entrainment at more than half of the cross-sections. The relative instability of the bed in the central channel area increased with higher discharge, such that at the 5 year ARI event the majority of the channel bed had potential for particle mobility. This suggests that the bed of the existing channel is active at events with a frequency of 1 to 3 years ARI (as would be expected in a dynamically stable stream). The bed material on the sides of the channel (comprising gravel bars and low-level floodplain) was more stable due to lower shear stress there, and this stability is enhanced by reasonably complete vegetative cover.

9.2.5 Assessment of Bank Stability Based on Maximum Permissible Velocity

Tables of maximum permissible velocity appear in many channel design, engineering and hydraulics publications (e.g. Chang, 1988). These values assume a bare channel surface (i.e. no grass or other lining or vegetation). Vegetation failure usually occurs at much higher velocities than for bare soil.

For the alluvium in the upper banks of Bowmans Creek, the values of maximum permissible velocities in the literature suggest that bare bank material would be at risk of erosion at a velocity exceeding 0.8 m/s for short duration events, and conditions of velocities exceeding approximately 0.4 m/s for long duration events (longer than half a day). A grass covered surface would be at risk of erosion for velocities exceeding 2 m/s for short duration events and conditions of velocities exceeding approximately 1.5 m/s for long duration events (longer than half a day). In this analysis, the bank stability was assessed using 2 m/s as the threshold index of stability, as the majority of the banks are grassed, and the majority of flood events would be relatively short lived.

The analysis of bank stability potential indicated a low likelihood of bank instability for the 1, 2 and 5 year ARI events. For the 10 year ARI event and the 20 year ARI event some sections of the banks had potential for instability. This suggests that the channel banks could erode in places during the higher flood events. Bare banks would be unstable for events with a frequency of 1 to 3 years ARI (and larger events). Some sections of bare banks were observed on Bowmans Creek, and it is the occasional erosion of these banks that explains the process of widening of the incised creek corridor over time.

9.2.6 Assessment of Bed Scour in the Existing Channel

There are four main bed material scour processes that occur in Bowmans Creek:

- Active layer bed scour (also called disturbance depth, live bed scour, or moving layer depth);
- General scour (longitudinally local contraction scour and bend scour affecting the entire cross-section);
- Local-scale scour immediately adjacent to obstructions (large woody debris in this instance); and
- Maintenance of pool-riffle morphology by scour.

For the existing channel, mean and maximum active bed layer scour depth, and mean and maximum general scour depth was estimated using a range of equations. Some of these methods are discharge or shear stress dependent, and therefore vary with discharge, while others are largely dependent on particle size of the bed material and are therefore not affected were invariant with discharge. Active layer scour depth was less than general scour depth. General scour depth would be expected to be of the same order as the observed natural variations in bed elevation, and this was the case, with pool depths in Bowmans Creek being observed to vary up to about 1.4m and having a mean depth of 0.7 – 0.9m. Active layer scour depth was predicted to be shallow, of the order of 0.1 – 0.3m at most.

9.2.7 Summary of Existing Channel Geomorphic Condition

Bowmans Creek remains on a trajectory of incision and widening, which probably began up to 60 years ago. The rate of incision has been slowed by exposure of a number of bedrock outcrops. Bed material in the channel is predicted to be mobile during flood events in the range of 1 – 3 years ARI, while the grass covered bars and benches are mostly stable. The grassed banks are predicted to be generally stable for floods up to the 5 year ARI event, but for higher events the banks are likely to erode in places. Bare banks are likely to erode during flood events of in the range of 1 – 3 years ARI. Active layer scour depth is predicted to be shallow, of the order of 0.1m to 0.3m at most, while predictions of general scour depth matched the observed variations in bed level, with pools being 0.7 – 0.9m deep on average, and up to 1.4m deep.

Direct observations of these processes have not been made in this or previous studies, but the field observations were consistent with these model predictions. Flood frequency analysis undertaken for this study suggested that the June 2007 flood was a 34 year ARI event in lower Bowmans Creek. In an event of this magnitude, the bed material would be expected to be mobile, bedforms would be expected to change, and areas of bank erosion would be expected. Observations consistent with these expectations were made by Marine Pollution Research (2008) during an ecological survey in late June 2008. At the surveyed cross-sections, compared to surveys made in the year prior to the flood of 2007, scour of the bed was up to 0.9 m and deposition was up to 0.4 m (Maunsell Australia, 2008). Cross-sections with scour outnumbered those with deposition.

9.3 Geomorphological Design Aspects of the Proposal

9.3.1 Design Principles

Approaches to channel design fall into three categories (Skidmore et al., 2001):

- Analogue approach (adopts an existing stream as a template);
- Empirical approach (using equations that relate channel characteristics derived from regionalised data sets, and assumes equilibrium conditions);
- Analytical approach (using hydraulic models and sediment transport functions to derive equilibrium conditions).

For this project the analogue approach has been adopted, with the two diversion channels being (as close a possible) ‘carbon copies’ of the two sections of the existing channels that they would replace. The rationale for adopting this approach was that the diverted sections of Bowmans Creek should behave similarly to the existing sections that they would replace. Provision of near identical morphology and sediment transport processes would also mean minimal change to the availability of hydraulic habitat for biota.

In the long term, the diversions would not be expected to result in any interruption to bed material sediment supply from upstream, or from within the channel itself. The diversion channels will be deformable, allowing for natural adjustments of the bed and banks within the range of existing rates of change.

The diversion channels have been designed to accept all flows up to the 5 year ARI event. Larger floods would flow down both the existing and the diversion channels. Thus, for these larger floods, shear stresses in the diversion channels are expected to be lower than in the existing channel.

The low flow channel would be lined with a buried geosynthetic clay liner, and then overlain with approximately 600mm depth of gravel/cobble bed material. The depth of this bed material would be expected to adjust over time. The liner may be located deeper in some sections underneath large woody debris structures, as these are likely to create scour holes.

For the purpose of modelling the geomorphic characteristics of the diversions channels, it was assumed that the bed material of the channels would be composed of a particle size distribution that represented an "average" of the 10 sampled bed particle distributions (see **Section 9.2.3**).

9.3.2 Design Method for Basic Channel Form

The first step in channel design was to draw a plan shape to fit within the designated corridor that would be minimally impacted by future mining subsidence. The 2008 thalweg and cross-section survey data provided by Pegasus Technical, plus the field measurements of width and depth undertaken for this study, were then used to characterise the morphology of the sections of Bowmans Creek that would be diverted in terms of:

- Thalweg elevation,
- Low flow channel bed width,
- Low flow channel bank height,
- Extent of low-level active floodplain,
- Elevation and extent of higher level inset benches, and
- Width of top of macro channel

These data were used to produce a carbon copy of these features of the channels within the corridor of the proposed diversion channels. This was done for each diversion, starting with three given lines that defined the location of the thalweg, and the left and right upper boundaries of the macro-channel, where it intersected the existing ground surface level (i.e. the upper Bowmans Creek floodplain terrace).

The elevation of the thalweg profiles was based on the surveyed thalweg profiles of the existing channels (from 2008 Pegasus Technical survey). Details of the development of the design are provided in **Appendix 7**. The resulting designed channels are as close as possible in geomorphological form to the existing channel sections that they would replace. They have almost identical variability of width and depth and comparable pools and riffles.

9.3.3 Design of Channel Features

Figure 2.9 is a typical cross section through a diversion channel which shows the proposed placement of a geosynthetic clay liner under the bed of the channel in order to prevent leakage into the alluvium. The geosynthetic clay liner will be covered with a 200 mm layer of protective fine material and a 600mm deep cobble bed layer. The bed material will comprise material similar in size cobbles to that found in the existing creek bed. This material will be selected from spoil extracted during excavation of the diversion channels. In order to further enhance the stability of the diversion channels rip-rap protection will be provided on the outside of the tighter bends, and large rock positioned at the upstream and downstream ends of riffles to act as controls against incision. Large woody debris in the form of engineered log jams (Brooks et al, 2006) will be installed to further enhance the geomorphic and habitat diversity in the diversion channels.

9.4 Geomorphological Impacts of the Proposal

9.4.1 Assessment of Bed Stability Based on Bed Shear Stress

An analysis of potential bed particle mobility in the diversion channels and adjoining existing channels was undertaken on the same basis as that for the existing creek described in **Section 9.2.4**. In order to account for flow into the excised section of channel, the HEC-RAS model for each diversion, including a short section upstream and downstream, was modelled separately using the flow in the diversion channels derived from the TUFLOW model. The analysis indicated a low likelihood of bed material mobility on the sides of the proposed Eastern Diversion channel for most of its length. The stability of the bed to the sides of the diversion channel (gravel bars and low floodplain) will be enhanced by the proposed complete vegetative cover. For the 1 year to 5 year ARI events the central channel bed would be close to the threshold of entrainment or above the threshold (similar to the existing channel).

The analysis indicated an area of significantly higher potential bed instability towards the lower end of the Eastern Diversion, near where it would enter the existing oxbow channel. This area will be reinforced with a grade control structure to prevent excessive scour. Apart from this one point of high shear stress, the predicted relative stability of the bed of the Eastern Diversion was similar to that of the reach of the existing channel that would be excised.

The analysis of potential bed particle mobility indicated a high likelihood of mobility for exposed bed material (gravel bars and low floodplain) on the sides of the proposed Western Diversion channel for events ≥5 year ARI event. These areas will be heavily revegetated to protect the surface against scour and will utilise anchored erosion protection matting to provide protection immediately after construction. The relative stability of the bed of the channel of the proposed Western Diversion was found to be similar to that of the reach of the existing channel that would be excised.

9.4.2 Assessment of Bank Stability Based on Maximum Permissible Velocity

The analysis of bank stability potential indicated a low likelihood of bank instability for the proposed Eastern Diversion for all modelled flows. Bare banks would be unstable in some areas for events with a frequency of greater than about 5 years ARI. The banks of the channel of the Eastern Diversion are predicted to be more stable than those of the reach of the existing channel that would be diverted, with instability occurring for floods of about 5 years ARI or greater. For the Western Diversion the analysis indicated a low likelihood of bank instability for all modelled flows.

9.4.3 Bed Scour in the Proposed Diversion Channels

Mean and maximum active bed layer scour depth, and mean and maximum general scour depth was estimated using the same methodology that was use to assess the existing channels. The analysis indicates that active layer scour depth will be of the order of 0.1m to 0.3m while general scour depth will be of the same order as the planned variations in bed elevation. A 600mm depth of gravel/cobble bed material is generally appropriate for the diversion channels. The predicted scour depths in the diversion channels were similar to those predicted for the existing channel. The analysis also indicates that pools in the diversions will have the capacity to be self-sustaining.

9.5 Mitigation Measures

The proposed diversion channels will function in a similar way to the existing channel, although there will be some key differences which have been taken into account in developing the design of the channels:

- A rock ramp will be installed in the bed of the channel to ensure stability towards the downstream end of the proposed Eastern Diversion to account for the fact that the diversion is shorter and steeper than the reach of the existing creek that it will replace.
- A locally thicker bed layer will be provided in the areas where local scour pools are predicted to occur adjacent to the large wood structures that will be provided as a further enrichment of the aquatic habitat.
- The diversion channels will be similarly active as the existing channel, which means that the channels will undergo change in shape and location through time. The rate of change will depend on the protection of the channel surfaces, either by artificial means (rock beaching, matting, rock bars) or natural vegetation cover.
- Measures to ensure that the channels are protected against flood events with high scour potential until the plants have become established and provide full ground coverage include extensive use of erosion protection matting (see Landscape Design Drawings in Plan Set 3) and the initial construction of temporary low block banks (see **Section 12.4.5**).

In the foreseeable future, Bowmans Creek would be highly unlikely to adopt an alternative alignment to that of the proposed diversion channels. While the channel will continue to move within the defined macro-channel corridor, and the side slopes of that macro-channel may occasionally erode as the channel widens its corridor, the chance of an avulsion under high flood conditions is remote. Avulsions typically occur on highly sinuous and low gradient streams, perched on an active (frequently flooded) floodplain. In contrast, Bowmans Creek is incised into a terrace and contains most of the flow during high flood events, so there is little spare energy available to cut a new course through the terrace. In the future there might be a "line of weakness" on the terrace, following the boundary between the part of the terrace that suffered little or no subsidence and areas that suffered significant subsidence. The subsided areas would be partially filled to create a free draining landscape on the terrace. The filled area will be rehabilitated to have a similar or better vegetative cover to the rest of the terrace surface, so the weakness would arise from the potential for flow concentration. While a small channel could erode in this area, it would not become an alternative major flow path for Bowmans Creek.

9.6 Monitoring and Management

Monitoring the geomorphology of the diversion channels will be undertaken to assess the stability of the diversion channels, the variability and character of channel forms, and the bed material particle size distribution in the diversion channels. This monitoring will include establishing 10 survey cross-sections locations on each of the Western and Eastern diversion channels which will be surveyed every 5 years or following a flood event greater in magnitude than about a 5 yr ARI event (150 m^3/s peak flow) together with the previously surveyed cross sections in the active sections of the existing channel. At the same time as the cross section survey a longitudinal thalweg profile survey of the diversions will be undertaken and bed material will be sampled for particle size analysis. Statistical comparisons will be made between the data from the diversion channels with that from the existing channel. An investigation into the causes and any remedial actions will occur if there is a variation of more than 20% in the statistics of the data from the diversions compared to the existing channel.

9.7 Commitments

ACOL will commit to the following monitoring and mitigation actions relating to the geomorphic characteristics of the section of Bowmans Creek between the New England Highway and the Hunter River.

1. The diversion channels will be constructed in accordance with the civil engineering and landscape plans.

2. Cross section survey will be undertaken every five years or immediately after a flood that has a peak flow greater than 150 m^3/s (about 5 years ARI) at all existing cross sections in the existing creek. For purposes of this commitment, flow will be determined from the Office of Water gauging station.
3. Cross section survey will be undertaken every five years or immediately after a that has a peak flow greater than 150 m^3/s (about 5 years ARI) at 10 new cross sections and along the thalweg of each diversion channel. The cross sections will be established to be representative of the various geomorphic forms within the channel.
4. At the same time as the 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.
5. 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.

9.8 Conclusion

Bowmans Creek remains on a trajectory of incision and widening, which probably began up to 60 years ago. The rate of incision has been slowed by exposure of a number of bedrock outcrops. Bed material in the channel is predicted to be mobile during flood events of while the grass covered bars, benches and banks are mostly stable.

The physical form of the two diversion channels has been designed such that they would be (as close a possible) ‘carbon copies’ of the sections of the existing channels that they would replace. The rationale for adopting this approach is that the diverted sections of Bowmans Creek should behave in a similar hydraulic and geomorphic manner to the existing sections that they would replace. Provision of near identical morphology and sediment transport processes will also mean minimal change to the availability of hydraulic habitat for biota.

Analysis of the hydraulics of the proposed channels suggested that they would have similar levels of geomorphic stability as the existing channel. There was one predicted point of significantly higher bed instability near the lower end of the Eastern Diversion. This area will be reinforced with a rock grade control structure to prevent excessive scour. The pool-riffle sequence has been designed to be a copy of that in the existing channel, but for the Eastern Diversion channel some sections of the sequence had to be shortened or removed (due to the diversion channel being shorter than the section of existing channel that it is intended to replace). The designed pool-riffle sequence should remain relatively stable in terms of location and depth variation, as modelling suggests that at least some of the pools have the capacity to be self-sustaining (through velocity reversal effects at times of high flow).

The channel design incorporates elements that will reduce the risk of excessive geomorphic instability. These include one rock grade control structure on the downstream end of the Eastern Diversion, rock bars to stabilise the locations of riffles and prevent upstream migrating incision, rock beaching on the outside of meander bends, soft treatments (such as erosion control matting) on bare surfaces to provide temporary stability until vegetation becomes fully established, and a thicker channel bed sediment layer where local scour holes are expected to form in the vicinity of large woody debris structures.

10 AQUATIC AND RIPARIAN ECOLOGY

10.1 Introduction

The proposed creek diversions are located on the lower 6km section of Bowmans Creek between the New England Highway and the Hunter River confluence, and this section of the creek provides the following important ecological functions:

- Fish passage between the Hunter River and the remaining 50km of aquatic and fish habitat in Bowmans Creek plus other upper catchment tributaries upstream of the New England Highway;
- Off-line fish refuge habitat during extended Hunter River flood events;
- Fish nesting habitat in the form of gravel bars in pools;
- A measure of drought refuge habitat in the form of deeper pools;
- A complex of aquatic ecological habitats (cobble and sediment pools and riffles, rock bar pools) with varying depths and different aquatic and emergent plants to support a complex assemblage of aquatic macroinvertebrate fauna; and
- Riparian vegetation corridors that link the Hunter River riparian flora through to the upper Bowmans Creek and provide additional foraging and feeding habitat for woodland birds and other native fauna that live in remnant patches of woodland in the locality.

Whilst this section of the creek provides these important functions, the section is not pristine and some of these functions are compromised by past practices (e.g., engineered bank protection, realignments for the New England Highway plus Northern Railway bridges), by agricultural practices (clearing of riparian and floodplain vegetation, bank erosion and water quality deterioration exacerbated by loss of riparian vegetation and by stock damage) and introduction of exotic species (riparian species such as willows, pasture grasses and weeds plus aquatic pest species; carp and plague minnow). Fish passage is available intermittently owing to the combined intermittency of flow, the shallow nature of some of the creek sections that dry out or where surface water flow is often through cobbles thus isolating pools. Water quality is also affected by the natural occurrence of saline seepage from outcrops of Permian rock which is particularly apparent in the pool immediately below the New England Highway that can become locally significant during extended drought periods.

Accordingly, the provision of two diversion channels represents both a challenge to provide the important ecological functions of the existing creek and an opportunity to provide overall better ecological function by addressing some of the factors currently leading to creek channel deterioration.

This is not to say that bank erosion and channel variability should be restrained. Bowmans Creek downstream of the highway is an incised channel, and the degree of incision increases towards the junction with the Hunter River. That is, as outlined in the Geomorphology section above, the creek is geomorphologically active within the incised corridor, redistributing bed material, and building and destroying bars, benches and banks. Accordingly, the view adopted for the design of the diversions is that a degree of channel instability is ecologically favourable and that channel form variability is required for ecological significance. Accordingly, the diversion channels should have the same range of physical forms, bed material, and stability characteristics as the existing channel, i.e. mimic the existing channel as close as possible. Additionally, provision of the diversion channels provides the opportunity to address the other factors that have led to overall deterioration in riparian and aquatic ecological function in this section of the creek, mainly clearing of riparian and floodplain woodland and exacerbation in bank instability and water quality from stock access.

10.2 Existing Conditions

The lower sections of Bowmans Creek have been the subject of detailed flora and fauna analysis and survey, most associated with coal mining activities and studies have spanned the period 2001 to the present. There have been detailed flora and fauna studies undertaken by ERM associated with the ACOL underground mining operations and there have been aquatic ecological surveys undertaken for several mines adjacent to Bowmans Creek including studies on Bowmans Creek upstream of the New England Highway and studies for ACOL commencing with the surveys for the original EIS in 2001 (HLA-Environmental 2001) through to regular biannual surveys undertaken for the approved mine (see ERM 2005 through to ERM 2009c in References and see MPR 2001 through to MPR 2009b in References). To date there have been five 'during mining' surveys conducted (to Autumn 2009) and the next scheduled survey is Spring 2009.

10.2.1 Water Quality

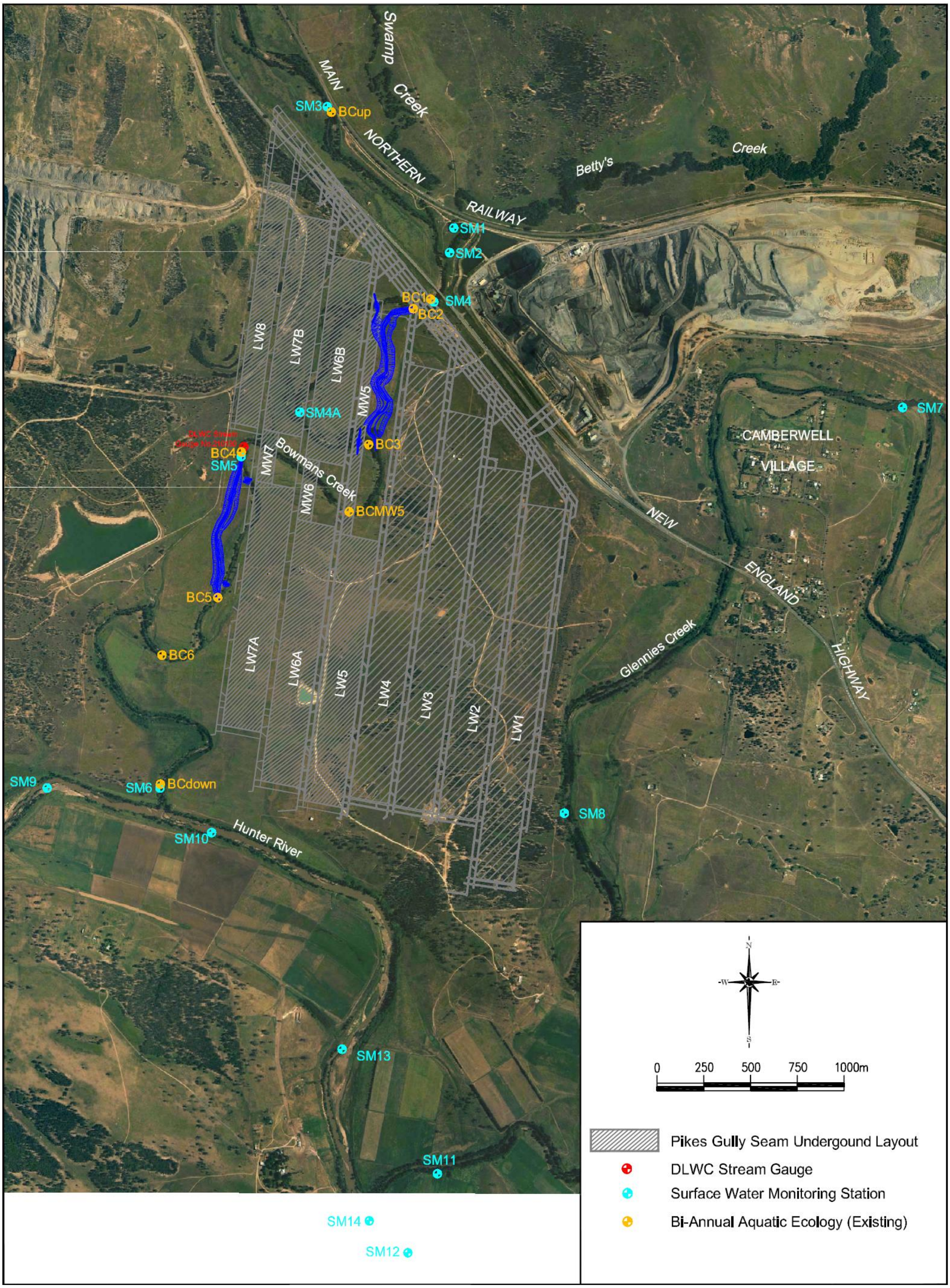
There are three sources of surface water quality data for Bowmans Creek in the study area;

- The Office of Water Foy Brook Gauge 210130 data (see summary of flow data in **Section 8);**
- The ACOL whole of mine monthly water quality monitoring of sites in Bowmans Creek, Bettys Creek and the Hunter River since September 2004 (presented in ACOL monthly reports and summarised in **Table 8.3**); and
- Spring and autumn water quality monitoring of Bowmans and Glennies Creeks collected as part of ACOL stream health monitoring (presented in bi-annual stream health reports and summarised in **Appendix 9**).

The locations of water quality and stream health monitoring sites are shown on **Figure 10.1**. For the ACOL data it should be noted that the additional Bowmans Creek site SM4A was established in March 2007. The upstream Bowmans Creek site SM3 was sampled over the complete sampling period, but was dry over the period 13 March to 7 June 2007.

Variations in mean Electrical Conductivity (EC), Total Dissolved Solids (TDS), alkalinity, and pH between ACOL sites were similar, with the exception of Site SM4, which had significantly higher mean values recorded for all parameters. For site SM4 water quality is directly related to creek flow rate; when flows are low, EC, alkalinity and TDS values at SM4 increase and when flow is very low or stopped, values peak. This result is linked to baseflow derived locally from the Permian groundwater at site SM4, as the baseflow has conductivity in the range 1,100 to 9,390 µS/cm EC (Aquaterra, 2009). Thus, when there is a long dry period with little to no surface water in-flow, conductivity in pool SM4 becomes highly elevated (as observed). The combined results also indicate that the baseflow component to Bowmans Creek is very low, as even when there is a small stream flow there is little effect of the high conductivity at site SM4 on sites downstream from SM4. This result was also found in the water quality data collected for the stream health monitoring program which showed that downstream EC values were always within the default range set for Lowland Rivers by ANZECC (2000) Guidelines.

The stream health water quality data indicated that Bowmans Creek dissolved oxygen saturation values were linked to flow with combined site mean values around 90 % saturation in moderate flow periods (e.g., Spring 07 to Autumn 09) and lower mean values (around 50 to 60%) during both high (e.g., Autumn 07) and low flow (e.g., Spring 05 and Autumn 06) periods.



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Diversion Project

Figure 10.1
Proposed Diversion Channels and
Existing Stream Health Monitoring Sites

From the consideration of the combined ACP water quality monitoring program and the stream health field water quality measurements, it is concluded that for all the sites where measurements were made (with the exception of site SM4), water quality was generally reasonable and acceptable for the maintenance of aquatic ecological function. Water quality deteriorated during low flow and flood flow periods with the main aquatic stress arising from low dissolved oxygen concentrations (during low flows) and from excessive turbidity (during high flows). Site SM4 is highly stressed by elevated conductivity during low to no flow periods.

10.2.2 Riparian and Floodplain Ecology

ERM (2005 to 2009c) have undertaken various environmental assessment studies of the terrestrial ecology of the ACOL site and have been undertaking biannual (spring and autumn) flora and fauna surveys of the ACOL lease area (summer 2005 then autumn and spring in subsequent years to date). The following description of the floodplain/riparian ecology of the study area is derived from these reports. The Bowmans Creek floodplain between the New England Highway and the Hunter River has been previously disturbed by cattle grazing, weed encroachment, vegetation clearing and rubbish dumping. The riparian vegetation is characterised by a narrow strip of *Casuarina riparian* woodland with small sections of river red gum open forest. The area adjoining the creek riparian vegetation is mostly characterised by continually grazed pasture and relatively isolated patches of open woodland. There is a small remnant area of regenerating woodland to the east of the oxbow (see **Figure 10.2**). Land use is predominantly livestock grazing, with some irrigation and cultivation on the Hunter River floodplain. The location of these vegetation habitats is indicated on **Figure 10.2**. No threatened flora species have been identified within the site.

Riparian Woodland

The strip of riparian vegetation along the creek line is dominated by an overstorey of *Casuarina cunninghamia* (river oak) and there is a sparse to absent midstorey and moderate groundcover. This community is characteristic of the northern two thirds of the site, with sporadic regeneration evident. There are isolated occurrences of *Schinus areira* (pepper tree), *Angophora floribunda* (rough barked apple), *Populus alba* (white poplar) and *Salix babylonica* (weeping willow) throughout this community. The shrub layer is restricted to scattered thickets of *Lycium ferrosum* (African boxthorn) and the occasional stand of *Arundo donax* (giant cane). The groundcover is dominated by *Verbena bonariensis* (purpletop), *Cynodon dactylon* (common couch), *Gomphocarpus fruticosus* (narrow-leaved cotton bush) and *Bidens pilosa* (cobblers pegs). In lower lying areas, sedges and rushes dominated the ground cover and included species such as *Juncus usitatus* and *Schoenus apogon* (river club rush). *Typha orientalis* (broad-leaved cumbungi) is commonly encountered in isolated pockets of the creek.

River Red Gum Stands

ERM identified two narrow bands of *Eucalyptus camaldulensis* (river red gum) open woodland along the banks of Bowmans Creek near the Hunter River and outside the lease area (**Figure 10.2**). It is confined to the riparian corridor outside of the mining lease area, approximately 1km upstream from the Hunter River confluence. ERM (2009b) note that no regeneration of *E. camaldulensis* is evident and the maximum diameter at breast height was 45 cm. The understorey species are similar to the remaining vegetation communities and are characterised by both native and introduced grass species. Relatively high levels of disturbance were noted along the entire length of the riparian corridor and included cattle grazing, clearing, weed invasion and erosion.

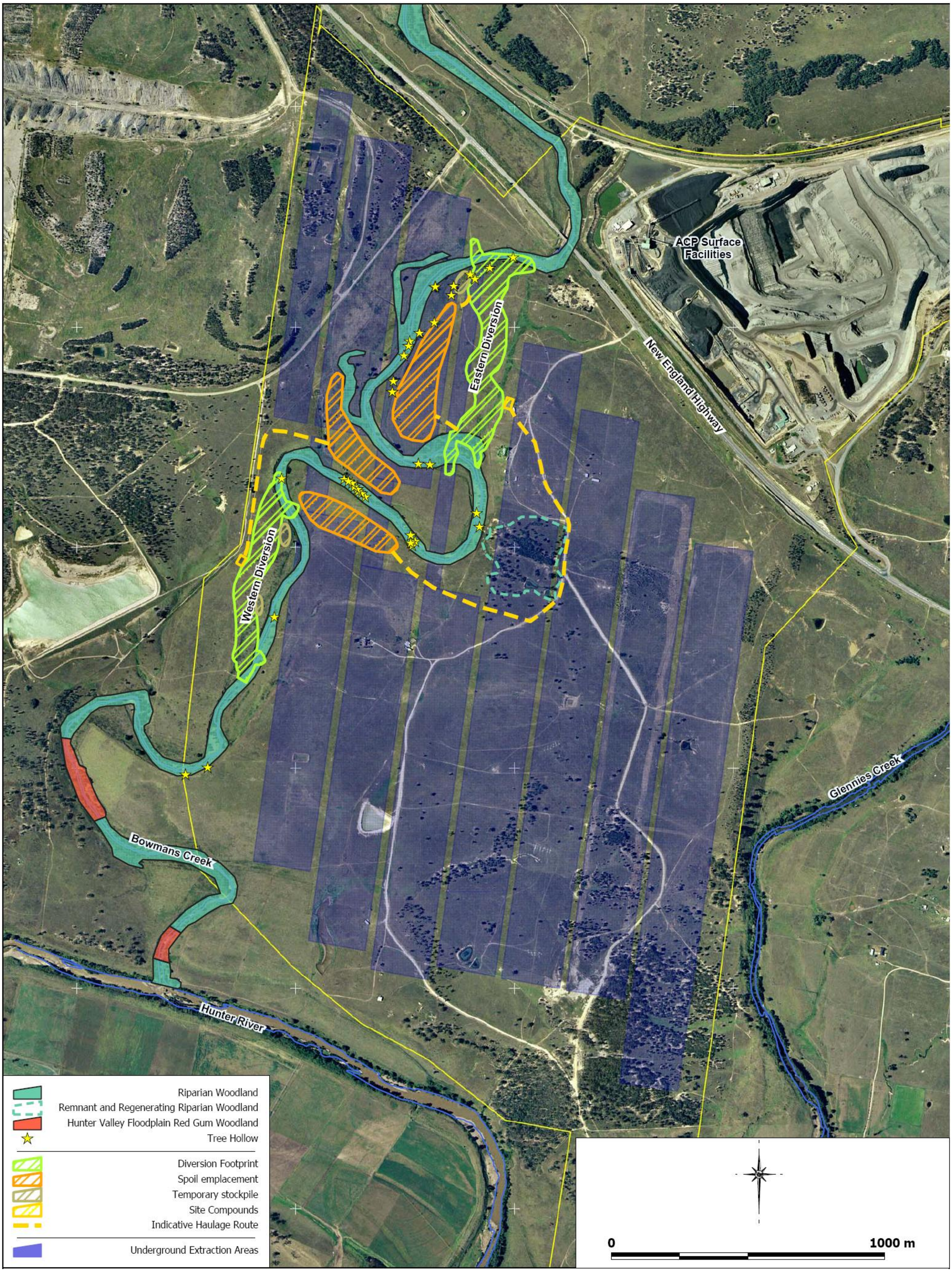

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Figure 10.2
Bowmans Creek Vegetation Communities and Proposed Works

Grasslands

Two grassland sub-communities occur within the paddocks adjacent to the riparian vegetation corridor, namely dry pasture and pasture that has been improved in the past. Within the areas of dry pasture, isolated trees exist and some regeneration is occurring. Scattered trees noted include *Allocasuarina luehmannii*, (bulloak) *Eucalyptus crebra* (narrow-leaved ironbark), *Eucalyptus melliodora* (yellow box) and *Eucalyptus moluccana* (grey box). Scattered shrubs of *Maireana microphylla* (eastern cotton bush) and *Acacia amblygona* (fan wattle) occur. Exotic species such as the woody weed *Lycium ferocissimum* (african boxthorn) occur below the canopy of the isolated trees.

The improved pasture community is located on the alluvial creek flats. Many exotic herbaceous species are present. Species used to improve the pasture for grazing value include *Lolium sp.* (rye grass), *Chloris gayana* (rhodes grass), *Paspalum dilatatum* (paspalum), *Medicago sativa* (lucerne), *Trifolium repens* (white clover) and *Pennisetum clandestinum* (kikuyu). Additional common pasture species noted include *Aristida vagans* (threeawn speargrass), *Cymbopogon refractus* (barbed wire grass), *Dichelachne rara, Microlaena stipoides* (weeping grass) and *Lomandra glauca* (pale mat rush).

Whilst the myrtaceous trees in the area provide seasonal foraging resources for nectivorous birds and mammals; (e.g. *Eucalyptus camaldulensis (July to February)*, *E. crebra* (April to November) and *A. floribunda* (August to November), their availability is relatively sparse due to the dominance of *Casuarina cunninghamia* (river oak). The grasses and sedges provide seed and stem resources for granivorous and herbivorous species. *Casuarina cunninghamia,* that dominates the riparian corridor, provides a limited seasonal foraging resource for highly mobile granivorous fauna such as the glossy black cockatoo. Understorey species such as *Lycium ferocissimum* (African boxthorn) provide foraging resources for many species favouring fruits and berries. Eucalypts would also provide suitable feeding/foraging resources for folivorous fauna such as the common brushtail possum and insectivorous birds such as treecreepers.

The riparian habitat has a moderate layer of leaf litter (typically five centimetres deep), a variety of fallen logs and a few rock outcrops that provide sheltering resources for small ground-dwelling mammals and reptiles. Hollow resources are limited on the site, however small to medium hollow resources have been recorded (see locations on **Figure 10.2**) and would support a range of fauna species that utilise these smaller hollows. The grassy understorey and fallen timber also provides suitable foraging substrate for the Grey-crowned Babbler and Speckled Warbler. Bowmans Creek provides habitat for water birds and frogs as well as a drinking resource for many native species.

Seven threatened fauna species listed under the TSC Act (three birds, three microchiropteran bats and a flying fox) have been identified as likely to occur within the study area or locality, *Pteropus poliocephalus* (grey-headed flying-fox), *Miniopterus schreibersii oceansis* (eastern bentwing-bat), *Mormopterus norfolkensis* (eastern freetail-bat), *Myotis macropus* (large-footed myotis), *Pyrrholaemus sagittatus* (speckled warbler), *Melanodryas cucullata cucullata* (hooded robin) and a breeding population of *Pomatostomus temporalis temporalis* (grey-crowned babbler eastern sub-species).

With respect to species listed under the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999, seven migratory bird species are identified as having the potential to occur within 10 kilometres of the site. Five of these are terrestrial birds and two are wetland birds. Habitat for the wetland birds (Latham's Snipe and Painted Snipe) is not provided on the site. The terrestrial migratory birds are:

- *Haliaetus leucogaster* (white-bellied sea-eagle);
- *Hirundapus caudacutus* (white-throated needletail);
- *Monarcha melanopsis* (black-faced monarch);

- *Myiagra cyanoleuca* (satin flycatcher); and
- *Rhipidura rufifrons* (rufous fantail).

10.2.3 Aquatic Ecology

Bowmans Creek is about 56 kilometres (km) long and the headwaters are located in the Little Brothers Range, at an elevation of about 650m Australian Height Datum (AHD). It has a catchment area of approximately 265 km^2. The lower section of Bowmans Creek between the New England Highway and the Hunter River confluence is 6km long and approximately 4.5km of this section is located within the ACOL Mining Lease overlying LW 5-8. Bowmans Creek experiences variable flow and it is generally perennial, although flow can cease during severe droughts (e.g, for several months preceding the July 2007 flood).

The number of pools in the Bowmans Creek study area varies with flow conditions. In the 2006 geomorphology study, undertaken during low flow conditions, there were 44 separate pools identified (ERM 2006a). For the MPR June 2008 walkover inspection when there was moderate surface flow (around 37ML/day or about 15^{th} percentile flow) there were around 24 pools within the study area, ranging in length from 10m to 500m. Most pools were wide (10m) and shallow (to 1m deep) with a few deeper pools (to 2.5m deep). Several pools (the top pool and the weir pool) are located within exposed basement rock, although neither are rock-bar constrained. Most of the pools are connected by cobble riffle zones, and the remaining pools are structured as "chain-of-ponds" type (see Rutherford et al, 2000), with more or less permanent pools (dependent on depth) separated by bars of sediment stabilised with vegetation. Many riffle or narrow pool sections are bordered by exposed cobble beds on one side, with steep sided banks on the other. Pools at the lower end of the study area are steep sided on both sides as the creek erodes down to the level of the Hunter River. When pool water levels are low, the Bowmans Creek exposed channel is colonised by terrestrial species, such as spike rushes (*Juncus sp*), and Casuarinas. Grasses and weeds rapidly colonise previously wet bank areas or newly exposed sediment bar deposits. The newly established in-stream vegetated areas have the potential to form islands or extended terrestrial banks, particularly if flow conditions remain low for a sufficient time for trees to develop to a mature enough stage (as occurred in the extended drought period preceding the 2007 June flood), and can influence the localised formations of flow channels during and following subsequent high flow periods.

Aquatic vegetation includes both true aquatic plants and edge emergent plants. Cumbungi (*Typha sp.)* stands are the most commonly encountered emergent macrophyte and often comprise the main vegetation on sediment bars between pools. Curly pondweed (*Potamogeton crispus*) and watermilfoil (*Myriophyllum sp.)* are the most common submerged macrophytes. An additional six submerged and emergent macrophyte species have been recorded over all Bowmans Creek surveys, they are; clasped pondweed (*Potamogeton perfoliatus*), sago pondweed (*Stuckenia pectinata*), slender knotweed (*Persicaria decipens*), maundia (*Maundia triglochinoides*), common reed (*Phragmites australis*) and the introduced watercress (*Nasturtium officinale*).

MPR (2001) concluded that 'no major barriers to fish migration were found within the Bowmans Creek study area'. Observations of water availability during 2006 drought periods noted minimal or zero surface water flow with only very shallow pools available in the upper reaches of the study area (i.e., for about 2.5km of creek immediately downstream of the New England Highway pool). Whilst there was flow further downstream, the small NSW Office of Water (NOW) gauging weir (located approximately 2.6km downstream from the New England Highway) and the rock bars below this weir were also deemed to inhibit fish passage during drought or low flow conditions, and there are some minor impoundments noted upstream of the New England Highway behind road crossings. However all structures are considered suitable for fish passage under a range of flow conditions. Subsequent aquatic habitat surveys between spring 2007 and autumn 2009 confirm that this remains the case.

Creek Sections to be Excised by the Proposed Eastern Creek Diversion

The upper creek section to be excised adjacent to the Eastern Diversion (from below the pool at site SM4/BC1 (see **Figure 10.1**) to the beginning of the oxbow under LW6B, consists of a series of broad, flat bottomed pools connected by constricted flow channels. Pool lengths range between 100m and 300m, and are generally straight with few backwaters or zones that would provide refuge in high flows. At least two retaining fences exist along sections of the western bank, in some parts actively stabilising the bank edge. Bank gradients are generally shallow with few steep areas along pool edges. Pool depths at the time of field inspection averaged 1m, with 1.5m maximum depths. Riffle water depths averaged 0.3m depth. The upper oxbow reach of the creek to be excised (under LW6B and MW5 in **Figure 10.1**) is a meandering creek channel consisting of a series of short narrow pools 10 to 20m in length, separated by shallow constricted riffle sections.

Creek Sections to be retained between the Proposed Eastern and Western Creek Diversions

The remaining oxbow reach of the creek to be retained (under MW5, MW6 and MW7 in **Figure 10.1**) is a meandering creek channel consisting of a series of short narrow pools 10 to 20m in length, separated by shallow constricted riffle sections. Riparian banks are less than 1m high with a series of three man-made dams bordering the creek line to the north within a former creek alignment. The eastern (outside) bank of the downstream oxbow creek reach (west of MW7 in **Figure 9.1**) is very steep and approximately 5m high. This bank was severely eroded with undercut banks and slumped trees following the June 2007 flood. The inside bank is more depositional with lower gradient, and consists of a grassed cobble bed. There is a continuous pool through the end of the oxbow and into the southern bend (towards the start of the proposed western diversion in **Figure 10.1**). There is then a straight narrow reach with short pools (to 1.5m deep) all connected by shallow, constricted cobble-riffle zones. Banks on both sides of the creek are relatively similar and vary between 2m and 3m height. Part of the western bank bordering the channel is steep with riparian trees abutting the bank edge, some of which are tilting and toppling into the stream. There is a short cobble riffle section on the bend of the creek upstream of the NSW Office of Water (NOW) weir pool that is bordered by large concrete blocks and a retaining fence on the western bank. The NOW weir pool is 1m deep. There are a number of bedrock outcrops through this creek section that would act as fish passage barriers during periods of low flow. The creek channel immediately below the NOW weir contains a number of boulders, with bedrock present in-stream and on the western bank. The pool extends for around 150m, and has a depth of 1.5 to 2m.

Creek Sections to be excised by the Proposed Western Diversion

The section of creek to be excised adjacent to the Western Diversion has pools that are relatively deep (to 2m) and are constrained in a narrow (to 5m width) incised flood channel with very steep banks, mostly along the eastern edges.

Creek Sections below the Proposed Western Diversion

The next reach of creek to be retained below the proposed Western Diversion is similar to that encountered immediately upstream and consists of a narrow channel, with steep eroding banks on the eastern pool edges. There are two pools separated by a mixed cobble and sediment riffle section, with the lower pool widening and the bank becoming steep along the western side. The remaining reach of Bowmans Creeks to around 400m upstream from the Hunter River confluence consists of a deeply incised channel 10-15m below the surrounding floodplain. The ponds are shallow, 0.8 to 1m deep throughout the section, some with exposed cobble bars on the inside corners of creek bends. Riparian banks are steep (~45º) and vegetated by grasses and weeds, with scattered riparian Casuarinas, Eucalypts and Willows. Bank undercutting is present along the outside edge during most surveys between autumn 2007 and spring 2008.

10.2.4 Monitoring

To date there have been ten aquatic ecology surveys in Bowmans Creek (between spring 2001 and autumn 2009) that have incorporated sampling for macroinvertebrates and fish, including two that used electro-fishing techniques. A total of 39 edge and 2 riffle habitat sites have been sampled over these 10 surveys. Seasonal summary statistics for the sampled edge habitats are presented in **Table 10.1**.

- To date, a total of 70 aquatic macroinvertebrate taxa (taken to AusRivAS required family level) have been identified from the combined studies.
- Four of the taxa were recorded from riffle habitats only; riffle beetles (family Elmidae), water pennies (family Psephenidae), fly larvae (family Dolichopodidae) and dobsonflies (family Cordyalidae).
- The majority of the taxa are insects (67%), with the remainder being molluscs (12%) and crustaceans (9%). Arachnids, flatworms, annelid worms, leeches, roundworms and springtails made up the remaining 12% of which none were greater than 2%.
- There were thirteen taxa that were found in Bowmans Creek during six or more of the ten surveys, and six of those taxa were also common throughout the creek (i.e. occurring at over 75% of total sites sampled); midge fly larvae (sub-family Chironominae), freshwater shrimp (family Atyidae), damselflies (family Coenagrionidae), mayflies (family Caenidae), water boatmen (family Corixidae) and caddis flies (family Leptoceridae).
- Prior to the major flood event in June 2007 (i.e., during or towards the end of extended drought), there were relatively low site SIGNAL scores (spring 2001, 2005 and autumn 2006). The combined site SIGNAL score for the survey immediately following the flood (autumn 2007) was also low and overall creek SIGNAL scores have improved over each consecutive sample season since then, peaking in spring 2008.

The stream health data indicate that the aquatic ecological habitats of Bowmans Creek have been in a state of recovery since the combined extended pre-June 2007 drought and since the major flood in June 2007. For at least one year prior to the flood, sections of Bowmans Creek within the study area were isolated and drying up and there was a marked reduction in the extent and variety of fish and macroinvertebrate fauna. The flood destabilised, swept away or smothered much of the remaining habitat features with silt and most likely scoured much of the macroinvertebrate fauna out of the creek as well. Since the floods, Bowmans Creek has sustained regular flows throughout the study area, enabling aquatic habitats (macrophyte beds, new logs and new detritus) to re-establish over time with increasing macroinvertebrate site diversity, SIGNAL scores and fish diversity recorded over consecutive seasonal surveys. Based on the number of new taxa encountered on each consecutive sample occasion since June 2007 it would appear that the recovery of the macroinvertebrate fauna assemblage in edge habitats in Bowmans Creek has not yet been achieved.

To date there have been 14 fish species recorded from the Bowmans Creek catchment, two of which are introduced species (**Table 10.2**).

- The introduced pest species, plague minnow (*Gambusia holbrooki*), has been the most commonly encountered fish during all aquatic ecology monitoring surveys, generally recorded at every monitoring site sampled in Bowmans Creek.
- Carp have also been commonly observed over all surveys, with the exception of high flow periods during autumn and spring 2007.
- The larger native fish species such as Australian bass, eel-tailed catfish, long-finned eel and mullet, have all been caught or observed in sections of Bowmans Creek within the study area (i.e., between BC1 and SM4A) during periods of low surface flow (autumn 2006 survey) when there was no possibility of fish passage between pools.

Table 10.1: Macroinvertebrate Summary Statistics for Bowmans Creek (2005 to 2009)

Flow**	Dry	Low	Low	Dry	Dry	Medium	High	Medium	Low	Medium
Flow rate (ML/day) (Now gauge)	N/A	1.7	0.7-0.8	0.4	0.4	123-129	840-158	28-25	3.3-4.9	20-26
No of Sites	N=2	N=3	N=4	N=2	N=4	N=4	N=4	N=4	N=6	N=6
Season and Year	Sp01	Sp05*	Sp05	Au06*	Au06	Au07	Sp07	Au08	Sp08	Au09
Total number of invertebrate taxa:	8	33	33	31	31	25	30	32	37	44
Mean number of taxa per site:	5	23	20.5	16.3	15.5	14	17	18.8	18.8	19.8
Standard Error:	0	3	1.9	4.7	1.8	2.5	1.9	1.1	1.8	1.9
Creek SIGNAL score:	3.88	4.43	4.06	4.59	3.83	3.71	4.53	4.99	5.1	4.95

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

** Dry represents no surface flows during time of sampling between the majority of site pools.

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

Medium flow is when there is sufficient flow to allow fish passage through most to all of the site.

High flow is when there is sufficient flow to allow fish passage through all of the site with no impediments.

Table 10.2: 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	*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					
Note*: Life cycle characteristics referenced from Thorncraft & Harris 2000.					

With regard to other possible fauna associated with the Bowmans Creek aquatic habitats, the combined MPR and ERM studies have reported amphibians (tadpoles and frogs), ducks and other water birds, long-necked turtles, water dragons and water skinks. The following amphibians are reported from Bowmans Creek:

- *Crinia signifera,* common eastern froglet (all surveys);
- *Limnodynastes tasmaniensis*, spotted marsh frog (recorded once in summer 06);
- *Paracrinia haswellii*, red-groined froglet, (recorded once in spring 07);
- *Litoria peronii*, emerald spotted treefrog, (recorded, spring 07 to spring 08);
- *Litoria latopalmata*, broad-palmed frog, 3 times, (recorded, spring 07 to spring 08);
- *Litoria leseuri*, Leseur's frog (recorded once in spring 07);
- *Uperoleia laevigata*, smooth toadlet (recorded once in autumn 05).

Whilst platypus and Australian water rat are recorded from the lower section of Glennies Creek below the Highway, there have been no records or sightings in the Bowmans Creek study area below the Highway.

10.2.5 Groundwater Dependent Ecosystems

The ERM and MPR flora, fauna and aquatic ecology reports reviewed for this report all considered the occurrence of Groundwater Dependent Ecosystems (GDEs) in the Creek Diversion study area. Potential GDEs of the study area were identified using the eight-step rapid assessment (DLWC 2002) and it was concluded that there are no known or likely wetland, terrestrial or aquifer/cave ecosystem GDEs in the study area.

- Assessment of riparian vegetation did not indicate any specific riparian plant communities, which could be considered groundwater dependent.
- Downstream of the study area, the two stands of *Eucalyptus camaldulensis* (river red gum) are restricted to the streams and the associated banks and there are no large floodplain remnants of *Eucalyptus camaldulensis* within the catchment. Accordingly these stands would be expected to get at least 50 % of their water directly from the stream with the balance derived predominantly from rain retained soil moisture in the banks and the remainder from groundwater.
- With regard to aquatic GDEs, the lateral extent of saturated alluvials (as indicated on **Figure 7.1**), may include parafluvial zones in the creek. However, as the creek is perennial and the baseflow is very small, riparian and edge emergent vegetation plus riffle zone fauna are considered more dependent on fluctuating surface water levels than on groundwater.
- During prolonged drought conditions such that the baseflow may start to become significant (as encountered in 2007 prior to the June 2007 flood), there are no active riffles, there are only small disconnected pools remaining and the pool edge and bar vegetation dies off. At that time salinity of the baseflow only becomes significant in the SM4 pool, thus limiting the remaining aquatic macroinvertebrate assemblages that could reside in the pool and limiting the microinvertebrate fauna that could reside in the hyporheic zone.

10.3 Threatened Species, Endangered Ecological Communities and Key Threatening Processes

The two strips of River Red Gum downstream of the proposed diversions and outside the ACOL lease area are considered to be part of the River Red Gum population in the Hunter Catchment, which is listed as an endangered population under the *Threatened Species Conservation Act 1995* (TSC Act). With regard to other threatened flora, the DECC database search identified one threatened flora species, *Digitaria porrecta* (finger panic grass), within 10 kilometres of the site. Habitat for an additional three threatened flora species has been recorded on the DEWHA database within 10 kilometres being, *Diuris tricolor* (pine donkey orchid), *Eucalyptus glaucina* (slaty red gum) and *Thesium australe* (austral toadflax). However, no threatened flora species were recorded by ERM within the site during the various surveys.

Seven threatened fauna species listed under the TSC Act (three birds, three microchiropteran bats and a flying fox) have been identified as likely to occur within the study area or locality:

- Four *Pyrrholaemus sagittatus* (speckled warbler) have been observed foraging in the southern woodland, to the south east of the ACOL lease area (ERM, 2006b). Speckled Warblers prefer a range of eucalypt dominated communities supporting a grassy understorey within gullies or rocky ridges and habitat ranges are up to 10 hectares. Bowmans Creek corridor is generally unsuitable breeding habitat for this species, however individuals may forage in the area as part of mixed flocks during winter.

- *Melanodryas cucullata cucullata* (hooded robin-south eastern form) has been identified in two locations within the southern woodland (ERM, 2007a) and are also likely to occur within the riparian corridor along Bowmans Creek. Home ranges of the Hooded Robin vary from 10 hectares in the breeding season up to 30 hectares outside of the breeding season. Hooded robins prefer eucalypt woodland supporting a diverse range of structures including mature eucalypt, saplings, shrubs and tall, native, grassy understorey (DEC, 2005b). The species is often recorded in agricultural areas along fertile creek lines and is known to inhabit regeneration areas. Roosting habitat includes fallen timber and low dead stumps. Breeding occurs between July and November during which cup-shaped nests are constructed one to five metres above the ground. Threats to survival include clearing resulting in habitat fragmentation and modification or destruction of habitat through heavy grazing, timber removal, frequent fire and exotic grass invasion (Robinson *et al*, 1996).
- *Pomatostomus temporalis temporalis* (grey-crowned babbler eastern sub-species) have been commonly encountered within the southern woodland and in or near Bowmans Creek in the patch of regrowth riparian woodland to the east of the creek ox-bow (see **Figure 10.2**). The family group occupying the southern woodland was reported to have increased from eight birds in September 2004 to twelve in January 2005 with the number of nests increasing from two to six respectively (Parsons Brinckerhoff, 2004b). The most recent monitoring survey (ERM, 2009b) reported that the number of grey-crowned babblers within the site appeared to be stable at around 12 individuals, with a total of 13 nests identified.
- *Myotis macropus* (Large-footed myotis) were recorded within the southern woodland during previous surveys (ERM, 2006b; Parsons Brinckerhoff 2004b).
- The site provides potential hunting and roosting habitat for *Mormopterus norfolkensis* (eastern freetail-bat) and hunting/foraging habitat only for *Miniopterus schreibersii oceansis*, *Myotis adversus* and *Pteropus poliocephalus.*

With regard to key threatening processes listed under the TSC Act and Fisheries Management Act the following are applicable to the creek diversion project:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands;
- Clearing of native vegetation;
- Invasion of native plant communities by exotic perennial grasses;
- Removal of dead wood and dead trees; and
- Predation by *Gambusia holbrooki* (mosquitofish).

10.4 Assessment of Proposal and Mitigation Measures

The alignment, cross sectional geometry and geomorphology of the proposed diversion channels are described in **Section 8** and **Section 9** above and the detailed engineering designs for the diversions are presented in **Plan Set 2**. The construction sequence is described in **Section 12.3** and the detailed landscape and habitat restoration for the diversion channels is described in **Section 12.5** and shown on the drawings in **Plan Set 3**.

Bowmans Creek in its present state is perennial with flow only ceasing during extended drought periods. Most of the creek line is characterised by shallow elongated ponds separated by cobble or sediment riffles or banks. There are pools throughout the creek that provide drought refuge, even in extended drought periods, as observed in 2001 and 2005/6. Many of the pools have gravel to cobble sized beds that provide suitable nesting areas for catfish.

Habitat complexity is generally good with varying creek substrata (cobbles, sediments, detritus and rock), emergent and aquatic plants, and some overhanging edge vegetation. There are also areas of eroding banks where the riparian vegetation is limited or where banks are destabilised by stock access. There is no 'large woody debris' in the form of log jams, only a few individual fallen trees associated with recent floods.

During low flows there is often not sufficient depth over cobble riffles to connect pools for fish passage. Fish passage can also be limited by rock bars in the centre of the creek below the NSW Office of Water (NOW) weir pool. During moderate flows there is suitable fish passage through the creek and upstream. During high flows there is also sufficient water depth for fish passage but passage for smaller species can be limited by the lack of resting or off-line pools.

The present creek has a narrow and interrupted band of riparian woodland along much of its length, but it cannot be termed "Hunter River riparian woodland" in its present state as it lacks the width (due to past clearing of the adjacent floodplain for pasture land) for the full development of this riparian woodland habitat. Notwithstanding, the remaining strip of riparian woodland provides habitat for a host of terrestrial fauna including a number of threatened woodland bird species that feed and forage there. The riparian woodland and isolated trees in the pasture land fringing the woodland also provide some tree hollow habitat that could be utilised by several bat species known from the locality.

The riparian woodland downstream of the ACOL lease area supports several stands of river red gums and the assemblages may be considered consistent with the "River Red Gum population in the Hunter River" which is listed as an endangered population. Whilst outside the proposed area for the creek diversions, the cumulative impacts on these populations arising from the diversions and the mining for which the diversions are being proposed have been considered.

10.4.1 Provision of Aquatic Habitat

The designs of the diversion channels have incorporated a high degree of geomorphic and landscape complexity which:

- Mimics the important (and differing) geomorphic characteristics of each of the sections of the creek to be excised;
- Provides comparable, or better quality aquatic habitat than the existing creek, including pools and riffles, supplemented with large woody debris log jams (which are largely absent from the existing creek);
- Provides comparable hydraulic conveyance to the existing creek.

The proposed diversions will therefore be capable of providing fish passage to link the Hunter River with the upstream aquatic habitats in Bowmans Creek. The diversions will also provide drought refuge pools for fish and suitable nesting habitat for catfish. In addition, similar aquatic habitat resources to those found in the existing creek will be provided to support other aquatic biota (macroinvertebrates, aquatic plants, emergent edge plants, amphibians and terrestrial animals directly associated with creek habitats; e.g., copper skinks, long-necked turtles, Australian water rat, ducks and fishing bats). In effect, the diversion creeks will mimic the existing creek.

Table 10.3 provides an analysis of the existing and final connected aquatic habitats in terms of creek length. The existing creek has a thalweg distance of 6,225m between the New England Highway and the Hunter River. The proposed diversions will excise 1,933m of Bowmans Creek riparian and aquatic habitat and replace it with 1,509m of constructed creek-line in two diversion channels. These lengths have been achieved by mimicking the existing channel sinuosity as far as possible. By directing the lower end of the Eastern Diversion into an existing section of oxbow creek and reconnecting this to the existing creek, an additional 125 m of in-line creek length is obtained making the overall direct line connection from the Hunter River to the New England Highway 5,641m. By offsetting the upper and lower block banks for both the diversions, up- and down stream from their respective confluences, an additional 385m of off-line creek and riparian habitat will also be retained, resulting in a total of 6,026m of creek and offline lagoon riparian and aquatic habitat.

Table 10.3: Existing and Proposed Reaches of Bowmans Creek

Reach		Existing Length (m)	Proposed Length (m)
A	Channel downstream of New England Highway (to ED confluence)	176	176
B	Creek between ends of Eastern Diversion (proposed length is new constructed length)	1,480	955
B3	Additional section of creek rehabilitated from old oxbow section & within Eastern Diversion	0	125
B1 & B2	*Creek Eastern Diversion backwaters*	*0*	*260*
B3	Old oxbow to be reconnected for diversions	0	125
C	Existing channel flowing east – west (Eastern Diversion to Western Diversion)	1,196	1,196
D	Creek between ends of Western Diversion	838	779
D1 & D2	*Creek Western Diversion backwaters*	*0*	*125*
E	Channel from Western Diversion confluence downstream to Hunter River	2,535	2,535
	Length of Creek (Hunter to NE Highway)	**6,225**	**5,641**
	Length of Off-line Creek Habitat	***0***	***385***
	Total Length of Connected Creek Habitat	**6,225**	**6,027**

Thus, there will be a net loss of 198m of aquatic habitat (or about 3.2% reduction compared to the existing creek. However, this loss is being offset by incorporation of the following design elements:

- Ensuring that there is no significant reduction in actual aquatic habitat area; thus under the 1 year ARI flood condition, whilst there small reduction in the lower active floodplain area from 6.7ha to 6.4 ha, the design provides for a net increase in the area of pools available (from 0.9ha to 1.1ha – see **Table 2.4**).
- Incorporation of off-line 'resting pools' (absent in the existing creek) that will be available for fish migrating upstream during low to moderate flow events (up to a 5 year ARI flood event). These will be located at four well-spaced places along the route from the Hunter River to the New England Highway. This is an important feature as under the current conditions fish need to cover the creek length against channel velocities of up to 1.9m/s (for 1 year ARI flood) and in excess of 3m/s (for 100 year ARI flood).
- A significant improvement in riparian habitat condition and cover (see **Section 10.4.1**).
- Incorporation of fish friendly riffle and rock bar structures that will ensure fish passage is available for moderate flows.

The remaining sections of excised creek will be retained as high flow channels. For the early years whilst the new creek diversions are settling and whilst the riparian revegetation is establishing, it is intended that the excised creek will take a proportion of the flood flows above the 1 year ARI flood level (see **Section 12.4.5** for further details). At final configuration, when all the block banks are in place, the diversion channels will take a proportion of flood flows above the 5 year ARI flow. As there will be mining under the excised portions of creeks, the ability of these creek portions to retain water will become progressively less over the mining sequence. Accordingly, there will be less viable aquatic habitat available and the excised creek sections will be allowed to revert to floodplain woodland. The excised sections of creek plus the floodplain lands between the excised creeks sections and the diversions will be incorporated into the overall conservation lands established by ACOL.

This will be actively managed as part of the existing ACOL *Environmental Management Strategy* and the environmental management plans prepared under the strategy such as the *Subsidence Management Plan* and the *Flora and Fauna Management Plan.*

Table 10.4 sets out the losses in terrestrial habitat arising from the proposed creek diversions.

Table 10.4: Losses in Terrestrial Habitats

Item	Pasture Grass	Riparian Woodland	Total
Diversion channels	13.9 ha	<1.8 ha	<15.7 ha
Stockpile areas	14.6 ha	0.0 ha	14.6 ha
Total	28.5 ha	<1.8 ha	<30.3 ha

The diversions will be constructed through pasture habitat and there will be a net loss of 13.9ha of pasture habitat. The interconnection of the diversions to the existing creek plus the construction of the block banks would affect up to 1.8ha of riparian woodland habitat although the actual area to be lost would be less, as parts of the construction works would be able to be undertaken without affecting riparian vegetation (e.g., on the banks opposite to the connections). There will be an additional 14.6ha of pasture grass land temporarily alienated for stockpiling materials excavated from the diversions channels.

To offset these losses the proposed diversions include the construction of riparian and floodplain areas that will be planted out to achieve an overall net increase in Hunter Valley River Oak Woodland and in Hunter River Red Gum populations.

The proposal also incorporates fencing of the complete riparian zones through the lease area (around the diversions, the excised creek and the remaining creek) to exclude stock, with both active and managed riparian revegetation to increase the current existing average riparian vegetated strip width of 45 m (bank to bank). Thus for the Eastern Diversion the riparian vegetated width will be planted out to a minimum of 93m and for the Western Diversion the riparian width will increase to a minimum of 75m. Additional fencing for stock exclusion will provide a greater buffer area of floodplain pasture land where natural regrowth of floodplain woodland can occur.

The expanded width riparian zones along the diversions channels and along the complete creek will also be incorporated into the existing ACP vegetation and terrestrial corridors that have already been fenced off and in which woodland re-vegetation is currently being managed.

Stock access for watering will be minimised by provision of on-demand watering points away from the protected riparian zones.

10.5 Threatened Species, Communities and Processes

10.5.1 Threatened Species Conservation Act 1995

The 'River Red Gum population in the Hunter Catchment' is listed as an endangered population under the *Threatened Species Conservation Act 1995* (TSC Act), and the two strips of River Red Gum downstream of the diversions and outside the ACOL lease area have been identified to be part of this endangered population for previous mine related surveys (ERM 2006b, 2009b). Management of this endangered population forms part of an existing flora and fauna management plan for the approved underground mining activities (Ashton Coal 2006b).

Seven threatened fauna species listed under the TSC Act have been identified as likely to occur within the study area or locality, *Pteropus poliocephalus* (grey-headed flying-fox), *Miniopterus schreibersii oceansis* (eastern bentwing-bat), *Mormopterus norfolkensis* (eastern freetail-bat), *Myotis macropus* (large-footed myotis), *Pyrrholaemus sagittatus* (speckled warbler), *Melanodryas cucullata cucullata* (hooded robin) and a breeding population of *Pomatostomus temporalis temporalis* (grey-crowned babbler eastern sub-species).

The relationship of the two river red gum stands and of the seven listed species to the study area is summarised in **Section 10.3** above and the potential for impact on these populations and species arising from the proposal have been considered in detail via seven-part tests annexed to **Appendix 9** to this report.

The existing riparian woodland strip provides feeding, foraging and roosting habitat for a variety of these fauna and the conclusion of the seven part testing is that safeguards can be incorporated into the management of the diversion construction to minimise disruptions to the local populations of the species and that the provision of overall increased riparian and floodplain woodland habitat will benefit all the species. As recommended in the seven-part testing, the proposal also incorporates harvesting, management and reuse of species-specific resources such as e.g., fallen logs, trees with roosting hollows and old fence poles. This is in line with the existing *Flora and Fauna Management Plan* which will be updated to incorporate the proposed creek diversion.

10.5.2 Fisheries Management Act 1994

No species of fish or aquatic invertebrates, as currently listed under the NSW Fisheries Management Act 1994 (FMA), or under the Commonwealth Environment Protection & Biodiversity Conservation Act 1999 (EPBC Act), were recorded in any of the Bowmans Creek monitoring conducted to date, and no protected fish, as listed under the FMA, have been found or observed in Bowmans Creek.

In May 2009 there was a report of southern purple spotted gudgeon (*Mogurnda adspersa*) in Goorangoola Creek, a major sub-catchment creek discharging to Glennies Creek (HCR-CMA Catchment News, Issue 17 May 2009). The southern purple spotted gudgeon is listed as endangered under the FMA. Since October 2008, up to 20 specimens have been found at five different sites in Goorangoola Creek. This species is known from both East Coast and Western flowing river systems and, up to the time of this discovery, the East Coast population was only known from coastal rivers north of the Clarence River. The species is found in slow moving or still waters of creeks, rivers, wetlands and billabongs, and prefers slower flowing, deeper habitats. Current populations are correlated with low turbidity. It is a benthic species, usually associated with good cover such as cobble and rocks in the Queensland parts of its range, or aquatic vegetation in its southern range. It is a common aquarium fish and there is a possibility that this population is an introduced population. Whilst its location in upstream Bowmans Creek sites cannot be discounted, to date this species has not been recorded in the Bowmans Creek study area from any of the fish surveys undertaken between Spring 2005 and Autumn 2009.

If there are southern purple spotted gudgeons in Bowmans Creek, then it is more likely that they would be found in the upper reaches of the creek. It is concluded that the proposed creek diversions are not likely to have an impact on any local population of this species.

Two fish species known or reported from Bowmans Creek are listed as species of concern in Morris *et al* 2001; The Darling hardyhead and the Freshwater catfish:

- The Darling hardyhead (*Craterocephalus amniculus*) is listed due to its taxonomic uncertainty. It is endemic to streams in the upper Darling River system. Specimens tentatively identified as *Craterocephalus amniculus* were collected from upper Bowmans Creek in 1976 and 1980, though no further individuals have since been collected (cited in Morris *et al* 2001). This species has not been observed or caught in any of the ACOL surveys (from 2005 onwards) and was not caught during the electro-fishing surveys of the creek in (2005-2006). Accordingly the possibility of this species being found in the study area is considered unlikely.

- Morris *et al* 2001 note that whilst coastal river freshwater catfish (*Tandanus tandanus*) populations are not currently listed as threatened in NSW, this species' distribution and abundance has been significantly reduced throughout the southern parts of its known range. This species has been recorded from a refuge pool located between BC1 and SM4A during the autumn 2006 drought, nests and adults were observed at site BC3 and juveniles were caught at Site BCdown, both sightings in spring 2008. Accordingly, the proposed creek diversion will be incorporating cobble bottom pools suitable for catfish nesting.

10.5.3 Key Threatening Processes

Of the possible likely threatening processes listed in **Section 10.3** the proposed creek diversion works would potentially 'alter the natural flow regimes of rivers, streams, floodplains & wetlands', would involve 'clearing of native vegetation' and could involve removal of dead wood and dead trees'. In regard to the possible impact on threatened species arising from these actions, the proposal has incorporated design and safety features to ensure that:

- There will not be any deterioration in key aquatic and fish habitat attributes arising from the proposal;
- Managed harvesting and reuse of dead wood and dead trees will be undertaken and the overall roosting facilities of the site will be increased;
- There will be more riparian and floodplain woodland habitat available to support local populations of threatened species; and,
- The new habitats will be an improvement over the present degraded or limited habitats, e.g., providing more habitat complexity, incorporating specific species' requirements (such as roosting sites, tree hollows and resting pools). Aquatic habitats will have better riparian bank stability and cover.

Accordingly it is concluded that the key threatening processes arising from the project construction will not impact any local populations of threatened species and that the design, rehabilitation and restoration works will enhance the feeding, foraging and roosting opportunities for these local populations.

10.5.4 Commonwealth EPBC 1999

With respect to species listed under the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999, seven migratory bird species are identified as having the potential to occur within 10 kilometres of the site. Five of these are terrestrial birds and two are wetland birds. Habitat for the wetland birds (Latham's Snipe and Painted Snipe) is not provided on the site. The terrestrial migratory birds are:

- *Haliaetus leucogaster* (white-bellied sea-eagle);
- *Hirundapus caudacutus* (white-throated needletail);
- *Monarcha melanopsis* (black-faced monarch);
- *Myiagra cyanoleuca* (satin flycatcher); and
- *Rhipidura rufifrons* (rufous fantail).

These species are wide-ranging with generalist habitat requirements and may occasionally use the site as foraging habitat. However, as the distribution of vegetation communities that occur on the site is not confined to the site, it is concluded that the proposed creek diversion works will have no significant impact on these migratory species.

10.6 Conclusion

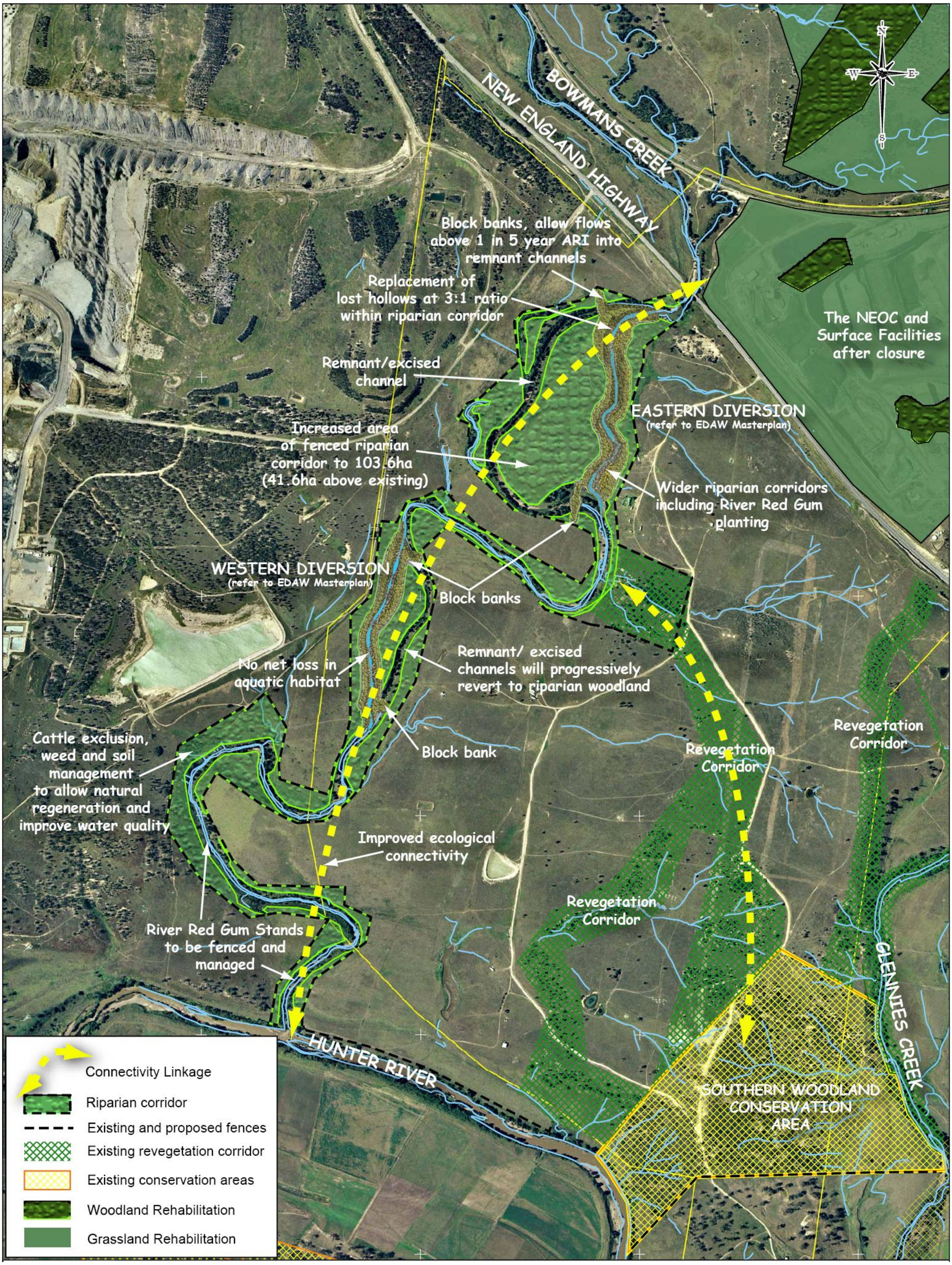
The proposed creek diversions will result in the excising of two sections of existing creek line (1,933m) which will continue to function as high flow overflow channels and will be actively managed to revert to floodplain woodland as part of the overall conservation lands being set aside by ACP. The proposed creek diversions have been designed to provide similar fish passage characteristics and sufficient aquatic habitat so that the actual loss of creek length is confined to 198m. This is achieved by incorporating a number of off-line channel sections that will provide valuable and connected aquatic habitat, fish refuge and fish passage resting ponds, particularly during moderate to high flow events. The design provides an overall slight increase in available aquatic habitat. The diversion creek design mimics the sections of creek to be excised thus providing similar aquatic habitat features, and there is an overall improvement, as the proposed riparian revegetation will enhance the creek aquatic attributes by, e.g. providing more shade from a denser and more complex riparian edge vegetation and providing overall more stability to riparian banks than the existing banks that are sparsely vegetated in many areas. Overall aquatic habitat improvement will also be achieved by stock exclusion from the creek riparian zone and active management of stock in buffer zones (including provision of on-demand stock watering points away from the protected riparian zones).

The proposed diversion and associated stockpiling will alienate 28.7ha of pasture grassland and up to 1.8ha of degraded riparian woodland. The 13.9ha of pasture grassland lost to the creek diversion will be offset by the provision of 13.9ha of aquatic and riparian woodland habitat to incorporate river red gum habitat as detailed in the landscaping proposal (**Section 12.5**). The remaining 14.8ha of pasture grassland temporarily alienated for stockpiles will be progressively managed towards grassy floodplain woodland habitat and will be managed under the existing flora and fauna management plan. Overall fauna habitat requirements, and particularly habitat requirements for the listed woodland birds and bats known from the locality, will be protected and enhanced by active management, also as specified in the existing flora and fauna management plan. All the creek aquatic and riparian habitats will be incorporated into the overall dedicated conservation area for ACP and will form part of the existing ACP riparian and terrestrial corridor system (see **Figure 10.3**).

The construction of the diversion channels, the incorporation of the block banks and the associated landscaping plans have been staged to promote stability along the new creek segments and the riparian banks. To this end the *Landscape Restoration Plan* (**Appendix 10**) incorporates active management over the life of the mine to ensure the continuing viability and proper functioning of the aquatic and riparian sections of the diversion creek sections.

The existing ACP *Environmental Management Strategy* and associated environmental management plans incorporate existing monitoring programs for flora and fauna as well as aquatic ecology (stream health). These will be adapted from the Spring 2009 seasonal monitoring to:

- Determine that the combined Bowmans Creek existing plus new diversion aquatic and terrestrial habitats are providing the design habitat functions and,
- Provide timely advice for active management of aquatic and riparian habitats should there be any negative deviation from the accepted habitat functions.



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Bowmans Creek Diversion Project

Figure 10.3
Post Mining Landscape, Connectivity and Offsets

11 HERITAGE

11.1 Aboriginal Heritage

ACOL commissioned Insite Heritage Pty Ltd (Insite Heritage) to prepare an Aboriginal archaeological heritage assessment of the area associated with the Bowmans Creek diversion project. A copy of the report is contained in **Appendix 11**.

11.2 Assessment Methodology

Community consultation with Aboriginal stakeholder groups and individuals was undertaken in accordance with the DECCW guidelines: *Interim Community Consultative Requirements for Applicants*. Letters of notification of the project were sent to the DECCW, NSW Native Titles Services, Office of the Registrar of Aboriginal Owners, Office of the Registrar ALRA, and Singleton Council.

Thirty one (31) letters of invitation were sent to those stakeholders known to ACOL in accordance with their own register. Public notices advising of the project and inviting registrations from community groups and individual Aboriginal stakeholders were published in the public notices sections of the Singleton Argus and Sydney Morning Herald newspapers on 11 September, 2009.

A total of 26 groups/individuals registered an interest in the Bowmans Creek diversion project. All registered groups /individuals were provided with a draft copy of the Aboriginal archaeological assessment report, prepared by Insite Heritage (**Appendix 11**).

All registered stakeholders were invited to attend an on-site meeting at ACOL offices on 13 October, 2009. The purpose of the meeting was to discuss stakeholders' perceptions of the project, cultural values of the area, Insite Heritage report and archaeological management strategies for the project. At the request of the stakeholders a workshop was held on 24 and 25 October, 2009. Ongoing consultation with the stakeholders will occur throughout the course of the project.

The Aboriginal heritage assessment process was undertaken inclusive of consultation in accordance with the DECC guidelines and involved consultation with the Aboriginal community (individuals and groups) listed in **Table 11.1**.

Table 11.1: List of Community Groups who have Registered in Response to the Consultation Process

Wonnarua Culture Heritage	Wonn1 Contracting	Yinarr Cultural Services
Hunter Valley Cultural Surveying	Hunter Valley Cultural Consultants	Upper Hunter Heritage Consultants
Giwirr Consultants	Yarrawalk Enterprises	Gidawaa Walang
Aboriginal Native Title Consultants	Ungooroo Aboriginal Corporation	Ungooroo Cultural and Community Services Incorporated
Barbara Foot*	Scott Franks	Culturally Aware
Lower Hunter Wonnarua Council Inc	Upper Hunter Wonnarua Council Inc	Wanaruah Custodians Aboriginal Corporation
Carrawonga Consultants	Minggaa Consultants	Cacatua Cultural Consultants
Bullin Bullin Heritage Consultants	Muswellbrook Cultural Consultants	Wanaruah Local Aboriginal Land Council
Wattaka Wonnarua Traditional Owners	Wonnarua Nation	

* Mrs B Foot has registered an interest in the process via the DECCW

A significant Aboriginal population remains in the area today and they take an active interest in their cultural heritage. All registered stakeholders have been forwarded a copy of the draft Aboriginal archaeological assessment for their review and comment.

11.3 Registered Aboriginal Heritage Sites

Aboriginal occupation within the Central Lowlands of the Lower Hunter Valley occurred over 20,000 years ago, however the majority of dated sites within the Hunter Valley are less than 4,000 years old (Brayshaw 1994). In the course of development related studies, evidence of Aboriginal occupation has generally been dated to the Holocene period (the last 10,000 years). At Glennies Creek, Koettig (1986) found evidence of a hearth and dated the associated charcoal to 10,000 to 13,000 years ago.

A search of the AHIMS (Aboriginal Heritage Information Management System) register was conducted for an area of 30 square kilometres surrounding the study area. The search identified 50 sites recorded in this greater area, however no AHIMS sites were recorded within the direct study area. The closest sites to the study area were located in a survey undertaken by Insite Heritage in 2008/9 for the ACOL Longwall/Miniwall 9 project. That study included the area containing the western diversion of Bowmans Creek. The Aboriginal archaeological assessment for Longwall/Miniwall 9 project identified seven (7) sites as shown in **Table 11.2** on the western side of Bowmans Creek. Of these none will be directly impacted by the creek diversion. The terrace flanking Bowmans Creek has been identified as a potential archaeological deposit (artefact scatters and isolated finds).

Table 11.2: Identified Artefacts

Survey Unit	Site	Landform	Exposure (Approx. m)	Visibility	Description
LWA2	1	Terrace	60 X 5	100% SV 50% AV	Artefact scatter: Exposure on edge of terrace Low potential for sub-surface material Artefacts: 1 chert, 1 FGS, 1 silcrete, 8 mudstone
LWA4	1	Ridge crest	5 x 10	30% SV 60% AV	Isolated find: Exposure on edge of dam Artefact: 1 mudstone
LWA4	2	Ridge crest	0.5 x 0.2	50% SV 60% AV	Isolated find: Exposure on edge of drill pad This is probably previously recorded site EWA80 (Witter 2002) Artefact: 1 silcrete
LWA4	3	Ridge crest	2 x 1.5	50%SV 100% AV	Artefact scatter: Exposure along vehicular track Artefacts: 4 mudstone, 1 silcrete
LWA4	4	Ridge crest	2 x1.5	50%SV 100% AV	Isolated find: Exposure along vehicular track Artefacts: 1 mudstone
LWA5	1	Creek bank	1x .5	<20% SV 30% AV	Isolated find: Exposure along creek bank Artefacts: 1 silcrete
LWA5	2	Creek Bank	1x .75	<20% SV 30% AV	Isolated find: Exposure along creek bank Artefacts: 1 mudstone

That part of the study area that contains the eastern diversion of Bowmans Creek is within the 2002 Witter archaeological assessment and has been the subject of ongoing monitoring and management consistent with the ACOL approved subsidence management plan.

The Waterhole Site (EWA 28 &19: NPWS site no. 37-3-0500) is considered a site of significance. The site is located north of the proposed eastern diversion. The site comprises a waterhole abutting sandstone outcrop on Bowmans Creek. The site covers a 250x100m area with 256 artefacts identified including 36 implements and three sets of grinding grooves (GG1, GG3, GG4) with visibility at 50%.

Although heavily disturbed, Witter identified a 50x50m area between exposed area EWA 28 and the grinding grooves expected to contain *in situ* deposits. It was considered that the site may possibly be an extension of the Bridge site located on the east bank of Bowmans Creek on the northern side of the New England Highway (**Figure 11.1**).

11.4 Geomorphology Assessment of Bowmans Creek

Of particular relevance to the proposed diversions is the geomorphology assessment of the floodplains of Bowmans Creek conducted by Peter Mitchell, (2002). The assessment sought to identify any potential palaeo-landscapes amongst the creek terraces.

The study identified the changes to Bowmans Creek since the 1955 floods demonstrating the dynamic character of the creek. Meanders have been modified. Human intervention has also modified the creek morphology with the reinforcing of the creek bank in sections.

The study found that the floodplains of "*Bowmans Creek have been cultivated and the soil is likely to be homogenized by ploughing to a depth of 25 to 30 cm. The flood plain has also been subject to extensive sedimentation and possible sheet erosion during the 1955 floods. This sediment was estimated at about 45cm deep thus reducing the potential for the identification of Aboriginal sites within this layer.*"

This is consistent with the findings of the 2008 survey where artefacts were located on small spoil heaps associated with burrows, or depressed exposures.

11.5 Archaeological Assessment

The aim of the study for the Bowmans Creek diversion project was to identify the impacts on known Aboriginal sites including areas of potential archaeological deposits. As the area has been subject to previous surveys, the archaeological assessment has been based upon existing data and community consultation – no field work was required.

The results of the previous archaeological assessments relevant to the western and eastern diversions of Bowmans Creek are described above.

11.6 Impact to Aboriginal Heritage

Insite Heritage has assessed the potential impacts of the project upon Aboriginal heritage with respect to excavation of the diversion channels and placement of material as described below.

11.6.1 Excavation of the Diversion Channels

The excavation of the proposed diversion channels will impact upon Aboriginal heritage in the following manner:

- Excavation in potential archaeological deposits as identified on the western terrace by Witter 2002 and Besant etal (2009a, 2009b) 2009. The potential deposits are the sub surface artefacts likely to be located on the western terrace associated with the small surface expression recorded in the Brunkers Lane site (Witter 2002) and the seven small lenses recorded during the 2009 Longwall/Miniwall 9 project assessment (Besant et al, Insite Heritage 2009).

- The excavation of the channels will not impact upon the recorded surface lenses referred to above.
- The eastern diversion will not impact on the Waterhole site (refer **Figure 11.1**) however the excavation will be within approximately 20 metres of the Waterhole site.

11.6.2 Placement of Alluvial Soils from the Excavation of the Diversion Channels

The distribution of the soil excavated from the channels will occur on the creek terraces adjacent to the diversion channels. This activity has the potential to impact upon the recorded lenses of artefacts however the current distribution plan will not impact on these lenses.

Subsurface deposits will however be covered by the fill. The significance of any the deposits will be assessed before stripping of the existing topsoil prior to filling.

11.6.3 Subsidence

Subsidence impacts associated with the Bowmans Creek diversion project have been assessed by SCT and are reported in detail in **Appendix 4** and summarised in **Section 6** above.

SCT report that the project will result in subsidence and cracking of the surface. There is the potential for the project to impact upon subsurface deposits.

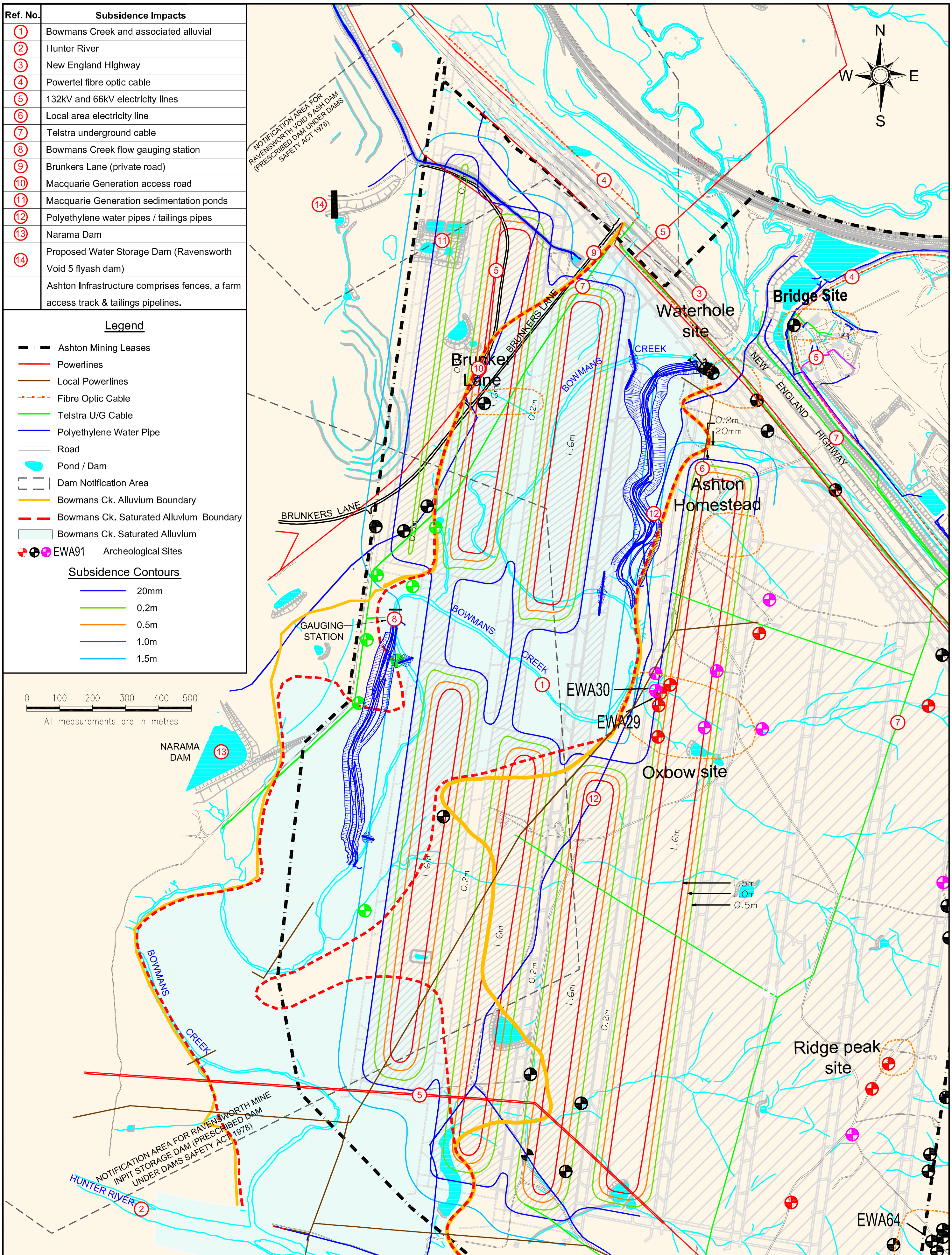
11.6.4 Significance Assessment of Identified Sites

Significance Criteria

The basic processes of assessing significance for items of heritage are outlined by *The Australian ICOMOS Charter for the Conservation of Places of Cultural Significance: the Burra Charter* (amended 1999) and associated Guidelines. Sites may be significant according to several criteria, including scientific or archaeological significance, significance to Aboriginal people, aesthetic value, the degree to which a site is representative of archaeological and/or cultural type, and value as an educational resource. In New South Wales the nature of significance relates to historic, aesthetic, social, scientific, cultural or educational criteria and sites are also assessed on the degree to which they exhibit rare or representative characteristics of their type, or whether they exhibit historic or cultural connections. The significance assessment is based on the following:

- **Scientific Significance** – is rated low, medium and high. In order to determine scientific significance it is necessary to first place sites within a local and regional context. This process enables the assessment of any individual site in terms of merit against other sites of similar nature within similar contexts.
- **Public Significance** – of sites are assessed in terms of their educational value, to enhance community knowledge and appreciation of cultural heritage.
- **Representative Significance** – of individual sites is determined by factors such as representativeness, rarity, and the site’s potential to add scientific data to what is known about past human occupation of the Australian continent. Conservation outcomes are determined by comparison of a site’s qualities with known sites in the region that have been protected.

Ref. No.	Subsidence Impacts
1	Bowmans Creek and associated alluvial
2	Hunter River
3	New England Highway
4	Powertel fibre optic cable
5	132kV and 66kV electricity lines
6	Local area electricity line
7	Telstra underground cable
8	Bowmans Creek flow gauging station
9	Brunkers Lane (private road)
10	Macquarie Generation access road
11	Macquarie Generation sedimentation ponds
12	Polyethylene water pipes / tailings pipes
13	Narama Dam
14	Proposed Water Storage Dam (Ravensworth Void 5 flyash dam)
	Ashton Infrastructure comprises fences, a farm access track & tailings pipelines.



Bowmans Creek Diversion Project

Figure 11.1
Archeological Sites

AshtonCoal

ACOL FILE: A-4059.dwg

11.6.5 Statement of Significance

The project will impact upon a small portion of the potential archaeological deposits of parts of the Bowmans Creek floodplain. The floodplain has been assessed to have the potential for deposits buried by recent alluvial flood deposits. Any archaeological deposits within the terraces are likely to have been reworked by flood events and channel migration. Gemorphological assessment has shown that the terraces are Holocene in age and there is no potential for Pleistocene deposits within the proposed work area.

The potential archaeological deposits within the alluvial terraces of Bowmans Creek within the study area are considered to be of moderate scientific significance.

All sites within the Bowmans Creek area are of cultural significance to the Aboriginal community.

The Waterhole Site (37-4-0500), located north of the proposed Eastern Diversion, will not be impacted by this proposal. This site is rated as high significance; a rating reinforced by Aboriginal stakeholders in the course of consultation.

11.7 Aboriginal Heritage Mitigation and Management

The requirements of the existing ACP *Aboriginal Heritage Management Plan* will be implemented including the management and mitigation strategies:

(i) Mitigation measures will include a salvage program of terrace deposits confined to the area to be impacted.
(ii) The methodology for the salvage will be developed in consultation with the stakeholders.
(iii) Continued consultation will be undertaken with the community regarding actual impact in comparison to assessed impact.
(iv) Proposed mitigation will include inspection of the creek bed for grinding grooves once the creek has become more accessible.
(v) An analysis methodology for material retrieved and determination of the ultimate location for the storage of artefacts will be determined by the community.

Strategies to manage any inadvertent impact upon the known sites adjacent to the works area, particularly the Waterhole Site will be drawn from best practice as outlined in the *Burra Charter* (Australian ICOMOS charter for places of cultural significance), the *NSW Heritage Manual* 1998 (DUAP and NSW Heritage Office) and the NPWS *Aboriginal Heritage Assessment Guidelines* 1997.

Measures that will be employed to ensure that no inadvertent impacts occur at the Waterhole Site where earthworks are in close proximity to grinding grooves etc will include:

(i) Clear fencing of the site to form a boundary between contractors and the outer perimeter of the site.
(ii) 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 (ie. Fines etc administered by DECCW).
(iii) Inclusion of a cultural awareness component in the general induction of contractor workers working on the project.

ACOL has in place an Environmental Management System supported by a raft of Environmental Management Plans consistent with Condition No 3.3 of the development consent. The *Archaeology and Cultural Heritage Management Plan* associated with the underground mine will be amended as necessary having regard to potential impacts, management recommendations, outcomes of consultation with the Aboriginal communities and the conditions of approval.

11.8 European Heritage

No items of European heritage are known to exist within the area proposed to be disturbed by the Bowmans Creek diversion project.

12 CONSTRUCTION

The construction of the channels and associated block banks, together with the proposed landscape and vegetation restoration within the riparian corridors is an important component of this proposal. This section describes the proposed construction and rehabilitation works and the measures to minimise construction impacts including erosion and sediment control, noise and dust management, and traffic management.

As shown on **Figure 2.8** the construction and initial vegetation establishment program is anticipated to last for 6 months.

Detailed engineering design drawings for the diversion channels and block banks have been prepared by Hyder Consulting. A full set of design drawings is contained in **Plan Set 2 in Volume 3**. Landscape drawings prepared by EDAW, which also form part of the drawing set for this project are contained in **Plan Set 3 in Volume 3**.

12.1 Earthworks Design and Quantities

Based on the engineering design drawings, the estimated earthwork quantities for each of the diversion channels are set out in **Table 12.1.**

Table 12.1: Estimated Earthworks Quantities

Item	Eastern Diversion (m^3)	Western Diversion (m^3)	Total (m^3)
Bulk earthworks	140,000	180,000	320,000
Detained earthworks – low flow channel	20,000	15,000	35,000
Block banks	3,500	3,500	7,000

The majority of the materials required to construct the block banks and the gravel bed and bars in the new channels will be sourced from materials extracted as part of the excavation and stockpiled separately for subsequent re-use. Excess material that is not required for the channels and block banks will be stockpiled in one of three locations identified on **Figure 2.6**.

The main materials that will be brought onto site comprise:

- Boulders for construction of rock bars and scour protection at selected locations on bends and block banks;
- Large logs for construction of engineered log jams (in addition to any salvaged from the clearing necessary for construction);
- Geosynthetic clay liner, geotextile and erosion control matting;
- Plant materials, seed and soil ameliorants for revegetation of the diversion channels and excess spoil.

12.2 Environmental Management and Site Induction

Because some elements of the works will be undertaken in close proximity to Bowmans Creek and know Aboriginal sites, a high standard of environmental management will be required. All workers entering the site for the first time will be given an induction that makes specific reference to:

- "No-go" archaeological areas adjacent to the defined works area;

- Awareness and of the potential for discovery of archaeological remains during the excavation process and the requirement to immediately stop work and seek expert advice;
- The purpose of the site barrier fencing and the requirement for all machinery to remain within the fenced area;
- The requirement to avoid damage to specifically identified trees that will be marked with orange safety fencing;
- The requirement to minimise removal of existing trees wherever possible, even if these are located within the designated works area;
- Site health and safety policy; and
- Site environmental policies including avoidance of fuel spills, erosion and sediment control and waste management.

12.3 Construction Staging

The construction of each of the diversion channels will be undertaken sequentially using the steps set out below. An indicative schedule is shown in **Figure 2.8**. Construction will commence at the downstream end of each diversion and progress upstream so as to ensure that all joins in the geosynthetic clay liner have the exposed edge on the downstream side.

1. Site establishment including:
   - A construction compound including workers facilities and utility supplies,
   - Haulage roads and safe access to New England Highway,
   - Survey marks etc,
   - Erection of site barrier fencing including protection of those individual trees on the floodplain that are to be retained.

   In addition to the machinery fleets required for the bulk earthworks and detailed channel shaping as described below, the following machinery will be required throughout the duration of the construction works:
   - 1 x grader;
   - 1 x watercart.
2. Setout of diversion corridors and stockpile areas;
3. Install erosion and sedimentation controls and barrier fencing to demarcate exclusion zones for construction activities in accordance with ACOL's *Erosion and Sediment Control Management Plan*;
4. Strip topsoil from each corridor and stockpile for later reuse on diversion channel batters and spoil stockpiles in accordance with the ACOL *Soil Stripping Management Plan*;
5. 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 and will run in a circuit between the excavation and the designated locations for placement of surplus spoil into designated stockpile areas. 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. The following machinery fleet is indicative for this phase of work:
   - 5 x 657 scrapers;
   - 2 x D9 dozers;
   - 2 x 330 excavators;

- 4 x trucks (40-50t articulated and 20t road registrable dump trucks).

6. Detailed channel shaping that will involve over-excavation of the low flow channel and trimming of batters using excavators loading onto trucks. The following machinery is indicative for this phase of work and the subsequent laying of the geosynthetic clay liner followed by the detailed construction of the required channel shape:
   - 1 x 330 excavator for detailed excavation;
   - 1 x 330 excavator for placing of liner, cobbles, rock and logs;
   - 6 x trucks attending the above (40-50t articulated and 20t road registrable dump trucks);
   - 1 x 330 long reach excavator for trimming batters;
   - 1 x truck attending trimming; and
   - 1 x 966 loader to load stockpiled materials.
7. 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 that runs under the New England Highway;
8. Once the excavation is complete, laying of the geosynthetic clay liner in accordance with the manufacturers guidelines will be undertaken. 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 liner will be anchored at the top of each batter and anchored on the batters and covered with a protective layer of fine material;
9. 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);
10. 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;
11. 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 Design Drawings* (**Plan Set 2**). This will be undertaken using excavators, backhoes and trucks;
12. Detailed landscaping and revegetation work in accordance with the *Landscape Design Drawings*. 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. This work will be undertaken using small backhoes and light tip trucks;
13. The construction of the block banks and subsequent cut-in of the ends of the diversion channels will be undertaken following completion of revegetation. As these works are likely to occur sometime after completion of the detailed channel shaping, a separate machinery fleet will be required comprising:
    - 2 x 330 excavators;
    - 4 x trucks;
    - 1 x 966 loader.

12.4 Erosion and Sediment Control

Erosion and sediment control for the construction works will be undertaken in accordance the relevant aspects of the following approved management plans for the Ashton Coal Project (ACP) that reflect the procedures and practices set out in *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004):

- *Erosion and Sediment Control Management Plan* (Part 2)
- *Soil Stripping Management Plan*.

Specific erosion and sediment control measures that will be implemented in conjunction with the construction of the Bowmans Creek diversion channels and block banks are shown on the following drawings that for part of the civil engineering design drawings in **Plan Set 2**:

- *C045 Eastern Diversion Sediment and Erosion Control Plan;*
- *C046 Western Diversion Sediment and Erosion Control Plan;*
- *C047 Sedimentation and Erosion Control Details.*

12.4.1 Site Access

During site establishment, a standard stabilised access of roadbase or crushed aggregate will be constructed at the access into the work sites compound which will serve as the control point for all machinery, vehicles and personnel entering and leaving the sites.

12.4.2 Sediment Control and Water Management

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).

The main earthworks comprise the excavation of the diversions which will take place from downstream to upstream (leaving in place a narrow barrier of existing alluvium 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 run under the Bowmans Creek bridge and feed into the ACP water management system. All sediment laden water collected within the excavation will be treated in this manner.

12.4.3 Stockpiling of Excess Material

Topsoil (approximately 150 mm) will be progressively removed from the excavation and stockpile areas and separately stockpiled within the designated stockpile areas (see **Figure 2.6**) in accordance with the existing *Soil Stripping Management Plan* to provide a resource for subsequent placement of topsoil onto excavated batters and soil stockpiles. The stockpiles locations have been selected to be mainly in areas that are not affected in a flood with an average recurrence interval (ARI) of 20 years. 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. The stockpile locations have also been selected to be in areas that do not require haulage across the creek channel either for initial placement of material or for subsequent re-use of stockpiled material for filling of subsidence troughs.

Stockpiles will be established in accordance with the stockpile construction details show on drawing *C047: Sedimentation and Erosion Control Details*. Other than topsoil, initial stockpile material will be placed to a maximum of 3m high to create a bund along the perimeter of the designated stockpile area nearest the creek. The outside batter of this area will be revegetated as soon as practicable. Subsequent stockpiling of materials will occur behind this bund.

From observations of the existing creek bank, 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. For purposes of reconstructing the bed of the creek, quantities these materials will be selectively stockpiled within the designated stockpile areas for subsequent use in reconstruction of the bed of the creek. Approximate quantities of the required stockpile materials are:

- Eastern Diversion:
  - Fine silt/sand with no gravel - 6,000 m^3
  - Cobbles – 14,500 m^3
- Western Diversion:
  - Fine silt/sand with no gravel - 3,000 m^3
  - Cobbles – 12,500 m^3

Material that is not required for construction of the low flow channels will be formed into a free draining stockpiles (approximately 3 m high) and revegetated. As subsidence occurs this material will be subsequently be removed and used as required to fill the subsided area sufficiently to create a free draining landscape. This will occur as a series of campaigns that take place shortly after each subsidence episode. Following each campaign, the stockpiles will be revegetated.

In addition, separate stockpiles of suitable excavated material will be created adjacent to the location of the block banks. Estimated quantities required for these are:

- Eastern Diversion:
  - Upstream - 2,000 m^3
  - Downstream – 1,600 m^3
- Western Diversion:
  - Upstream - 2,200 m^3
  - Downstream – 1,400 m^3

12.4.4 Rehabilitation of Diversion Channels

As outlined in **Section 12.3** the detailed earthworks construction will follow progressively behind the bulk earthworks and will be followed immediately by the rehabilitation works as described in **Section 12.5**. Throughout this stage of the works the ends of the channels will remain blocked off to protect the vegetation establishment from creek flow. Any runoff or groundwater entering the works area will be pumped to the Ashton water management system as described in **Section 12.4.3.**

Once the rehabilitation works have been completed, the remaining ends of the channels will be removed commencing at the downstream end. Rehabilitation of the banks of the channels will be undertaken immediately.

12.4.5 Construction of Block Banks

The block banks will be constructed in stages in order to minimise the risk of damage to the rehabilitation works. Initially, the sides of the block banks on the floodplain will be constructed to their design height with a temporary low section (about the level of a 6 month ARI flow) within the main low flow channel of the creek (approximately 1m high) near the upstream end of each diversion. By allowing floods to be divided between the existing creek and the diversion channel, the flow regime in the diversion channel in a 5 year ARI flood would be similar to that which would occur in a 1 year ARI flood if all flow was directed into the diversion channel.

The timing of construction of the permanent, full height, block banks upstream and downstream of the diversions will be contingent on two factors:

- The groundwater modelling indicates that there is a relatively low risk of connective cracking that would cause drainage of alluvial groundwater into the Permian rocks until mining of the Upper Liddell seam. If groundwater monitoring in the vicinity of where LW6B passes under Bowmans Creek indicates that there has been no significant reduction in groundwater water levels as a result of mining of the Pikes Gully seam, and surface water monitoring shows that there has been no reductions in flow or drop in pool water levels, the full height block banks will not be constructed until just before mining occurs in the Upper Liddell seam at the same location (approximately early 2015).
- If, on the other hand, groundwater monitoring indicates that there has been significant reduction in groundwater water levels as a result of mining of the Pikes Gully seam, and there is a noticeable change in the surface water flow and pooling regime, the full height block banks will be constructed immediately in order to mitigate the risk of floodwater draining into the underground workings.

If the latter condition occurred, there would be an increased risk of damage to the rehabilitation works. Should such damage occur, ACOL commits to reinstatement of the rehabilitation works. To further mitigate this risk, the first stage of revegetation of the channels will focus on the establishment of good ground cover using grasses to maximise erosion protection within the diversion.

12.5 Rehabilitation

Landscape restoration will be undertaken in accordance with the following ACP approved management plans as well as the site specific requirements set out in the *Landscape Restoration Report* (**Appendix 10**) and the *Landscape Design Drawings* (**Plan Set 2**):

- *Landscape and Revegetation Management Plan*
- *Weed Management Plan*

The landscape restoration for the Bowmans Creek diversions aims to establish plant communities that are characteristic of those that were present prior to European colonisation. Objectives of the approach 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 in 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 landscape restoration 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. Broad planting and seeding phases are described below.

12.5.1 Proposed Vegetation Communities

A flora and fauna assessment of the area was undertaken in 2001. The assessment included a summary of eight (8) 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 (6) of the previous flora and fauna assessments, the NPWS Wildlife Atlas and the 2001 study (refer Appendix 10 – Landscape Restoration Report). No threatened species (flora or fauna) were observed on the site.

Additionally, seven (7) specimens of River Red Gum (*Eucalyptus camaldulensis*) were identified in the narrow riparian corridor of the southern meander of Bowmans Creek, on the adjoining property to the west. 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 (**Plan Set 3** – *Landscape Design Drawings*).

12.5.1.1 Hunter Valley River Oak Forest

This community is proposed for the low active floodplain and adjoining inset benches. The low active floodplain comprises of a cobble / sand / silt material mix placed over a synthetic clay liner, while the inset benches comprise of 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).

12.5.1.2 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 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).

12.5.2 Rehabilitation Program

12.5.2.1 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;
- Assess initial species performance, in order to tailor the initial species planting lists.

12.5.2.2 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,
  - approximately 40 species for the Hunter Floodplain Red Gum Woodland community on the Lower Side Slopes, and
  - 20-30 species for the Hunter Valley River Oak Forest community within the Low Active Floodplain and Inset Benches; and
- Increase numbers and density of particular species where required.

12.5.2.3 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.

12.5.3 Rehabilitation Methods

The restoration will take a measured approach to flood risk and cost, commensurate with ACOL's requirement for early commencement of the works, 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;
- 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.

As discussed in **Section 12.4.5**, it is proposed to initially construct temporary block banks to a level that will direct flows up to about 6 month ARI into the diversion channels. Larger flows will then split between the existing channels and the diversions. The effect of this flow split will be that a 5 year ARI flood in Bowmans Creek would lead to a flow in the diversion channels equivalent to about a 1 year ARI flow if all flow was directed into the diversion channel. On this basis, the 'flood resistant' treatment of the low level benches has been set at the notional 1 year ARI flood level as determined from the flood analysis (**Section 8**). It is considered that this 1 in 5 year ARI storm level provides an acceptable level of risk from flood damage to the restoration works in the early stages of the project.

12.5.4 Corridor Management

The landscape restoration method presented in detail in **Appendix 10** 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 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 meet these.

12.6 Noise

Spectrum Acoustics were engaged to undertake an assessment of the potential noise impacts on receptors in the local area from the construction of the proposed diversions.

Operationally, while the proposed modification will result in additional coal being recovered, the mining rate and processing rate, and therefore noise emissions from other parts of the ACP will not change as a result of the proposed modification. Accordingly the noise assessment is for construction noise.

12.6.1 Assessed Construction Activities

Construction of each diversion would take approximately four months and involve the noise-generating activities and equipment described in **Section 12.3**. In terms of noise production, the bulk earthworks stage would produce significantly higher noise emissions than the subsequent stages due to the scrapers and dozers. Assessment of worst case noise impacts has therefore been based on the bulk earthworks stages of the project with anticipated durations of seven weeks (eastern diversion) and 11 weeks (western diversion). The total duration of the earthworks phase of the project is expected to be four months, with construction activities occurring during the daytime only (7am – 6pm).

12.6.2 Noise Criteria

Assessment of noise emissions from the project have been compared with established Ashton Coal Project (ACP) criteria for two of the receptors: 38 dB(A),$Leq_{(15\ minute)}$ at Property 18 (Turner), and 35 dB(A),$Leq_{(15\ minute)}$ at property 130 (Bowman). Property 187 (Stapleton) is sufficiently distant from the ACP that his has not been assigned ACP noise criteria in any previous noise study for ACP. This receiver is in the Hunter Valley Operations (HVO) noise affectation zone, however, and has a criterion of 41 dB(A),$Leq_{(15\ minute)}$ day, evening and night for noise from HVO.

The construction activities would occur during the daytime only (7am – 6pm). Accordingly, the cumulative noise from HVO and the proposed works should be below the recommended acceptable level of 50 dB(A),Leq (day) in Table 2.1 of the NSW Industrial Noise Policy (INP).

12.6.3 Noise Modelling

Noise emissions were modelled using the Environmental Noise Model (ENM) by considering two scenarios; one with a single representative noise source at the centre of the eastern diversion and another with a noise source at the southern end of the western diversion. A total sound power level of 119 dB(A),$Leq_{(15minute)}$ was calculated for the bulk excavation plant.

Recent analysis of ACP wind data by Spectrum Acoustics has found that winds from the N, NE and SSW are applicable at various times of the year (winds from the SE also occur during the warmer months but are noise-reducing relative to the three receiver locations and have not been assessed). Calm daytime (neutral) and temperature inversion conditions (INP default 30C/100m) were also modelled for each scenario.

12.6.4 Predicted Noise Levels

The three nearest receptors were assessed, these were:

- Turner (Property 18), approximately 2,100m east within Camberwell Village.
- Bowman (Property 130), approximately 2,600m south-east.
- Stapleton (Property 187), approximately 2,500m to the south-west, south of the Hunter River.

Point-calculation results for the above receptors are summarised in **Table 12.2**.

Table 12.2: Predicted Bulk Earthworks Noise Levels dB(A), $Leq_{(15minute)}$

Receiver	Atmospheric Condition					
	Neutral	Inversion	N wind	NE wind	SSW wind	Criterion
Eastern Diversion						
Turner (Pty 18)	<20	35	25	<20	36	38
Bowman (Pty 130)	<20	29	33	30	<20	35
Stapleton (Pty 187)	<20	30	25	30	<20	50*
Western Diversion						
Turner (Pty 18)	<20	30	<20	<20	33	38
Bowman (Pty 130)	20	30	30	23	25	35
Stapleton (Pty 187)	30	36	37	39	27	50*

* Daytime cumulative noise limit.

The results in **Table 12.2** are discussed below for each receiver.

- ***Turner:*** Predicted levels range from <20 dB(A) under favourable conditions to 36 dB(A) under adverse conditions. Given that the construction activities are likely to occur during summer months, the likelihood of temperature inversions during daytime hours or SSW winds (which prevail throughout winter months) is minimal and noise levels of 30 dB(A) from the proposed diversion activities or less would be the norm.
- ***Bowman:*** The worst case predicted level of 33 dB(A) at this receiver is 2 dB below the criterion and is considered acceptable.
- ***Stapleton:*** The worst case predicted level from the bulk excavation works is 39 dB(A). When added to the allowable noise limit of 41 dB(A) from HVO, the total in 44 dB(A). This is 6 dB below the daytime recommended level of 50 dB(A) and is considered acceptable.

12.6.5 Conclusion

Noise levels generated from the construction proposed diversions are predicted to be below the relevant criteria, with the major noise-producing activities occurring for a relatively short duration. As such, no specific noise mitigation measures are required.

12.7 Air Quality

PAEHolmes were engaged to prepare an assessment of the potential air quality impacts generated from the construction of the proposed diversions.

It should be noted that the additional coal that is proposed to be recovered from the underground mine will not change the approved mining rate, and will have minimal impact on the overall duration of the predicted and approved impacts from the ACP underground mine.

PAEHolmes recently completed an assessment of the proposed SEOC and existing ACP including the predicted cumulative impacts of the ACP operations and the surrounding mining operations. Data from that assessment has been utilised in this assessment.

12.7.1 Existing Air Quality and Meteorology

The proposed diversions are located within an area where the air quality is heavily influenced by the surrounding mining operations. The Narama and Ravensworth open cuts are located to the west, the NEOC to the north east, Hunter Valley Operations – South to the south.

ACOL have a comprehensive air quality monitoring network (see **Figure 12.1**) consisting of dust gauges, total suspended particulate (TSP) monitors, Tapered Element Oscillating Microbalances (TEOM)s that measure real time particulate matter concentrations less than 10 micron (PM10) and two weather stations.

The diversions are proposed to be constructed commencing in late summer 2010, with completion expected by winter to early spring 2010. Climate in the area is characterised by seasonal changes. The predominant summer winds are from the east-south-east, winter winds from the west-south-west and autumn and spring comprising a combination of both east-south-east and west-north-west winds. A greater proportion of rainfall occurs during the summer months, with a more even spread over the remaining seasons, the lowest rainfall is generally recorded in winter. Much of the year is characterised by a water deficit.

Summers are often characterised by extremely hot conditions with the highest temperatures exceeding 45 degrees Celsius (ºC). The average temperature during summer ranges from a maximum of more than 31ºC, to a minimum of 16ºC. During winter temperatures have been recorded below -4 ºC with the average temperature ranging from just over 4ºC to more than 18ºC. Frosts occur regularly during May to August, where on average more than 27 days per year record temperatures below 2ºC (temperatures less than 2ºC measured at 1.2m typically equate to a ground surface temperature of 0ºC, BoM 2008).

12.7.2 The Assessment of Air Quality Impact

The construction of the diversion channels will result in the release of particulate matter. Estimates of dust emissions for the construction activities were made based on commonly used emission factors developed both locally and by the US EPA. Particulate emissions have been estimated for the following activities:

- Bulk Earthworks;
- Detailed Channel Shaping; and
- Construction of Block Banks.

Landscaping and revegetation has not been considered due to the expected relatively small contribution to total particulate emissions from that aspect of the project.

Using the standard emission factors the proposed works are predicted to generate 32,386kg of TSP (this estimates all dust generated from the operations, and does not relate to dust at a single location, the prevailing winds determine the level of dust received at a particular receptor). In comparison to the existing ACP operations this equates to approximately 2% of expected TSP emissions and only 0.1% of the cumulative emissions from all mining sources in the area.

It should be noted that the heavy earthworks phase is limited to less than 6 months and emission estimates for the diversion project are based on conservative worse case assumptions and the actual emissions are likely to be less.

The proposed construction works are located 2.0km to 2.5km from the nearest privately owned receptor. Ashton owned residences are located closer to the proposed diversions and will be managed according to agreements with those residents, if the dwellings are tenanted at the time of construction.

Separation distances of 2.0km to 2.5km provide an adequate buffer to minimise any potential impact from even significantly large projects, and in this case are most likely to ensure dust levels from the project would not be discernable.

The small contribution of the project to the total dust levels, short duration, and large separation from sensitive receptors, mean that if the project were modelled, this would result in very low predicted dust concentrations (much less than any uncertainty in dispersion modelling). Thus specific dispersion modelling is not considered to be warranted for this project.

12.7.3 Mitigation Measures

Notwithstanding the small contribution of the diversion project to total dust levels at receptors in the area, it is important for construction projects to apply appropriate dust control.

The main sources of dust from the diversion project are bulk earthworks and wind erosion from exposed surfaces. It is proposed that a water cart will, where necessary, operate to dampen areas for scrapers and hauling to minimise emissions from bulk earthworks.

Truck movements and haul route distances have been minimised to the greatest practical in terms of access routes, and positioning of spoil areas and overall operational management.

Revegetation and rehabilitation will be completed as soon as practical following disturbance to minimise wind erosion.

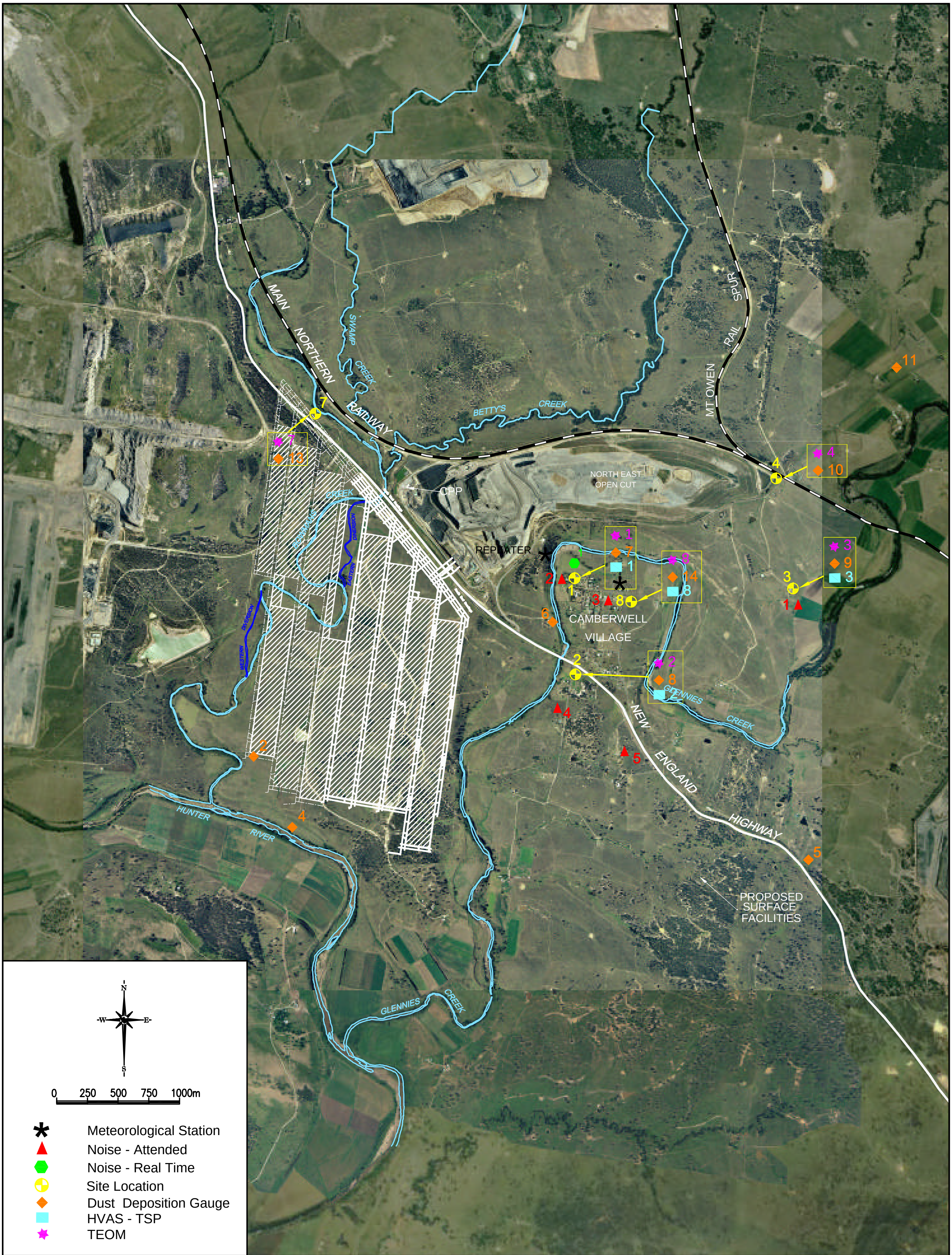
12.7.4 Conclusions

Emission estimates for the diversion project show that the contribution to total dust levels is small when compared to the existing ACP and SEOC project and other sources in the vicinity (2% and 0.1% respectively).

The works are located well away from the nearest private sensitive receptors in the prevailing down wind direction (receptors south of Camberwell Village).

There is negligible potential for any dust impact to arise from this project at private residences, largely due to separation distances of 2.0km to 2.5km and the small nature of the project.

Dust emissions will be minimised through use of a water cart, minimising material handling and prompt revegetation following completion of earthworks.



AshtonCoal

Bowmans Creek Diversion Project

Figure 12.1
The Existing ACOL Monitoring Network for Meteorology, Air and Noise

12.8 Traffic

ACOL commissioned Sinclair Knight Merz Pty Ltd (SKM) to undertake a traffic impact assessment of the proposed construction access points with the New England Highway to facilitate the diversions of Bowmans Creek. A copy of the report is contained in **Appendix 10**.

12.8.1 Traffic Assessment Methodology

The traffic assessment undertaken by SKM included:

- Review of existing road network conditions incorporating a review of traffic volumes, road safety data on the New England Highway from the New South Wale Roads and Traffic Authority (RTA);
- Estimation of traffic associated with construction phase of the Bowmans Creek diversion project and assessment of access arrangements to and from the site via the New England Highway; and
- An assessment of traffic implications, road safety and traffic management measures for the project.

12.8.2 Existing Conditions

12.8.2.1 Road Network

The ACP is located near the village of Camberwell, on the New England Highway. The ACP's current operations are access via Glennies Creek Road, which intersects the New England Highway north-west of Camberwell.

The New England Highway is part of the National Highway network and forms the main inland route between Sydney and Brisbane.

The diversions of Bowmans Creek require access from the New England Highway at two (2) locations. The eastern construction entrance is located approximately 380m east of the Bowmans Creek (Foy Brook) Bridge. This access currently services a dairy farm (Property 130) and maintenance activities associated with Ashton Underground Coal Mine. The current layout of the intersection is of Type BA (Basic) featuring two east bound lanes. The existing highway is a two-way, three lane road with a straight horizontal alignment on sightly sloping terrain in the vicinity of the proposed eastern entrance. The highway has a 17m wide sealed road surface that consists of approximately three x 3.3m wide lanes, a 1m wide painted median island and 2 x 3m wide shoulders. Sight distance from the intersection is very good in both directions.

The northern construction entrance is proposed at the existing private road known as Brunkers Lane located approximately 520m west of Bowmans Creek (Foy Brook) Bridge. The current layout of the intersection is a Type CHR (Channelised Right Turn) layout featuring an additional Auxiliary Left Turn (AUL) lane. The CHR lane is approximately 180 metres in length, and the AUL lane is approximately 160 metres in length. The existing highway is a two-way, two-lane road with a slight curved horizontal alignment on flat terrain in the vicinity of the proposed western entrance.

12.8.2.2 Traffic Volumes

A seven (7) day classified count of traffic on the New England Highway east of Camberwell was undertaken from 23 to 29 October, 2008. The average daily traffic volume during that week was 11,109 vehicles including 17% heavy vehicles. The average weekday volume was slightly higher at 12, 391 vehicles, including 18% heavy vehicles.

The AM peak hour on a weekday is between 6.00am and 7.00am, with an average weekday volume of 1,306 vehicles per hour, the majority of which are heading westbound. The PM peak hour is between 4.00pm and 5.00pm with an average of 947 vehicles per hour, mostly eastbound.

RTA data collected at Bowmans Creek (Foy Brook) Bridge (station number 05.037) on the New England Highway shows a steady growth in traffic since 1980, with a peak in the late 1990's and an overall linear growth rate of 1.7% per annum (base year 2004).

12.8.2.3 Road Safety

Data obtained from the RTA about road safety history on the New England Highway between Singleton and Muswellbrook indicates that between September 2003 and August 2008 there were 88 crashes recorded, including four fatal crashes and 32 injury crashes. A crash rate, where the number of crashes is compared to the volume of passing traffic, has been calculated at approximately 10 crashes per 100 Million Vehicle Kilometres Travelled (MVKT). This is significantly below the NSW state average crash rate of approximately 75 crashes per 100MVKT.

Immediately south of Bowmans Creek in the general vicinity of the proposed construction access points, there were three crashes recorded in the past five years, including one injury crash. There were two off-path type crashes and one where a temporary object on the roadway was hit

12.8.2.4 Public Transport and School Buses

The proposed Bowmans Creek diversion project is located away from regular public transport services. Singleton and Muswellbrook are the main public transport hubs near Camberwell. Several bus and coach services travel the highway past Camberwell (with no scheduled stopping in Camberwell). These services include:

- A daily service with return between Newcastle and Dubbo on Sid Fogg's Coachlines; and
- A daily service with return between Sydney and Toowoomba on Greyhound Australia.

Two school bus services operate through Camberwell, with several bus stops within Camberwell, and isolated stops at some properties along the New England Highway. They include:

- Singleton to Camberwell operated by the Blue Ribbon Bus Company Pty. Ltd; and
- Hebden – Ravensworth - Singleton operated by the Blue Ribbon Bus Company Pty. Ltd.

The nearest railway stations to Camberwell are at Singleton and Muswellbrook.

12.8.2.5 Traffic Generation Activity

The vehicle activity associated with the construction of Bowmans Creek diversion project is:

- An average of five truck movements per day over a six-month period, peaking at approximately ten per day between the two site access points;
- Trucks will originate from north and south of the site, based on the location of the equipment and material origins;
- Trucks will be in operations during daylight hours only, seven days a week; and
- Various truck types will be in operation, including:
  - Small tippers;
  - Table tops;
  - 27 tonne and 33 tonne semi trailers; and
  - Truck and trailers in a "truck and dog" configuration

12.8.3 Bowmans Creek Diversion Traffic Impact Assessment

The construction of the diversion channels will require the use of both intersections. Each diversion will take approximately 4 months to construct and be undertaken during daylight hours, 7 days a week.

To assess the traffic implications of the additional vehicles movements on the road network and the operation of the two interactions, SKM undertook SIDRA Intersection computer modelling. The

Level of Services (LOS) and average delays by vehicles using the intersection would be determined by the modelling and assessed against the RTA LOS criteria.

SKM concluded that the highest average delays are experienced by vehicles turning into and out of the proposed construction site entrances. No delays are experienced by through traffic on the New England Highway. The impact of the additional vehicle movements on the road network would be negligible, with the delays and queuing quarantined to the side roads, which are private roads.

12.8.4 Road Safety

SKM concluded that as the number of additional vehicles generated as a result of the creek diversion works is expected to be very low (maximum of approximately ten movements per day arriving from both directions and distributed over both intersections), no significant reduction in road safety is expected.

The intersection of Brunkers Lane and New England Highway offers protected turn lanes to reduce the impact of slowing or accelerating vehicles from highway flows.

The straight alignment, good sight distance and second southbound lane at the eastern entrance contribute to a satisfactory traffic arrangement, given the low volume of construction vehicles being generated by the site, as well as the short term program of the construction activity.

12.8.5 Traffic Management Measures

In line with SKM recommendations, advance warning signage such as those shown in **Figure 12.2** will be installed for the duration of the creek diversion works. This signage installation would highlight to other motorist the possibility of a truck braking or turning, and allow them to be forewarned of the need for heightened awareness or to slow down.

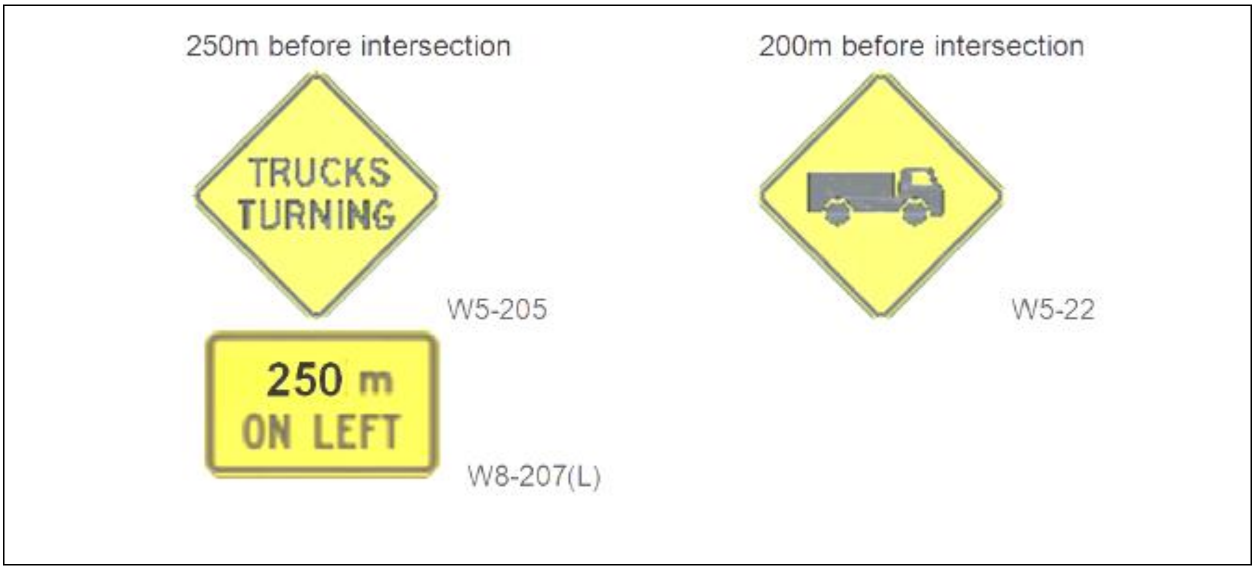


**Figure 12.2:
Proposed Warning Signs on the New England Highway Approaches to the Intersections**

12.9 Waste Management

Waste management for the construction works will be undertaken in accordance the relevant aspects of the approved *Waste Management Plan* (9 September 2003) for the Ashton Coal Project.

Quantities of waste generated during the construction works are expected to be minimal because all excavated material will either be re-used for construction of the low flow channels and block banks or will be stockpiled for subsequent filling of subsidence areas to create a free draining landscape.

Separate bins will be provided within the works compound for recyclable materials such as metals and paper/cardboard as well as general putrescibles waste.

Any waste oil, batteries, tyres, etc will be taken to the main Ashton site for recycling/disposal along with similar wastes from other parts of the Action Coal Project.

Any trees removed during sit clearing will be salvaged for use in the constructed log jams or, if unsuitable will be used within the landscape restoration.

In accordance with the Aston *Waste Management Plan*, all personnel working on the site will be inducted, including the required waste management practices.

12.10 Commitments

In relation to the construction and vegetation restoration for the channels and block banks, ACOL proposes the following commitments:

1. All workers involved in the construction of the diversions channels and block banks will receive site specific induction that includes requirements for good environmental management including minimisation of noise and dust, erosion and sediment control, Aboriginal heritage, avoidance of fuel spills and waste management requirements.
2. Erosion and sediment control for the construction works will be undertaken in accordance the relevant aspects of the ACP *Erosion and Sediment Control Management Plan* and *Soil Stripping Management Plan*, and the specific site details shown on the relevant civil engineering design drawings (C045 – C047).
3. Topsoil will be separately stockpiled within the designated stockpile areas in accordance with the existing ACP *Soil Stripping Management Plan* to provide a resource for subsequent placement of topsoil onto excavated batters and soil stockpiles.
4. All areas in which filling of subsidence troughs occurs will be topsoiled and revegetated in a manner that is consistent with the final land use.
5. During and immediately after mining of the Pikes Gully seam groundwater monitoring together with visual monitoring of stream flows and pools within Bowmans Creek 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.
6. Landscape restoration will be undertaken in accordance with the *Landscape Restoration Report,* the *Landscape Design Drawings* and the existing ACP *Landscape and Revegetation Management Plan* and *Weed Management Plan.*
7. A staged program of vegetation establishment will be undertaken in accordance with the staging set out in the *Landscape Restoration Report.*
8. Weed control will be regularly undertaken within the rehabilitation areas in accordance with ACOL's *Weed Management Plan* with particular attention during the first 12 to 18 months after initial vegetation establishment, so as to facilitate the colonising of the great majority of available niches by native species.
9. In the event of significant flood damage to the channels, ACOL commits to prompt full restoration works in accordance with the *Landscape Restoration Report* and the *Landscape Design Drawings.*
10. Noise nuisance will be minimised by limiting the use of heavy machinery for construction of the channels to daylight hours (7am-6pm) seven days per week.

11. Dust generation on the Project Area will be minimised by implementation of the following:
    - Disturbed areas will be minimised;
    - Dust suppression water spraying (water trucks) will be used on all active haul roads and stockpile areas where required;
    - Prompt revegetation following completion of earthworks.
12. Existing ACP monitoring for dust and noise will continue throughout the construction program.
13. Advance warning signage will be installed on the New England Highway for the duration of the creek diversion construction works.

12.11 Conclusions

At its simplest, the construction of the diversion channels involves the excavation and revegetation of two channels totalling about 1,735m in length. Although the design calls for considerable complexity in the geomorphic detail and vegetation establishment in order to mimic the characteristics of the existing channels, none of the activities pose any unusual environmental risks that cannot be appropriately managed and mitigated by means of the construction and rehabilitation processes outlined in the preceding sections.

As evidenced by the damage to vegetation and scour in Bowmans Creek as a result of the June 2007 flood, the existing creek is vulnerable to damage. Additional features such as extensive use of erosion protection mesh and the use of rock armouring on bends and at the ends of riffle zones, have been included in the design of the diversion channels in order to minimise the risk of damage caused by a flood during the early period of vegetation establishment. Notwithstanding, ACOL commits to repair any significant damage to the diversion channels caused by flooding during the life of the mine.

13 DRAFT STATEMENT OF COMMITMENTS

13.1 Introduction

ACOL intend to construct the Bowmans Creek diversion and associated longwall mining in an environmentally responsible manner. During the preceding sections of this EA report, potential impacts have been described, together with avoidance or mitigation measures to lessen the impact of the project on the environment.

To ensure that the Bowmans Creek diversion project operates with environmental safeguards in place during its life cycle, ACOL is committed to the integration of the project into the comprehensive Environmental Management Strategy currently employed at the ACP.

13.2 Operating Limits and Hours

The following limits will be applied to the construction of the diversions:

- ACOL will construct the diversion within the hours of 7am to 6pm Monday to Sunday;
- Peak truck movements at the site access intersections will be limited to 5 vehicles per hour; and
- Underground operational time will be as per existing approvals.

13.3 Management and Offset Measures

Table 13.1 provides a summary of the identified mitigation and management measures proposed to be implemented to minimise the impacts of the Bowmans Creek Diversion project on the receiving community and environment.

Table 13.1: Monitoring, Management and Offset Measures

Item	Description
1.	**Mining**
1.1	All mining will be undertaken within the approved mining lease.
1.2	The final extraction design of each subsequent seam below the Pikes Gully seam, including whether longwall panels are stacked or offset, will be subject to the results of impact monitoring and subsidence from the preceding seam and would be detailed in an SMP consistent with the current SMP approval process.
2.	**General**
2.1	Filling of subsidence troughs and reshaping of the subsided landform will be undertaken in as necessary to create a free-draining landform and to obviate the potential for pooling of water on the surface. This approach is expected to reduce the potential for surface pooling and inflow into the mine.
2.2	The diversion channels will be constructed in accordance with the civil and landscape designs (**Plan Sets 2 and 3**) including the placement of an impermeable geosynthetic clay liner under to bed to eliminate baseflow losses from the constructed channels.

Item	Description
2.3	A geosynthetic clay liner will be place under the low flow section of the diversion channels to minimise loss of base flow from the diversion sections of the creek.
2.4	All workers involved in the construction of the diversions channels and block banks will receive site specific induction that includes requirements for good environmental management including minimisation of noise and dust, erosion and sediment control, Aboriginal heritage, avoidance of fuel spills and waste management requirements.
3.	**Subsidence Monitoring and Mitigation**
3.1	ACOL will review and modify mine plans in response to actual subsidence and geotechnical behaviour associated with mining in the deeper seams based on monitoring experience, expert interpretation, and other advice.
3.2	The Southern limits of LW5, LW6 and LW7 will be offset at least 200m from the Hunter River alluvium.
3.3	ACOL will continue to Monitor and manage subsidence as approved within the SMP process. Particular actions that will be include in the SMP process are:- • A continued strategy of monitoring of subsidence over Longwalls 1 to 4 in the lower seams as each seam is mined will allow more accurate predictions of subsidence parameters above Longwalls 5 to 8. (Per Condition 3.27) • Complete End of Panel Reports with particular reference to subsidence. • ACOL will refine the multi-seam panel geometry below Bowmans Creek to ensure long term overburden bridging below the creek if ongoing monitoring and numerical modelling of multi-seam operations indicates that this is necessary. • ACOL will consult with Ravensworth Underground Mine to assess geotechnical and groundwater interactions and to determine monitoring criteria.
3.4	ACOL commits to complying with existing development consent conditions such as:- • Condition 3.16:- No tunnelling or mining shall occur directly underneath the piers or abutments of Bowmans Creek Bridge. The RTA must approve access tunnel layouts in the vicinity of the Bridge. • Condition 3.17:- The angle of draw for the mine subsidence after removal of the coal is to be kept outside of the New England Highway Road Reserve.
4.	**Groundwater**
4.1	The current groundwater monitoring network will be maintained and expanded to monitoring of water extracted from the mine workings as the lower seams are mined.
4.2	Three additional nested groundwater monitoring points 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; and • On the eastern side of LW6B near the upstream end of the Eastern Diversion.

Item	Description
	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 detect any drainage of the alluvium.
4.3	An additional monitoring bore will be installed to the south of LW2 to provide monitoring down to the Lower Barrett seam.
4.4	Monitoring of the volume of water extracted from the mine workings will be undertaken for the life of mine.
4.5	Volumes and qualities of individual sources of groundwater inflows will be undertaken where separation is possible.
4.6	Operational monitoring and response plans will be implemented in relation to the Bowmans Creek floodplain around Longwalls 6A and 6B, in order to assess and mitigate the operational risk posed by potential connective cracking between the underground mine and the surface water environment above the floodplain alluvium.
4.7	The ACOL *Groundwater Trigger Action Response Plan* will be reviewed and extended to include monitoring of the lower seam inflows as they are mined.
5.	**Water Licensing**
5.1	ACOL will offset, under existing Water Access Licences, 47.5 ML per annum to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek for the duration of underground mining.
5.2	At the conclusion of mining in the ACP underground operations, ACOL will permanently surrender existing Water Access Licences with a share component of 20 ML per annum to the Minister administering the *Water Management Act 2000* for the loss of base flows in Bowmans Creek.
5.3	ACOL will account for water extracted from the underground workings under bore licences issued or required in accordance with the 2002 development consent and the *Water Act 1912*
6.	**Surface Water**
6.1	Water level monitoring will be undertaken in two pools immediately above LW6B as part of the routine monthly monitoring program. While mining is occurring in LW6B, water levels will be monitored weekly.
6.2	ACOL will continue the existing surface water quality monitoring program.
7.	**Geomorphology**
7.1	Cross section survey will be undertaken every five years or immediately after a flood that has a peak flow greater than 150 m^3/s (about 5 years ARI) at all existing cross sections in the existing creek. For purposes of this commitment, flow will be determined from the Office of Water gauging station.
7.2	Cross section survey will be undertaken every five years or immediately after a flood event that has a peak flow greater than 150 m^3/s (about 5 years ARI) at 10 new cross sections and along the thalweg of each diversion channel. The cross sections will be established to be representative of the various geomorphic forms within the channels.

Item	Description
7.3	At the same time as the 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.
7.4	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.
8.	**Construction of Diversion Channels**
8.1	Erosion and sediment control for the construction works will be undertaken in accordance the relevant aspects of the ACP *Erosion and Sediment Control Management Plan* and *Soil Stripping Management Plan*, and the specific site details shown on the relevant civil engineering design drawings (C045 – C047).
8.2	Topsoil will be separately stockpiled within the designated stockpile areas in accordance with the existing ACP *Soil Stripping Management Plan* to provide a resource for subsequent placement of topsoil onto excavated batters and soil stockpiles.
8.3	During and immediately after mining of the Pikes Gully seam groundwater monitoring together with visual monitoring of stream flows and pools within Bowmans Creek 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.
8.4	Noise nuisance will be minimised by limiting the use of heavy machinery for construction of the channels to daylight hours (7am-6pm) seven days per week.
8.5	Dust generation on the Project Area will be minimised by implementation of the following: • Disturbed areas will be minimised; • Dust suppression water spraying (water trucks) will be used on all active haul roads and stockpile areas where required. • Prompt revegetation following completion of earthworks.
8.6	Existing ACP monitoring for dust and noise will continue throughout the construction program.
8.7	Advance warning signage will be installed on the New England Highway for the duration of the creek diversion works.
9.	**Rehabilitation and Land Management**
9.1	All areas in which filling of subsidence troughs occur will be topsoiled and revegetated in a manner that is consistent with the final land use.
9.2	Landscape restoration will be undertaken in accordance with the *Landscape Restoration Report,* the *Landscape Design Drawings* and the existing ACP *Landscape and Revegetation Management Plan* and *Weed Management Plan.*
9.3	A staged program of vegetation establishment will be undertaken in accordance with the staging set out in the *Landscape Restoration Report.*

Item	Description
9.4	Weed control will be regularly undertaken within the rehabilitation areas in accordance with ACOL's *Weed Management Plan* with particular attention during the first 12 to 18 months after initial vegetation establishment, so as to facilitate the colonising of the great majority of available niches by native species.
9.5	In the event of significant flood damage to the channels, ACOL commits to prompt full restoration works in accordance with the *Landscape Restoration Report* and the *Landscape Design Drawings.*
9.6	Stock proof fencing will be installed and maintained along the boundaries of the rehabilitation works on the diversion channels. Stock proof fencing will also be installed along both banks of the existing creek (at least 5 m from the alignment of any riparian trees) for the full length of the existing creek between the New England Highway and the Hunter River.
9.7	Where required, stock watering troughs will be installed at strategic locations on pasture areas adjacent to the creek.
10.	**Riparian and Aquatic Habitat**
10.1	ACOL's existing *Flora and Fauna Management Plan* will be implemented and, where necessary, updated to reflect specific features of this project.
10.2	Any isolated trees that have been identified as providing hollows, and which are located close to the construction and stockpile areas, will be protected with orange barrier netting during construction.
10.3	Fish passage will be maintained in the diverted creek sections under at least moderate flow conditions.
10.4	Resting pools will be included within the diverted creek sections.
10.5	Large woody debris will be used to restore aquatic habitat.
11.	**Aboriginal Heritage**
11.1	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.
11.2	Should any Aboriginal artefacts be detected during the Project, work in that location will cease immediately and the finds will be reported to the ACOL Environmental Manager. At which time the Management strategy as defined in the ACOL *Archaeology and Cultural Heritage Management Plan* will be implemented in accordance protocols with agreed with the Aboriginal community. Work will not recommence in the area until instructed to do so by the ACOL Environmental Manager.
11.3	Methodologies that will be employed to ensure that no inadvertent impacts occur at the Waterhole Site where earthworks will be in close proximity: • 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

Item	Description
	repercussions of not adhering to the WMS (ie. Fines etc. administered by DECCW). • Inclusion of a cultural awareness component in the general induction of contractors working on the project.
12.	**Environmental Management Systems and Plans**
12.1	Environmental management of this project will be undertaken using existing *Environmental Management Strategy: Phase 2 Underground Mining Operations* and associated and to manage, mitigate, or monitor impacts associated with this Project.
13.	**Environmental Monitoring and Reporting**
13.1	ACOL will undertake ongoing environmental monitoring as detailed in this EA.
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.

14 PROJECT JUSTIFICATION

14.1 Introduction

The Director General's requirements states the EA Report must include:

> *A conclusion justifying the project, taking into consideration: the suitability of the site; the economic, social and environmental impacts of the project as a whole; and whether the project is consistent with the objects of the Environmental Planning & Assessment Act 1979.*

This section addresses this requirement.

14.2 Need for the Proposed Modification

The proposed modification of the Ashton development consent for the Bowmans Creek diversion is required for the following key reasons:

- It permits the maintenance of a cost effective business, with sustainable capital and operating costs, and thereby provides security of employment for 195 direct employees and 35 construction positions as well as flow on effects to the regional economy;
- It provides access to an additional 5.3 million tonnes of run of mine (ROM) coal through significantly improved resource recovery, and reduced sterilisation, over the four targeted seams than would be possible under constraints imposed by the existing development consent;
- It provides approximately $80 million of additional revenue to the State and Federal Governments;
- Notwithstanding the SMP approval for the use of miniwalls in the Pikes Gully seam, miniwalls have the disadvantage of being inefficient in terms of resource extraction, questionable economic viability and potential uncertainty in relation to the degree of subsidence that would occur as a result of their use in the lower seams;
- A multi-seam miniwall mine plan option would add an additional 11,000 metres of roadway development per seam resulting in a total cost impost of $66 million total for all four seams;
- The total economic impact between mine plan options (miniwall and creek diversion) is $259 million over the life of the mine and potentially significantly more if miniwall mining is found to be unsuitable for the lower seams;
- Budget forecasts indicate a $13.00 cost differential for miniwall versus longwall methods for every tonne of coal sold which is mined within the Bowmans Creek area. These additional costs during a period of contracting coal prices, may lead to a questionable viability of the underground operation in this area;
- It provides significantly improved flexibility to modify the mine plan within the mining footprint and certainty that mining of lower seams will be technically and economically feasible;
- It provides significant environmental benefits by way of enhanced riparian vegetation and a large area of existing creek and floodplain that will be excluded from degradation by domestic stock;
- It reduces the salt load to Bowmans Creek and the Hunter River.

The coal mining industry is of fundamental importance to Australia's economic and social prosperity. Global energy demand is increasing and will continue to play a vital role in economic growth and social advancement.

Many of the world's economies are heavily reliant on coal to meet basic energy needs domestically and internationally. Coal is a proven safe, secure and relatively inexpensive source of energy. Coal provides approximately 90% of NSW energy needs, 75% of Australia's energy needs and 24% of global energy needs and is used to produce about 39% of the world's electricity.

Access to energy remains a critical development need, particularly for approximately one quarter of the world's population who do not have access to electricity. As living standards in Third world countries increase, the demand for coal is forecast to continue to rise, along with clean coal technologies and other renewable energies, in conjunction with the capture and storage of greenhouse gas emission. The ACP modification will contribute toward satisfying both domestic and international energy markets, whilst contributing to the prosperity of local, national and international economies.

14.3 Project Alternatives

Table 14.1 details the alternatives to the proposed diversion configuration project that were considered in the development of the proposed design.

Table 14.1: Alternatives Considered to the Proposed Mine Configuration

Alternative	Analysis of Alternative		Justification for Chosen Configuration
	Negative	Positive	
EIS Diversion	– Long "gun barrel" alignment – Limited geomorphic and ecosystem opportunities – Significant loss of riparian and aquatic habitat	– Simple channel shape resulting in lower cost – Good resource recovery	– Chosen option mimics geomorphic features of existing creek – Chosen option provides opportunities for significant improvement in area and quality of riparian and aquatic habitat
Oxbow Diversion	– Significantly steeper bed gradient – potential scour. – Large hydraulic control structure required to correct for change in channel gradient. – Full width longwall mining reduced. – Significant loss of riparian and aquatic habitat	– Reduced land disturbance.	– Chosen option mimics geomorphic features of existing creek – Chosen option provides opportunities for significant improvement in area and quality of riparian and aquatic habitat
No Diversions	– Sterilisation of significant quantity of coal resource. – Potential business viability impact and, in turn, employment security. – Miniwalls not proven for lower seams – a risk which would later equate to project and employment security risk.	– No alteration to creek	– Inefficient resource recovery and potential sterilisation of remaining resource
Proposed Diversions	– Potential long term impact on alluvial and Permian groundwater regime – Changed water availability and ecological conditions in excised sections of creek	– Greater resource recovery – Significant area of enhanced riparian vegetation and habitat – Improved business viability and employment security	– Mimics geomorphic features of existing creek – Provides opportunities for significant improvement in area and quality of riparian and aquatic habitat – Improved employment security – Better economic and resource recovery than the current approved plan

14.3.1 The "No Project" Alternative

The direct consequences of not proceeding with the project can be summarised as follows:

- Employment and socio-economic benefits of the proposed ACP modification described in **Section 1.2** will not be realised.
- Environmental benefits described in **Section 2.8** will not be realised.
- Realisation of the economic value of the coal resource will not occur.

14.4 Objects of the Environmental Planning & Assessment Act 1979

The objects of the EP&A Act are:

"(a) to encourage:

(i) the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment,

(ii) the promotion and co-ordination of the orderly and economic use and development of land,

(iii) the protection, provision and co-ordination of communication and utility services,

(iv) the provision of land for public purposes,

(v) the provision and co-ordination of community services and facilities, and

(vi) the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats, and

(vii) ecologically sustainable development, and

(viii) the provision and maintenance of affordable housing, and

(b) to promote the sharing of the responsibility for environmental planning between the different levels of government in the State, and

(c) to provide increased opportunity for public involvement and participation in environmental planning and assessment."

The objects that are relevant to this modification application are considered briefly below.

14.4.1 Proper Management, Development and Conservation of Natural and Artificial Resources

Environmental Planning and Assessment Act Section 5 (a) object (i) is to encourage:

> *"the proper management, development and conservation of natural and artificial resources, including agricultural land, natural areas, forests, minerals, water, cities, towns and villages for the purpose of promoting the social and economic welfare of the community and a better environment."*

The proposed diversions will enable the extraction of additional coal that is one of the state's natural resources. The design of the diversions has taken into consideration the natural resources in the area including:

- Maximising recovery of the coal resource while conserving the maximum portion of undiverted creek.
- Maintenance of the flow regime in Bowmans Creek.
- The creation of geomorphically complex diversions that mimic the characteristics of Bowmans Creek and avoid adverse impacts to the undiverted portions of the creek.
- The utilisation of material extracted during the excavation of the diversion alignments for the filling of subsidence troughs in order to maintain a free draining landscape effectively utilises that resource.
- The preservation of a small existing stand of River Red Gum.
- The enhancement of the Bowmans Creek riparian corridor and adjoining floodplain through the establishment of significantly enhanced riparian vegetation (including the planting of River Red Gums) and the exclusion of domestic stock from the riparian zone along the full length of the creek.
- The utilisation of excavated materials to fill subsidence profiles maintains the agricultural productivity of subsided lands.

The Draft Statement of Commitments set out in **Section 13** of this EA details the measures proposed by ACOL to avoid, minimise and ameliorate impacts, ensuring the proper management of natural and artificial resources. These measures include the conservation and enhancement of existing vegetation, enhancement of the Bowmans Creek riparian corridor to improve the quality and diversity of native vegetation and habitat, exclusion of domestic stock from land between the existing creek channels and the diversions and the linkage of these areas to the ACP post mining landscape and connectivity plan.

The development of the State's coal resource provides direct employment security for the existing 180 personnel employed in the underground and results in direct and indirect economic benefits to the local and regional communities through the construction and additional resources recovered.

14.4.2 Promotion and Co-ordination of the Orderly and Economic Use and Development of Land

Environmental Planning and Assessment Act Section 5 (a) object (ii) is to encourage:

"the promotion and co-ordination of the orderly and economic use and development of land".

The ACP Underground mine is well established and includes an existing approved CHPP. It is located in close proximity to both the New England Highway and Main Northern Railway line as well as numerous other coal mining developments. The Bowmans Creek diversion project provides for the economic recovery of additional coal resources through the utilisation of existing infrastructure. The ACP and neighbouring mines have been approved by the Minister for Planning (or his/her delegate) in his/her role of co-ordinating the orderly and economic use and development of land. This environmental assessment report considers the cumulative impacts of all of these mines to allow a co-ordinated assessment of the modification to the existing ACP as part of overall mine development in the area.

Mining is consistent with the land use planning zone objectives for the Rural 1(a) zoned land under the *Singleton Local Environmental Plan* 1996. The Bowmans Creek diversion project and the environmental enhancements proposed will provide better environmental and economic returns on the land than if current land use continues in that:

- Approximately 10ha of existing floodplain grazing land will be re-vegetated within the creek diversion corridors to provide high quality riparian habitat;

- Approximately 15ha of land between the excised sections of creek and the diversions will be fenced to exclude domestic stock and will, as natural colonisation occurs, provide valuable wildlife habitat.
- The creation of a free draining landscape and the re-use of topsoil salvaged during the earthworks for rehabilitation of filled areas of the subsidence troughs will permit the continued use of the land for grazing and opportunistic fodder cropping.

An important feature of the proposed Bowmans Creek project is that it seeks to maximise recovery of the coal resource and thereby minimise the sterilisation of any remaining resource. This contributes to the orderly and economic use of the land.

The ACP, of which the Bowmans Creek modification is part, is located in close proximity to Glendell Open Cut, Narama Open Cut, Ravensworth Underground Mine, Integra Colliery and Integra Open Cut. The area is therefore an intensive mining, coal handling and processing zone already. This project seeks to further maximise resource recovery from an area appropriate for mining and mining purposes, thereby conforming with the orderly and economic use of land in the Hunter Valley.

14.4.3 Protection, Provision and Co-ordination of Communication and Utility Services

Environmental Planning and Assessment Act Section 5 (a) object (iii) is to encourage:

> *"(iii) the protection, provision and co-ordination of communication and utility services,"*

The ACP is located within an area that has a range of existing utility infrastructure consisting of 132kV, 66kV and 11kV power lines, copper telecommunication cables and a fibre optic cable.

The proposed modification to the existing ACP will not result in any additional impacts to these services above that already assessed in the original ACP EIS. The development of the underground mine will require the realignment/management of power lines and telecommunication cables to ensure services are not adversely affected by subsidence. The protection and/or relocation of the relevant utilities will be undertaken in consultation with the utility service provider to ensure little or no disruption to the service. Management of the impacts to the services will be consistent with the prevailing SMP developed for the underground mine.

The Project is therefore consistent with this object of the Act.

14.4.4 Protection of the Environment

Environmental Planning and Assessment Act Section 5 (a) object (vi) is to encourage:

> *"the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats."*

The development and operation of a mine and the extraction of coal inevitably has an impact on the environment. The major environmental risks associated with the Bowmans Creek diversion project include the potential impacts on groundwater and surface water, clearing of native vegetation and loss of habitat for threatened fauna species, cultural heritage and to a lesser degree impacts to the local community from noise and air quality.

The Bowmans Creek diversion project has been designed to avoid or minimise potential impacts. Where impacts remain, proposed mitigation measures and offsets to protect the environment (as described in **Sections 7** to **12**) are proposed, including:

- Design of the diversions to minimise the area of riparian vegetation to be cleared;

- Design of the diversion channels to provide comparable or better aquatic habitat including the re-introduction of large woody debris (log jams) provision of deep pools for fish refuge as well as riffles that provide comparable opportunities for fish passage;
- Revegetation of the banks of the diversion channels to provide significantly better riparian habitat than is available along the existing creek;
- Fencing to exclude stock from the existing creek as well as the diversions. This, together with the ongoing management of weeds along the existing creek in accordance with the ACP *Weed Management Plan,* will over time, allow the natural regeneration of a greater diversity of habitat within the existing creek;
- Alignment of the fencing to exclude domestic stock from the riparian areas will have the added benefit of excluding domestic stock from the floodplain areas between the diversion channels and the excised sections of channel. Vegetation in these areas will be allowed to regenerate naturally and this will be complemented by appropriate plantings on areas that have been filled to provide a free draining landscape following subsidence, leading to a valuable area of richly diverse habitat ranging from densely vegetated riparian areas to patches of open woodland on the floodplain;
- Preservation of the existing stand of River Red Gums together with the reintroduction of this community into the rehabilitated riparian zones associated with the diversion channels;
- Enhancement of existing habitat and connectivity through the area.

The effectiveness of these protection and mitigation measures will be determined through an environmental monitoring program. This program will expand on the existing ACP monitoring program. Environmental protection measures will be reviewed and improved based on the results from the monitoring program.

14.4.5 Ecologically Sustainable Development

Environmental Planning and Assessment Act Section 5 (a) object (vii) is to encourage:

> *'ecologically sustainable development'*.

Ecologically sustainable development (ESD) is the exploitation of plants, animals and other resources at a level which allows the number and variety of species to remain much the same from generation to generation.

ESD is defined in the EP&A Act by reference to section 6(2) of the Protection of the Environment Administration Act 1991 which requires the effective integration of economic and environmental considerations in decision-making processes and provides the ESD can be achieved through the implementation of the following principles and programs:

- The precautionary principle;
- Inter-generational equity;
- Conservation of biological diversity and ecological integrity; and
- Improved valuation, pricing and incentive mechanisms.

ESD is founded on the basis that current and future generations should leave a natural environment that functions equally as well or better than the one inherited. The following section describes the consideration and application of ESD principles in relation to the Bowmans Creek diversion project.

14.4.5.1 Precautionary Principle

The precautionary principle means that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (Protection of the Environment Administration Act 1991).

Application of the precautionary principle to the Bowmans Creek diversion project needs to ensure that there has been:

- Careful evaluation of the proposal to avoid serious or irreversible damage;
- Predictable and transparent decision making for the proposal; and
- An assessment of consequences of various options undertaken.

The environmental consequences of the proposal have been documented in **Section 7** to **Section 12** and the associated specialist reports contained in appendices. Scientific and engineering analysis of the environment and likely impacts of the project has been thorough, and has involved field surveys, computer modelling, impact identification and measures to avoid, minimise and ameliorate impacts.

A change in the understanding of how the alluvial and groundwater systems function since the 2001 EIS has allowed the importance of certain impacts to be better understood, and has allowed ACOL to design a more efficient mining operation that protects the more important elements of the environment. While the approved SMP mine plan for the Pikes Gully seam contains miniwalls and can operate with minimal impacts to Bowmans Creek and the alluvium there is some scientific uncertainty with regard to the performance of the miniwalls on the lower seams, thereby also limiting the economic certainty of the underground if these resources cannot be extracted in that area without significant impact. The proposed diversions provide for greater certainty in impacts as mining progresses to the lower seams.

At all stages of project development there has been an open and transparent decision making process. Consultation has occurred with the various stakeholders and concerns addressed in the design of the diversions:

- Minimising the loss of base flow from Bowmans Creek by developing a design that includes a geosynthetic clay liner under the diversion channels to present loss of base flow.
- Designing each of the diversion channels to be an analogue of the adjoining existing channel in terms of its geomorphic features; meandering alignment, pools of various depths, riffles and cobble bars.
- The habitat and geomorphic characteristics of the diversion channels will be enriched by the inclusion of large woody debris which is largely absent from the existing channel. This will take the form of a number of engineered log jams.
- Rehabilitation plan that incorporates a significantly enhanced vegetation density and vegetation community richness compared to the existing creek channel.
- **Section 14.3** provides an overview of the various other project alternatives and justification for selected design often based on reducing potential environmental impacts.

14.4.5.2 Social Equity Including Intergenerational Equity

Social equity involves value concepts of justice and fairness so that basic needs of all sectors of society are met and there is a fairer distribution of costs and benefits to improve the well-being and welfare of the community, population or society (DUAP, 1995). Social equity also includes concerns for intergenerational equity which requires that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

The modification of the ACP represented in the Bowmans Creek diversion includes a range of mitigation and rehabilitation measures described in **Sections 7** to **12** and the Statement of Commitments to minimise impacts upon not only the current generation, but also upon future generations. Whilst the winning of the coal resource will remove an opportunity for future generations, the economic benefits generated by the Bowmans Creek diversion project will benefit current and future generations. The construction and operation of the mine will deliver significant economic benefits to the local community, the region and both state and federal governments during the life of the project whilst appropriately managing environmental impacts and making appropriate provision for rehabilitation and landscape restoration by the following mechanisms:

- Environmental management will be undertaken in accordance with existing management plans which will be implemented in an adaptive manner that accounts for the specific requirements of the project;
- Development and implementation of an adaptive environmental monitoring programme;
- Progressive revegetation of the diversion channels in a manner that complements and enhances natural regeneration;
- Progressive filling or construction of drainage systems to provide a free draining landscape;
- Payment of bonds for rehabilitation under mining tenements.

Coal is an essential component of life in Australia, and provides approximately $8 billion per annum in export income. It is the energy source for over 90% of the State's electricity, and energy is fundamental to sustaining and improving living standards. Coal provides a safe, secure, relatively inexpensive source of energy nationally and internationally, and will continue to do so until alternate renewable energy sources are developed to a commercially viable level. Coal allows us to maintain our current way of life while we tackle the difficult and long term task of developing economically viable renewable sources of energy. The wise use of our non-renewable resources such as coal will ensure Australia's economic future through export income and access to competitively priced energy. It will also help ensure that the legacy we hand to the next generation will be as valuable as the one we have inherited. Coal has a key role to play in ensuring a sustainable future for Australia.

14.4.5.3 Conservation of Biological Diversity and Ecological Integrity

Biological diversity refers to the variety of life forms on earth and is reflected at three levels by genetic diversity, species diversity and ecosystem diversity.

The geomorphology and rehabilitation of the diversion channels has been specifically designed provide equivalent or better ecological conditions that the existing creek. The proposed vegetation has been selected to reinstate vegetation communities that are representative of the local landscape prior to European occupation. It is noted that the current ecological health of the creek is poor. An objective of the project is to enhance the conservation of biological diversity and ecological integrity of the area.

The project is founded on known coal deposits in an area which is in the vicinity of existing coal mining activities, extractive industries, agricultural/pastoral activities, transport and utility service corridor developments. It will thereby promote the conservation of biological diversity and ecological integrity by not imposing any additional demands on the existing transport and utility service corridor developments.

The project has received a thorough examination consistent with statutory authority guidelines (see **Sections 7** to **12**), with special attention to the existing riparian and aquatic habitat and any threatened and endangered species that may potentially be impacted. Significance assessments have determined that the Bowmans Creek diversion project will not have a significant adverse impact on any species and will provide significant additional habitat.

Environmental and rehabilitation procedures will ensure the project does not adversely impact the local environment in the long term.

14.4.5.4 Improved Valuation, Pricing and Incentive Mechanism

This principle requires that environmental factors should be included in the valuation of assets and services, such as:

- Polluter pays – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.
- The users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any wastes.
- Environmental goals having been established, they should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

The process of identifying project impacts (positive and negative) on the environment and formulating actions or works to mitigate negative impacts recognises the value of both the resource and environment. The Environmental Assessment has examined the environmental consequences of the project and proposes mitigation measures and safeguards be implemented if the project proceeds. The costs of mitigation and associated management measures proposed for the project have, therefore, been included in the costs of the proposal to ensure that the local environment is protected from degradation. The proponent considers and acknowledges that the environment is a valuable resource for the local and broader communities and also for future generations and has designed the project to provide significant environmental benefits.

14.4.6 Provide Opportunity for Public Involvement and Participation in Environmental Planning and Assessment

Section 3 of this EA report details the public and government agency consultation that ACOL have undertaken in respect to the project.

The public and private landowners have been provided opportunity to discuss the project (in part or in full) with ACOL representatives. The EP&A Act 1979 provides through the public exhibition of the EA report, further opportunity for public involvement and participation in the environment planning and assessment process for the proposed modification.

14.5 Summation of Environmental Impacts and Benefit

Sections 7 to **12** of this EA report provide detailed analysis of the existing environment and the predicted impacts as a result of the Bowmans Creek diversion modification to the existing ACP. As documented in **Section 2** and **Sections 14.2** to **14.4**, the modification to the existing ACP will provide material economic, social and environmental benefits. However, these economic, social and environmental benefits are offset to some degree by the expected residual environmental impacts (i.e. impacts that will remain after the application of all avoidance, minimisation and management measures).

14.5.1 Residual Environmental Impacts

The main environmental residual impacts of the proposed modification to the existing ACP include:

- Changed groundwater regime between the Bowmans Creek alluvium and the underground workings leading to drainage of parts of the Bowmans Creek alluvium. The groundwater modelling indicates that groundwater levels in the Permian strata will be at a relatively uniform level throughout the area covered by the workings with lower levels near the New England Highway. Groundwater levels are predicted to recover substantially over 100 years including in the Bowmans Creek alluvium.
- The effect of the lowered groundwater will be that the reach of Bowmans Creek between the New England Highway and the Hunter River will change from a 'gaining' creek to a 'losing' creek with the rate of loss governed by the hydraulic properties of the alluvium and the length of creek from which water is lost. The project involves the placement of a geosynthetic clay liner under the diverted sections of the creek in order to prevent losses from these sections. Losses from the remaining 'active' sections of Bowmans Creek are predicted to average about 10.7 ML/year (less than 0.1% of the average annual flow and 2% of the 80th percentile low flow). This impact is smaller than predicted in the original EIS.
- Two sections of the creek that are excised from the 'active' creek adjacent to the Eastern Diversion will be subject to subsidence of up to 8.3m and adjoining sections will be subject to a complex pattern of tilting depending on the orientation of the excised channel to the subsidence areas. Although filling of the floodplain will be undertaken to create a free draining landscape, the remaining subsided sections of the creek channel (which will not be filled) will continue to receive some runoff from local catchments, and will be inundated during flood events in excess of a 5 year ARI. The deep pools formed by subsidence, changes to channel banks as a result of subsidence and the changed hydrologic regime will lead to progressive ecological change which will ultimately lead to a system that will function as a chain of ponds.

14.5.2 Environmental Benefits

Environmental benefits of the proposed modification to the existing ACP include:

- Replacement of existing degraded riparian vegetation along excised sections of the creek with improved quality and diversity of vegetation communities along the diversion channels (total about 11ha);
- Re-introduction of vegetation that is representative of vegetation communities that were present at the time of European occupation;
- Enhancement of an area of about 50ha of riparian corridor along the entire length of Bowmans Creek between the New England Highway and the Hunter River by means of fencing to exclude domestic stock and continuing control of weeds in accordance with the ACP *Weed Management Plan*;
- Exclusion of domestic stock from the areas of floodplain located between the diversion channels and the excised sections of creek (total about 15ha). This will allow the natural regeneration of floodplain vegetation supplemented by planting of suitable vegetation following filling of some areas to create a free draining landscape following subsidence;
- Retention of all except 3 hollow bearing trees;
- Establishment of improved wildlife corridors connecting existing vegetation and creeks.

14.5.3 Socio – Economic Benefits

The socio-economic benefit of the project and proposed modifications include:

- Improved efficiency of resource recovery over the four targeted seams compared with the existing mine plan;
- Additional $80 million revenue to the State and Federal Governments;
- Reduced risk of not being able to achieve extraction of all lower seams and the consequential sterilisation of this resource;
- Reduced costs of development by a total of $66 million total for all four seams;
- Should the ability to economically mine the Bowmans Creek area be lost there would be a significant impact on the business and potentially lead to the loss of employment for the 195 directly employed personnel and also further impact on an estimated 345 short term and indirect employment positions in the region; and
- Generation of employment for about 35 people for the six month period of construction and rehabilitation of the diversion channels.

14.6 Conclusion

The objectives and outcomes of the development of the Bowmans Creek diversion are based upon the following principles:

- Greater security on long term employment of about 195 people currently employed at the ACP underground mine and support facilities;
- Minimise adverse social, environmental and amenity impacts;
- Maximise the recovery of the mineable resources within the area;
- Maintain a cost effective business, with viable capital and operating costs;
- Utilise existing infrastructure where possible; and
- Minimise capital expenditure requirements.

Sections 6 to **12** of this Environmental Assessment report have considered the impacts, mitigation measures and benefits that the Bowmans Creek diversion modification to the Ashton Coal project will have on the physical and socio-economic environments. These have been considered against the objects of the EP&A Act, which includes the principles of ESD.

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 address 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.

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