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Appendix 6

Surface Water Management Strategy

South East Open Cut Project

&

Modification to the

Existing ACP Consent

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ASHTON COAL OPERATIONS PTY LIMITED

Ashton Coal South East Open Cut Project

Surface Water Assessment

301017-00136

5-Aug-09

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ASHTON COAL OPERATIONS PTY LIMITED
ASHTON COAL SOUTH EAST OPEN CUT PROJECT
SURFACE WATER ASSESSMENT

PROJECT 301017-00136 - ASHTON COAL SOUTH EAST OPEN CUT PROJECT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Draft for client review	Chris Kuczera	Ben Patterson	N/A		N/A	
B	Final Draft	Chris Kuczera	Ben Patterson	N/A			
C	Final for Submission	Chris Kuczera	Ben Patterson				
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EXECUTIVE SUMMARY

BACKGROUND

This report presents the results of the surface water assessment of the proposed South Eastern Open Cut (*SEOC*) Coal Mining Project. This assessment was undertaken by WorleyParsons on behalf of Ashton Coal Operations Pty Ltd (*ACOL*).

The SEOC site is located in the Hunter Valley approximately 15km north-west of Singleton and approximately 2.5km to the south-east of the existing Ashton Coal Mine. The New England Highway forms the north-eastern boundary of the site and Glennies Creek defines the western boundary.

The SEOC will produce up to 2.4 Million tonnes per annum (*Mtpa*) of coal product from a proposed annual extraction of 3.6Mtpa of Run of Mine (*ROM*) coal over a 7 year mine life. This will supplement the proposed 5Mtpa of ROM coal produced from the existing underground operation. ACOL seeks to modify the current approval to mine and process up to 5.2Mtpa of ROM Coal, to an annual rate of up to 8.6Mtpa.

The objective of this report is to provide sufficient information on the existing state of the surface water environment within the SEOC project area and the immediate surrounds, and to assess the potential impacts of the project on the surface water environment. The surface water assessment includes the following key components:

- **Flood Assessment**- Assessment of both the Glennies Creek and Hunter River flood behaviour at the subject site and the immediate surrounds.
- **Water Management Assessment** – Assessment of the existing water quality and quantity and the development of a surface water management plan for the life of the SEOC operation.
- **Watercourse Assessment** – An assessment of the existing watercourses within the SEOC project area and establishment of the watercourse rehabilitation requirements.

It is noted that stream geomorphology and hydrogeology assessments are documented in separate reports.

FLOOD ASSESSMENT

The SEOC site is located within historic flood extents of both Glennies Creek and the Hunter River. In order to determine the governing flood behaviour at the subject site, a detailed assessment of the Glennies Creek hydrology and floodplain hydraulics was undertaken. Historic flood levels observed during the 1955 Hunter River flood event were used to estimate the potential Hunter River flood levels at the SEOC site.

A hydrologic model of the Glennies Creek catchment was developed to predict discharge hydrographs adjacent to the SEOC over a range of storm events. The model was calibrated using recorded rainfall depths and stream gauging from two storm events. A sensitivity analysis was undertaken to determine the hydrologic impact of the Glennies Creek Dam. This assessment indicated that the dam would reduce the peak 100 year ARI discharge adjacent to the SEOC by approximately 27% to 32% depending on the level of the dam at the beginning of a storm event. Hydrologic modelling predicted that the peak discharges at the SEOC site for the 5 year, 20 year and 100 year Average Recurrence Interval (*ARI*) storm events would be 237m^3/s, 459 m^3/s and 834m^3/s respectively.

The SEOC site is affected by both Glennies Creek flooding and backwater flooding during Hunter River flood events. The Glennies Creek flooding was assessed using a flood hydraulics model (*HEC-RAS*). The model extended from the Township of Camberwell to the confluence with the Hunter River. Historic flood levels provided by *The Department of Water and Energy* at the Glennies Creek confluence during the 1955 flood event were adopted as the Hunter River 100 year ARI flood level.

The flood assessment concluded that Hunter River backwater flooding governs flood levels at the SEOC site. The resulting 100 year ARI flood level at the site is estimated to be 62.7m AHD. As this flood level would occur from backwater flooding, there would be negligible variation in the flood level across the SEOC site. A conservative flood planning level of 64m AHD is proposed for the SEOC. This flood planning level applies an additional 1.3m freeboard to the predicted 100 year ARI flood level.

It is proposed to construct a levee along the western extent of the SEOC project to prevent the ingress of floodwater into the mining operation. This levee would have a minimum crest elevation of 64m AHD.

SURFACE WATER MANAGEMENT

A Surface Water Management Plan (SWMP) was developed for the life of the mine. The SWMP includes the following key features:

- Runoff from undisturbed catchment areas upstream of the SEOC will be collected in two clean water dams. The collected water will be used in the mining operations. Any excess clean water will be pumped directly into Glennies Creek.

- Sediment laden runoff from disturbed and rehabilitated areas will be collected in four sediment retention basins that will be sized to retain all runoff during a 20 year ARI, 12 hr duration storm event. All collected water will be used in the mining operation.

- Runoff from the open pit, haul roads, ROM storage areas and some rehabilitated overburden areas will be directed into the SEOC pit. Collected mine water will be reused in the mining operation. In the event of a major storm event, the SEOC pit is likely to be partially flooded. Following a major storm event, captured water would be pumped to the final void of the existing ACOL open cut pit which would provide temporary storage until the excess water can be used in the mining operation.

- All waste water generated onsite would be treated using an aerated wastewater treatment system. Treated effluent would be disposed through irrigation of landscaped areas surrounding the infrastructure area.

A site water balance was developed for the existing ACOL operation. The water balance was calibrated using 18 months of data collected by ACOL. The calibrated water balance was then expanded to include the SEOC proposal and assessed the proposed surface water management for the ACOL operation holistically (*i.e including both the existing operation and the SEOC project*). The water balance was used to assess the drought security of the operation and the capacity to manage large volumes of runoff during major storm events. The following key conclusions were derived:

- The ACOL operation is likely to have sufficient water during above average rainfall years, possible minor water shortages during average rainfall years and is likely to experience shortages of varying levels of severity during below average rainfall years.

- There is sufficient storage to contain all mine water generated during a major storm event such as a 100 year ARI event.

WATERCOURSE ASSESSMENT

There are six (6) unnamed tributaries to Glennies Creek located within the project area. These water courses are all ephemeral and range in size from first order to second order streams. The upper sections of the watercourses are generally in good condition. The middle and lower sections are generally moderately degraded with limited riparian vegetation and evidence of channel erosion in places. Four of the watercourses will be disturbed by the mining operation.

The final landform will be free draining with the exception of the final void, which will have an estimated 37ha footprint. It is proposed to reinstate three watercourses within the project area. This will involve the establishment of naturalised creek channels and the revegetation of the riparian zone with native riparian vegetation.

In order to maintain a freely draining landform, one of the reinstated watercourses will be aligned across mine backfill, which will be up to 110m deep in places. Accordingly, there is a risk that settlement of the mine backfill could potentially alter the creeks design grades and reduce its water holding capacity. A range of mitigation measures are proposed to reduce this risk, these include:

- Delaying the final creek construction by approximately 5 to 6 years to allow for pre-settlement to occur. It is estimated that over 60% of total creep settlement would occur in this timeframe.
- Construction of a haul road along the proposed alignment of the creek to increase the level of compaction of the mine backfill in the vicinity of the proposed creek alignment.

PREDICTED SURFACE WATER IMPACTS

The following key surface water impacts have been identified:

- The SEOC project would result in the loss of up to 7.5% of flood storage in the Glennies Creek Floodplain during a 100 year ARI Hunter River flood event. However, it is noted that the Glennies Creek Floodplain contributes only a small fraction of the total flood storage in the greater Hunter River Floodplain, which includes the over bank regions of the Hunter River as well as the lower flood plains of other tributaries such as Bowmans Creek. Hence, the loss of flood storage in the greater Hunter River Floodplain will be a fraction of a percent. Accordingly, the impact of the displaced flood storage on the flood behaviour of the Hunter River is likely to be insignificant.
- It is considered that with the proposed water management control measures in place, the SEOC project is unlikely to adversely impact the water quality in Glennies Creek and downstream systems.
- The SEOC project would temporarily disturb four identified watercourses, which are unnamed tributaries of Glennies Creek. The final landform will incorporate the reinstatement of three of these watercourses. Sections of watercourses reinstated outside of the overburden emplacement will be rehabilitated to form naturalised ephemeral watercourses. The provision of a naturally draining flow path through the rehabilitated overburden area is considered a desirable outcome as it would allow stream flows from upstream catchments to continue to naturally drain into Glennies Creek. The reinstated channel will include a fully vegetated

riparian corridor and a constructed channel designed to withstand moderate levels of long-term settlement. Revegetation of the reinstated watercourses will generally increase the riparian species diversity above the current diversity, which has been depleted by former land-use practices (*i.e. clearing, cattle grazing and trampling*). As such, it is likely that the reinstated watercourse will have a similar, if not improved, net environmental function when compared to the existing watercourses.

- The predicted average annual loss in Glennies Creek stream flow will be approximately 330 ML/year during the initial 4 years of mining (*2010 to 2014*) and 450 ML/year during the final 3 years of mining and the 6 year rehabilitation period (*2015 to 2023*). A reduction of 450 ML/year is equivalent to 0.8% of the average annual Glennies Creek flow. The final void will encompass an estimated 37ha area which will not be free draining to Glennies Creek, and therefore will result in a minor permanent loss in stream flow that is estimated to be approximately 34ML in an average year. This is equivalent to approximately 0.06% of the average annual Glennies Creek stream flow.

MONITORING AND CONTINGENCY PLANS

ACOL have an ongoing water quality monitoring programme which commenced in September 2004. This monitoring programme incorporates 14 sampling locations, including three within Glennies Creek and 5 in the Hunter River. It is proposed to continue the existing monitoring programme and include an additional sampling location immediately downstream of the SEOC project area. Monitoring will be undertaken on a monthly basis. In addition ACOL will continue to monitor internal water quality and water movements.

If unforeseen or unacceptable levels of impact are identified, the following contingency measures would be implemented:

- Increased monitoring frequency and sampling points to identify and confirm the source of any suspected degradation to water quality.

- Review the SWMP in order to identify opportunities to improve or rectify any identified problem. The data collected as part of the monitoring programme will enable fully informed decisions to be made.

- If any component of the surface water management framework is identified as creating an unacceptable environmental impact, remedial actions will be established in close liaison with the relevant authority.

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APPENDICES

1. INTRODUCTION

1.1 Background

Ashton Coal Operations Pty Limited (*ACOL*) proposes to establish an open cut coal mine and ancillary facilities approximately 2.5km to the south east of the existing Ashton Coal Mine. The project is referred to as the *South Eastern Open Cut* (*SEOC*), which relates to the location of the proposed mine relative to the existing Ashton Coal Mine.

The project is a 'major project' which requires approval from the NSW Minister for Planning. An Environmental Assessment (*EA*) has been prepared in relation to an application to develop the SEOC. WorleyParsons was engaged by *ACOL* to undertake a surface water assessment for the development proposal, which will form part of the EA for the development proposal.

1.2 Location of the Project Area

The proposed SEOC site is located in the Hunter Valley approximately 15km north west of Singleton and approximately 2.5km to the south east of the existing Ashton Coal Mine. The New England Highway forms the north eastern boundary of the site and Glennies Creek defines the western boundary. Refer to **Figure 1** for site locality.

1.3 Project Overview

The SEOC Application is for:

- An open cut coal mine (*SEOC*) east of Glennies Creek, and south of the New England Highway producing up to 3.6 Mtpa of Run-of-Mine (*ROM*) coal.
- Infrastructure and facilities to support the SEOC.
- The integration of the SEOC infrastructure and processing of coal through the existing ACOL coal handling and preparation facilities.

Refer to the Environmental Assessment document for a detailed description of the development proposal.

1.3.1 Mine Layout and Operations

The proposed SEOC would encompass an area of approximately 300ha, which includes the active mining area, out of pit overburden emplacement area, ROM pad, infrastructure area, access road and a conveyer system which will transfer ROM coal from the SEOC to the existing Coal Processing Plant. Refer to **Figure 2** for a schematic of the mine layout.

The initial box cut would be excavated in the north of the SEOC area, and progressively move to the south over the 7 year mine life. The initial overburden from the box cut will be placed adjacent to the New England Highway to form a screening mound. The final void would be located in the southern end of the open cut area. Tailings from the existing underground operation would be disposed in the final void, prior to filling and capping proposed as part of the mine rehabilitation plans.

The SEOC will produce up to 2.4Mtpa of coal product from a proposed annual extraction of 3.6Mt of ROM coal. This will supplement the proposed 5Mtpa of ROM coal produced from the existing underground operation. ACOL seeks to modify the current approval to mine and process up to 5.2Mtpa of ROM Coal, to an annual rate of up to 8.6Mtpa.

1.3.2 Final Landform

Rehabilitation of disturbed areas would occur progressively over the duration of the project. The proposed final landform would consist of the following features:

- A self draining stable landform, that is variable and natural in appearance.
- A fully rehabilitated landscape consistent with surrounding vegetation communities.
- The re-establishment of a watercourse through the disturbance area.
- Filling and capping of the tailings storage void.
- Removal of all water storage and treatment dams.

The proposed final landform is presented in **Figure 22**.

1.4 Available Data

The following data was used for this study:

- An aerial survey of the SEOC development area and surrounding land.
- 2m regional contours.

- A recent aerial photograph of the site.
- 1 to 25,000 and 1 to 100,000 scale topographical map of the SEOC site and Glennies Creek Catchment.
- Rainfall data and climatic statistics supplied by the *Bureau of Meteorology.*
- Glennies Creek stream gauge data provided by *The Department of Water and Energy*.
- Water quality results and flow meter readings provided by ACOL.

2. STATUTORY REQUIREMENTS

2.1 Director Generals Requirements

In accordance with Section 75F of the EP&A Act, the Director General of the Department of Planning has issued requirements for the preparation of the Environmental Assessment for the proposed SEOC project. The requirements that have been addressed in this report are detailed in **Table 2-1**.

Table 2-1 – *Director General's requirements specific to this report*

Director General's Requirement	Applicable Section of Report
A description of the existing environment	**Sections 3 and 4**
An Assessment of the potential impacts of all stages of the project on the quantity, quality and long-term integrity of the surface water resource. The assessment must include any cumulative impacts associated with the concurrent operation of the project with any other existing or approved mining operations, taking into consideration any relevant guidelines, policies, plans and statutory provisions.	**Sections 8 and 9**
A description of measures that would be implemented to avoid, mitigate, rehabilitate and monitor the potential impacts of the project including contingency plans for managing any significant risks to the environment.	**Section 10**

2.2 Applicable Polices, Guidelines and Studies

There are a number of legislative and guidance documents for water resource management and assessment in NSW. The following documents have been considered in this assessment:

Water Policies and Statutory Provisions

Water Licensing

The water approvals and licensing within the project area are currently administered under both the Water Act 1912 and the Water Management Act 2000. In addition, the following water sharing plans are in force or have been drafted for the area:

- *Water Sharing Plan for the Hunter Regulated River Water Source 2003* – applies to Glennies Creek and the unconsolidated alluvial sediments underlying waterfront land (*i.e. within 40m of the top bank*).

- *Draft Hunter Unregulated and Alluvial Water Sources Water Sharing Plan (DWSP)* – applies to the unregulated alluvial water sources (*outside of Glennies Creek channel*) located within the Glennies Creek Extraction Management Unit within the Hunter Catchment.

Until the DWSP is commenced, licensing of activities, water use, water works and approvals are governed by the *Water Act 1912.* Water use approvals and in stream works are governed by the *Water Management Act 2000*. Licensing of groundwater bores within the fractured rock aquifers and basement rocks are and will continue to be governed by the *Water Act 1912*. At present, licensing of surface waters within the Project Area is also governed by the *Water Act 1912*. When the DWSP commences, licensing and trading rules of water associated with the unregulated rivers and alluvials associated with them (*as described within the DWSP*) will be governed by the rules contained within the DWSP and the approvals required under the *Water Management Act 2000*.

The DWSP has been on exhibition and the DWE is currently considering submissions before finalising the DWSP. It is anticipated that the DWSP will formally commence some time during 2009.

When the DWSP commences, the licensing of activities, water use, water works and approvals provisions of *The Water Management Act 2000* (*WMA*) (*contained within Parts 2 and 3 of the Chapter 3 of the WMA*) will apply to the area of the ACOL operation.

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 (*under Section 56 WMA*).

Hunter River Salinity Trading Scheme

The Hunter River Salinity Trading Scheme (*HRSTS*) commenced in 1995. Under the scheme, coal mines and power generators are conditionally permitted to discharge controlled amounts of saline water during periods of higher flow, when the effect of saline contamination would be minimised through dilution. The scheme adopts high flow targets for the Hunter River or 600 µS/cm at Denman and 900 µS/cm at the confluence of Glennies Creek. The ACOL operation does not have a license to discharge saline water under the HRSTS, and is considered a zero discharge mine operation, where all saline water is managed internally in the mine operation.

GUIDELINES

Australian Rainfall and Runoff

Australian Rainfall and Runoff (*AR&R*) is a document published in 1987 by the *Institution of Engineers, Australia* (IEAust). This document has been prepared to provide designers with the best available information on design flood estimation and is widely accepted as a design guideline for all flood and stormwater related design in Australia.

Floodplain Development Manual

The *Floodplain Development Manual* is a document published in 2005 by the *New South Wales State Government*. The document details Flood Prone Land Policy which has the primary objective of reducing the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the policy recognises the benefits from occupation and development of flood prone land.

Erosion and Sediment Control Guidelines

There are numerous guidelines which document best practice for erosion and sediment control. Relevant sections from the following guidelines have been used to formulate the erosion and sediment control aspects of the proposed SEOC:

- Managing Urban Stormwater*:* Soils and Construction *(Blue Book*), Department of Housing, 1998
- Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries (*note: this document is currently a consultation draft*)

Practical Consideration of Climate Change, Floodplain Risk Management Guideline Note, NSW Government – Department of Environment and Climate Change, Final November 2007

This document is a Floodplain Risk Management Guideline issued to assist Councils with the preparation and implementation of their Floodplain Risk Management Plans. The guideline outlines typical ocean level rise and peak rainfall and storm volume increases that should be considered in any climate change sensitivity analyses for flood risk assessment.

Australian Guidelines for Water Quality Monitoring and Reporting – ANZECC, 2000

These guidelines are the benchmark document of the National Water Quality Management Strategy (*NWQMS)* which is used for comparison of water quality monitoring data throughout Australia.

Rehabilitation Manual for Australian Streams (LWRRDC and CRCCH, 2000)

This document discusses creek rehabilitation concepts, including typical procedures and problems associated with creek rehabilitation. The document discusses a range of methods that can be employed to provide channel stability, improve aquatic habitat and establish riparian vegetation.

Relevant Studies

Glennies Creek Catchment – Total Catchment Management Study

The *Glennies Creek Total Catchment Management Study* was published by the Hunter Catchment Management Trust. The study comprises of two documents, titled the *Status of the Natural Resources Report* (*published in 2003*) and a *Management Strategy* (*published in 2004*).

The *Status of the Natural Resources Report* collates the best available information about natural resource management within the Glennies Creek catchment. The key focus points of the report are:

- Land-Use Planning and Legislation
- Water Quality and River Health
- Biodiversity and Ecosystems
- Integrated Land Management

The *Management Strategy* prioritises and outlines actions to address the issues identified in the *Status of the Natural Resources Report.*

Integrated Catchment Management Plan for the Hunter Catchment

The *Integrated Catchment Management Plan for the Hunter Catchment* was published by the NSW *Department of Land Conservation* in February, 2003. The document targets the following catchment management measures:

- Aquatic Health
- Soil Degradation
- Native Vegetation/Biodiversity
- Salinity

The document prioritises improvement measures, outlining broad objectives and proposed funding and timeframes for implementing the catchment targeted management measures.

3. EXISTING ENVIRONMENT

3.1 Site Description

The SEOC is located to the south of the Camberwell Village, within the Singleton Local Government Area. The current land use within the proposed SEOC disturbance area consists predominantly of agricultural activities, which includes both cattle grazing and some cultivation. There are some patches of native vegetation in the northern and eastern portions of the proposed disturbance area.

The site topography is characterised by the Glennies Creek Floodplain and two watercourses which run from the east to the west, and discharge into Glennies Creek. Site grades are generally less than 1% and elevations range between 50 and 100m AHD. Refer to **Figure 3**, for a site survey and aerial photograph.

The soils are generally yellow podsolic soils on the mid and upper slopes and water courses, with some patches of yellow soloth soil located adjacent to some water courses. Alluvial soils are present on the Glennies Creek Floodplain.

3.2 Climatic Data

3.2.1 SEOC Site

Rainfall Data

Daily rainfall and climatic data is available from numerous *Bureau of Meteorology* (*BoM*) weather stations located regionally to the project area. Some of these stations have short or non-continuous data sets and have subsequently not been used for this assessment. The regional BoM stations with adequate data sets are:

- *Jerrys Plains Post Office* (*BoM station 061086*) which is located 16km to the west of the SEOC.
- *Jerrys Plains (Carrington) (BoM station 61171*) which is located 11km to the southwest of the SEOC.
- Ravensworth (*Hillview*) *(BoM station 61028*) which is located 6km to the north of the SEOC.

Table 3-1 presents statistical rainfall data derived from the BoM rainfall records from the above stations.

Table 3-1 – *Comparison of Annual Rainfall Data*

Statistics	Jerrys Plains Post Office *BoM 061086* *1884 to Present*	*Jerrys Plains (Carrington)* *BoM 61171* *1959 to 1987*	Ravensworth (Hillview) *BoM 61028* 1911 to 1979
Elevation	90 (m AHD)	90 (m AHD)	91 (m AHD)
5th Percentile Rainfall (mm)	380	391	417
10th Percentile Rainfall (mm)	429	484	444
Mean Rainfall (mm)	638	635	654
90th Percentile Rainfall (mm)	832	828	845
95th Percentile Rainfall (mm)	876	862	908

Source: Bureau of Meteorology

With reference to **Table 3-1**, comparison of the statistical rainfall data from the three regional weather stations indicates that all stations have recorded similar rainfall patterns, with the low percentile, mean and high percentile rainfall depths at all three stations being within 5 to 10% of each other. This minor discrepancy is most likely due to localised topographical effects and possibly some variation due to the differences in monitoring periods. Considering that similar rainfall patterns have been recorded at all three stations, it was concluded that the *Jerrys Plains Post Office* (*BoM station 061086*) provides the most accurate indication of rainfall trends in the vicinity of the SEOC as it has the longest continuous data set (*from 1884 to the present*).

Additionally, ACOL has two established meteorological monitoring stations in the vicinity of the site, with the potential to collaborate data from adjoining mines. The stations are located in the village of Camberwell and at the Repeater Station on the ridge above the village. The stations have been in operation since September 2004. Over this period a total rainfall depth of 2533mm has been observed (*to June, 2008*). This compares favourably to the 2596mm observed at *Jerrys Plains Post Office* (*BoM station 061086*) over the corresponding period, reinforcing the above conclusion that the *Jerrys Plains Post Office weather station* provides the most accurate indication of long term rainfall trends in the vicinity of the SEOC (*having over 100 years of continuous records*).

EVAPORATION DATA

Average monthly evaporation and areal potential evapotranspiration (*PET*) rates for the SEOC site were extracted from the monthly climate maps provided by the BoM. The adopted monthly average evaporation and PET depths are presented in **Table 3-2**.

Table 3-2 – *Average evaporation and potential evapotranspiration at the SEOC site*

Month	Average Monthly Evaporation^ *(mm/month)*	Areal Potential Evapotranspiration *(mm/month)*
January	180	170
February	175	140
March	125	130
April	100	90
May	90	65
June	80	60
July	75	50
August	90	70
September	120	90
October	140	120
November	180	150
December	200	165

^ Evaporation from a Class A evaporation pan.

3.2.2 Glennies Creek Catchment

As the subject site is located on the Glennies Creek Floodplain, the climatic data in the greater Glennies Creek catchment is relevant to this assessment. Accordingly, rainfall records from the following BoM stations located within the Glennies Creek Catchment were used for this study:

- *Mount Olive (Fairholme)* (*BoM station 061047*) which is located at the confluence of Glennies and Goorangoola Creeks.
- *St Clair (BoM station 61115*) which is located immediately upstream of Glennies Creek Dam.

- *Goorangoola (BoM station 61021*) which is located 8km to the northwest of Glennies Creek Dam.
- *Carrowbrook (BoM station 61146*) which is located 4km upstream of Glennies Creek Dam.

Refer to **Figure 4** for the locality of the above rain gauges. **Table 3-3** presents statistical rainfall data derived from the BoM rainfall data recorded at the above stations. Data from the *Jerrys Plains Post Office* weather station is also included in **Table 3-3** to allow comparison between the Glennies Creek Catchment and adopted SEOC statistical rainfall data.

Table 3-3 – *Comparison of Annual Rainfall Data in the Glennies Creek Catchment*

Statistics	Jerrys Plains Post Office *BoM 061086 1884 to Present*	*Mount Olive (Fairholme) BoM 61047 1947 to 1983*	St Clair *BoM 61115* 1895-1949	Goorangoola BoM 61021 1885-1967	Carrowbrook BoM 61146 1960-Present
Elevation	90 (m AHD)	108 (m AHD)	152 (m AHD)	247 (m AHD)	214 (m AHD)
5th Percentile Rainfall (mm)	380	508	536	456	637
10th Percentile Rainfall (mm)	429	540	601	526	704
Mean Rainfall (mm)	638	870	860	832	1038
90th Percentile Rainfall (mm)	832	1172	1077	1192	1387
95th Percentile Rainfall (mm)	876	1286	1140	1235	1430

Source: Bureau of Meteorology

With reference to the rainfall data tabulated in **Table 3-3**, there is a clear trend indicating that annual rainfall depths progressively increase from the south to the north in the Glennies Creek Catchment. This trend is reflected in the lower percentile, average and higher percentile annual rainfall depths. Additionally, the design rainfall isopleths reported in *Australian Rainfall and Runoff* (*volume 2*) (*AR&R*) show a similar increasing trend in the average the rainfall intensities from south to north. This trend is likely to be the result of the orographic effect associated with the higher elevations in the upper extents of the catchment. This uneven distribution of rainfall intensities is accounted for in the Glennies Creek Hydrologic assessment, which is presented in **Section 4.1**.

3.3 Catchment Areas and Water Courses

The SEOC site is located at the downstream end of the Glennies Creek catchment, approximately 2km upstream of the confluence with the Hunter River. The proposed SEOC is located within both the Glennies Creek and Hunter River floodplains. Additionally, there are six unnamed tributaries to Glennies Creek located within the project area, these water courses range from smaller first order streams to larger second order streams.

This section discusses the existing conditions of each of the above watercourses from a water management perspective. An assessment of the ecological conditions of these water courses is documented in the Aquatic Ecology Assessment (*Marine Pollution Research, 2009*).

3.3.1 Glennies Creek

Catchment Description

Glennies Creek is a major tributary of the Hunter River. The contributing catchment area is approximately 515 km^2 and extends to the Mount Royal State Forest to the north, the Black Jack mountain range to the east and to Tank Mountain to the west. Refer to **Figure 4**, for catchment extents. Glennies Creek is fed by many tributaries, with Goorangoola Creek and Fal Brook being the most significant. The catchment is predominately dominated by cleared rural land with some remnant forest remaining in the Mount Royal State Forest and on some of the steeper topography within the catchment. The northern portion of the catchment is characterised by very steep terrain, with some slopes exceeding 20%. The catchment slopes remain relatively steep through the central portion of the catchment until Middle Fal Brook where the topography is flatter.

There are two existing coal mining operations in the southern portion of the catchment. These are the Integra mining complex (*which incorporates the Glennies Creek open cut and underground mine and the Camberwell open cut mine*) and the ACOL open cut and underground mining operations.

Glennies Creek Dam

In 1983, the New South Wales Department of Water Resources constructed Glennies Creek Dam (*also referred to as Lake St Clair*). The dam was built primarily to replace water withdrawn from the upper Hunter River for electricity generation by releasing environmental flows. The dam wall is located at the confluence of Glennies Creek and Baybuck Creek, immediately to the south-west of Baybuck Hill. The dam wall is a 67m high concrete faced rock filled embankment. The dam impoundment has a capacity of 283,000 megalitres and extends approximately 16km up Glennies

Creek when full. The Glennies Creek Dam spillway is an unlined cutting, draining to the south of the dam wall.

The contributing catchment area to Glennies Creek Dam is approximately 220 km^2, which is approximately 40% of the greater Glennies Creek catchment. As discussed in **Section 3.2**, average annual rainfall depths are higher in the northern portion of the catchment, which feeds Glennies Creek Dam. Hence, it is likely that the Glennies Creek Dam Catchment would yield over 50% of the total runoff volume from the greater Glennies Creek Catchment. Accordingly, the dam has a significant impact on the natural flow regime of Glennies Creek through moderating flood events and releasing stored water during dry periods to maintain base flows.

GLENNIES CREEK FLOW AND WATER QUALITY DATA

A stream flow gauge has been operating at Middle Fal Brook since 1955. The Middle Fal Brook gauge is located approximately 9km upstream from the SEOC site. The gauge location is indicated in **Figure 3**. The gauge has monitored daily discharges from 1955 and average daily temperature and Electrical Conductivity (*EC*) from 1995. Accordingly, the monitoring results provide a comprehensive baseline dataset of flow rates and water quality in Glennies Creek. This database was downloaded from DWE's website, and the key statistical information is tabulated in **Table 3-4**. As discussed above, Glennies Creek Dam was constructed in 1983. Accordingly, the daily flow rates have been presented in **Table 3-4** for both the pre and post dam periods.

Table 3-4 –*Baseline Glennies Creek flow rates and water quality*

	Units	10th Percentile	50th Percentile	90th Percentile	Average
Pre Dam Daily Stream flows (*1955 to 1983*)	ML/day	0.0	32.1	312.2	228.0
Post Dam Daily Stream Flows (*1983 to present*)	ML/day	20.7	61.6	228.5	152.0
Temperature (*1995 to present*)	°C	11.5	18.8	24.3	18.2
Electrical Conductivity (*1995 to present*)	µs/cm	290.0	352.1	588.1	403.1

With reference to the water quantity results in **Table 3-4**, the impact of Glennies Creek Dam on daily stream flows is clear. The post dam period observed significantly higher 10th and 50th percentile flow, but lower 90th percentile and overall average daily flows. This demonstrates the dams intended influence in moderating flows. The water quality results are discussed in context with additional water quality results in **Section 3.4**. However, it is noted that the water quality results are likely to be inversely correlated to the flow gauge results. For example, the higher EC values would be expected to occur during periods of low flow.

GLENNIES CREEK GEOMORPHOLOGY

An assessment of the Glennies Creek geomorphology has been undertaken by WorleyParsons, and is documented in a separate report titled Geomorphic Assessment of Glennies Creek *(WorleyParsons, 2009*).

3.3.2 Hunter River

The Hunter River drains one of the largest coastal catchments in New South Wales, covering some 22,000 km^2. The Hunter River catchment is shielded by rugged ranges to its north, and is significantly drier than any other coastal region of NSW. Annual average rainfall ranges from 1,100 mm at Newcastle to 640 mm at Scone in the upper reaches. In the driest years, rainfall can be as low as 600 mm at Newcastle and 375 mm in the upper valley.

Tributaries of the Hunter River include the Pages River, the Goulburn River, Wollombi Brook, Glennies Creek, Black Creek, the Williams River and the Paterson River. The Hunter River has a history of substantial flooding, with the largest recorded flood occurring in 1955.

Glennies Creek discharges into the Hunter River approximately 2km downstream of the proposed SEOC site.

3.3.3 Local Unnamed Tributaries

There are six (6) unnamed tributaries to Glennies Creek located within the project area. These watercourses are all ephemeral and range in size from first order to second order streams (*using the Strahler System*). For the purposes of this study, these water courses have been sequentially named from the north to the south as Tributary 1 (*T 1*) through to Tributary 6 (*T 6*). Refer to **Figure 3** for each water course alignment and contributing catchment area. **Figure 3** also details the location and direction of photographs taken of these tributaries.

TRIBUTARY 1 (T1)

Tributary 1 is a small ephemeral overland flow path which was identified from the site survey. T 1 is not a “blue line” on the 1 to 25,000 topographical map. T 1 has an estimated catchment area of 13 ha which incorporates the New England Highway and rural residential lots on both the eastern and western side of the highway. T 1 has no well defined channel, however, there is one small farm dam approximately halfway down the catchment.

TRIBUTARY 2 (T2)

Tributary 2 is a small ephemeral watercourse which was identified from the site survey and is identified as a “blue line” on the 1 to 25,000 topographical map. Applying the Strahler System of stream classification, T 2 would be classified as a first order stream. T 2 has no well defined channel and has an estimated catchment area of 26 ha which extends to the New England Highway to the east. The catchment is predominately rural land use with some areas lightly vegetated with native trees. There is one small farm dam approximately halfway down the catchment.

TRIBUTARY 3 (T3)

Tributary 3 is a small ephemeral watercourse which was identified from the site survey and is identified as a “blue line” on a 1 to 25,000 topographical map. Applying the Strahler System of stream classification, T 3 would be classified as a first order stream. **Photo 1** and **Photo 2** were taken from Glennies Street looking to the west and east respectively. As shown in both photos, T3 has no well defined channel, consisting of a grassed overland flow path, with numerous farm dams online to the watercourse. T 3 has an estimated catchment area of 64 ha which is defined by the New England Highway to the east and T 2 and T 4 catchments to the north and south respectively. The catchment is predominately a rural land use with some areas lightly vegetated with native trees. There are also 4 existing farmsteads within the catchment extent. There is one small farm dam approximately halfway down the catchment (*refer to **Photo 2***).

Photos 1 and 2 – Taken of Tributary 3 looking the west from Glennies Street (***Photo 1***) and looking to the east from Glennies Street (***Photo 2***).

TRIBUTARY 4 (T4)

Tributary 4 is the largest of the six tributaries identified within the project area. T 4 is a well defined watercourse with a contributing catchment area of approximately 289 ha. Applying the Strahler System of stream classification, T4 would be classified as a second order stream. The T4 catchment extends over 3km to the east of Glennies Creek, with the New England Highway roughly forming the eastern boundary. The catchment is predominately cleared grazing land with pockets of native woodland. **Photo 3**, which was taken in the upper extents of the catchment, indicates the typical ground cover in the upper extent of the catchment. There are numerous small farm dams located throughout the catchment, the majority of which are offline to the main watercourse.

In the upper extents of the catchment, the T 4 channel consists of a series of deep naturally occurring pools connected by a well defined channel which varies in width between 5 to 10m. A site inspection observed standing water in the pools, however, anecdotal evidence suggest the pools may dry up during extended periods of low rainfall. Hence, T4 is likely to be an ephemeral watercourse. **Photo 4** shows a typical channel profile in the upper extents of the catchment. As shown in **Photo 4** the channel appears to be stable with little sign of erosion. This is likely the result of the well established ground cover and riparian vegetation.


Photos 3 and 4 – Photo 3 was taken in the upper extent of the T 4 catchment, and indicates the typical vegetation cover in the catchment. **Photo 4** shows a typical section of channel in the upper sections of the T4 tributary showing the series of standing pools connected by a shallow channel.

In the lower extents of the catchment, the watercourse is moderately degraded, which is typical for rural watercourses which have been cleared and exposed to cattle grazing. The channel is generally eroded with head cuts up to 2 m deep in places. The extent of the erosion is visible in the aerial photograph of the site, refer to **Figure 3**. There is little riparian vegetation and the ground cover is less extensive than in the upper portion of the catchment. **Photo 5** shows a typical channel profile in the middle to lower portion of the catchment, while **Photo 6** shows the area adjacent to the confluence with Glennies Creek.


Photos 5 and 6 – **Photo 5** shows the typical T4 channel in the middle to lower portion of the catchment. The absence of riparian vegetation and access by grazing cattle has resulted in moderate channel erosion. Note the higher level of turbidity in standing pools, compared to **Photo 4** in the upper catchment. **Photo 6** shows a typical T4 channel in the lower portion of the catchment (*this* *photo was taken close to confluence with Glennies Creek*). Some remnant stands of riparian shrubs and trees were observed in the lower section of T4. Note the heavy incision of the channel in this location.

TRIBUTARY 5 (T5)

Tributary 5 is a moderate ephemeral watercourse which was identified from the site survey and is identified as blue line on a 1 to 25,000 topographical map. Applying the Strahler System of stream classification, T 5 would be classified as a second order stream. T 5 has an estimated catchment area of 162 ha which is defined by the T 4 catchment boundary to the north and east and the T 6 catchment boundary to the west. The catchment is predominately rural land use with some areas lightly vegetated with native trees in the upper extents. There are 2 existing farm dams online to the water course. The lower dam has been breached, refer to **Photo 7**. The lower portion of the T5 channel is aligned in what is believed to be an ancient Glennies Creek channel, flowing in a southerly direction for approximately 800m before discharging into Glennies Creek. This feature is clearly evident in **Figure 3**. There are two small first order streams which feed the lower section of the T 5 tributary. The southern stream is shown in **Photo 8**.

Photos 7 and 8 – **Photo 7** shows the breached dam online to the T 5 channel. **Photo 8** shows a minor tributary of T5, which is characterised by a short, steep grassed overland flow path with no remnant riparian vegetation.

TRIBUTARY 6 (T6)

Tributary 6 is a moderate ephemeral watercourse which was identified from the site survey and is identified as “blue line” on a 1 to 25,000 topographical map. Applying the Strahler System of stream classification, T 6 would be classified as a second order stream. T 6 has an estimated 113 ha contributing catchment, which consists of predominately cleared rural land. There are a number of small farm dams online to the water course.

It is noted that the T 6 catchment is positioned immediately to the south of the proposed SEOC pit and would not be directly impacted by the development. However, considering the close proximity to the development, T 6 has been included in this assessment.

3.4 Glennies Creek and Hunter River Water Quality Monitoring

A surface water quality-monitoring program has been undertaken by ACOL as part of the ongoing environmental monitoring programme for the existing operation. As part of this programme, surface water quality has been monitored at three locations on Glennies Creek, and five locations along the Hunter River. Monitoring commenced in September 2004 and is currently ongoing. **Figure 5** details the monitoring locations.

At each site, the following analytes have been measured on a monthly basis:

- pH
- Electrical Conductivity
- Total Dissolved Solids
- Total Suspended Solids
- Total Hardness/Alkalinity
- Oil & Grease

The resulting water quality data base was used to define the baseline water quality trends in both Glennies Creek and the Hunter River. Key statistical results from the water quality programme are presented in **Table 3-5**. Detailed results from the monitoring programme are graphically presented in **Appendix A**.

Table 3-5 – *Statistical Summary of Water Quality Observations*

	Monitoring Locations	Site No.	pH			EC (µS/cm)			TDS (mg/L)			TSS (mg/L)			Alkalinity (mg/L $CaCO_3$)		
			10%tile	90%tile	Average	10%tile	90%tile	Average	10%tile	90%tile	Average	10%tile	90%tile	Average	10%tile	90%tile	Average
Glennies Creek	u/s of Camberwell	SM 7	7.5	8.1	7.8	223	639	393	13.0	230.6	152.1	5.0	22.6	14.5	75.4	165.7	108.9
	Adjacent to SEOC	SM 8	7.5	7.99	7.8	235	704	394	13.7	239.9	153.1	8.0	39.3	18.8	77.0	157.2	107.1
	u/s of Hunter river	SM 11	7.7	8.1	7.9	236	690	396	14.0	226.5	151.7	6.0	25.8	14.0	75.4	181.9	110.8
	Middle Fal Brook Gauge					240	588	403									
Hunter River	u/s Bowmans Creek	SM 9	7.9	8.3	8.1	550	1039	753	23.7	504.4	289.5	6.7	36.3	24.7	159.9	305.7	227.8
	d/s Bowmans Creek	SM 10	7.9	8.4	8.2	571	1063	779	21.4	536.0	300.8	6.0	42.3	25.2	165.5	310.6	230.5
	Midway between Bowmans and Glennies Creeks	SM 13	7.9	8.3	8.2	561	1060	764	20.7	475.2	289.7	7.7	42.7	27.5	164.1	292.5	226.3
	u/s of Glennies Creek Confluence	SM14	7.9	8.4	8.2	621	1060	832	18.4	533.2	239.6	8.8	56.4	32.5	176.8	333.8	249.1
	d/s of Glennies Creek Confluence	SM 12	7.7	8.2	8.0	248	820	519	18.7	317.6	190.5	6.7	34.5	22.1	84.0	241.3	154.9
WQ Guidelines	ANZECC – Default trigger values for lowland rivers		6.5-8.0			125-2200 µS/cm for East Coast of Australia 200-300 µS/cm for coastal rivers in NSW			NA			NA			NA		
	Integrated Catchment Management Plan for the Hunter River		NA			P50 Salinity < 670µS/cm P80 Salinity < 920µS/cm At Singleton			NA			NA			NA		

With reference to **Table 3-5**, the water quality monitoring results indicate that the water quality in Glennies Creek is consistently superior to the water quality in the Hunter River, with average salinity, TDS, TSS and alkalinity observations approximately 30 to 50% lower in Glennies Creek. This is likely attributed to the base flow in Glennies Creek resulting from the controlled release of water from Glennies Creek Dam. As the dam's catchment is relatively pristine, the stored water would be expected to be of high quality, particularly with regard to salinity. Hence, any dam releases would significantly dilute any lower quality water in Glennies Creek.

The effect of Glennies Creek dam release is apparent in the Hunter River water quality observations sampled immediately downstream of the confluence between Glennies Creek and the Hunter River (*Monitoring Site: SM 12*). At this location salinity, TDS and TSS observations are approximately 30-40% lower than the upstream Hunter River observations. These observations imply that the inflow from Glennies Creek provides a significant contribution to the total Hunter River flow during base flow periods. As the Glennies Creek inflow is of higher quality, the lower quality Hunter River water is diluted, resulting in a clear improvement in Hunter River EC, TDS and TSS levels. This trend is apparent in the average and low, high percentile water quality monitoring results.

The observed EC levels at the Glennies Creek monitoring locations were similar to the values extracted from the Middle Fal Brooke data base (*refer to **Table 3-4***), which incorporates nearly 15 years of daily EC measurements.

The water quality results in **Table 3-5** are compared to relevant guidelines. The ANZECC guideline provides general water quality trigger values for slightly disturbed watercourses in South Eastern Australia. The salinity trigger values for low land rivers range from between 125µS/cm to 2200µS/cm. This large range indicates that the salinity levels in any given river system are highly variable, and are generally a function of the catchment geology and environmental state. The observed range of salinity measurements in both Glennies Creek and the Hunter River are within the lower half of this range. However, as the ANZECC guidelines are not catchment specific, this comparison is of limited value.

The *Integrated Catchment Management Plan for the Hunter River Catchment* was published by the *NSW Department of Land and Water Conservation* in 2003. This document is catchment specific and is therefore considered more applicable than the ANZECC guidelines. One of the key management targets outlined in the document is that by the year 2012, salinity levels in the Hunter River at Singleton do not exceed 670µS/cm 50% of the time and 920µS/cm 80% of the time. With reference to **Table 3-5**, the water quality monitoring results indicate that the salinity levels within the Hunter River downstream of the Glennies Creek confluence would meet the above water quality targets. However, it is noted that this is primarily attributed to the addition of less saline inflow from Glennies Creek because monitoring results in the Hunter River upstream of the Glennies Creek confluence would exceed the above water quality targets.

3.5 Local Water Users

The proposed SEOC site is located adjacent to Glennies Creek in the lower section of Zone 3a of the Hunter Regulated Water Source. There are approximately 1500 water extraction licenses within the total Hunter Regulated Water Source. A search of the DWE surface and groundwater licences database was undertaken to identify the existing surface and groundwater licenses within the local vicinity of the project. Licence information for the properties located in the local vicinity of the SEOC site are tabulated in **Table 3-6**. In addition, the locality of each license is presented in **Figure 6**.

Table 3-6 – *Existing water extraction license located in the local vicinity of the SEOC.*

WAL	License	Useage	Stream	Total Allocation (ML/year)	Sub Category
10354	20AL201200	Irrigation	Hunter River	195	General Security
10355	20AL203011	Irrigation	Hunter River	92	Supplementary
13381	20AL201348	Diversion Works	Glennies Creek	6	High Security
13382	20AL201349	Diversion Works	Glennies Creek	156	General Security
990	20AL201293	Farming	Hunter River	3	High Security
991	20AL201294	Irrigation	Hunter River	888	General Security
13389	20AL201716	Irrigation	Glennies Creek	120	General Security
Extraction Licenses Currently used by ACOL^					
997	20AL201311	ACOL Mining operation	Glennies Creek	11	High Security
8404	20AL200491		Glennies Creek	80	High Security
15583	20AL204249		Glennies Creek	354	General Security
1358	20AL203056		Glennies Creek	4	Supplementary
1120	20AL201624		Hunter River	3	High Security
1121	20AL201625		Hunter River	335	General Security
6346	20AL203106		Hunter River	15.5	Supplementary

^ ACOL has additional irrigation license from Bowmans Creek and domestic and stock licenses. These licenses are not used for mining operations.

4. FLOOD ASSESSMENT

The SEOC site is located within historic flood extents of both Glennies Creek and Hunter River flood events. In order to determine the governing flood behaviour at the subject site a detailed assessment of the Glennies Creek hydrology and floodplain hydraulics was undertaken. Historic flood levels observed during the 1955 Hunter River flood event were used to estimate the extent of a Hunter River flood.

This section details the hydrologic and flood hydraulics assessment undertaken for this study. A Glennies Creek Geomorphology Assessment has also been undertaken and is documented in a separate report titled *Geomorphic Assessment of Glennies Creek (WorleyParsons, 2009*).

4.1 Glennies Creek Hydrologic Assessment

A hydrologic model (*RAFTS*) of the Glennies Creek Catchment was created to determine discharge hydrographs at the SEOC site for a range of Average Recurrence Interval (*ARI*) storm events. The estimated discharge hydrographs were subsequently used in hydraulic models to examine the Glennies Creek flood behaviour in the vicinity of the SEOC site. The following sections detail the hydrologic modelling methodology, calibration and results.

4.1.1 Model Development

Hydrologic Model

The Runoff Analysis and Flow Training Simulation (*RAFTS*) software package was employed to quantify flood discharges from the lower section of the Glennies Creek Catchment. RAFTS is a deterministic runoff routing model which simulates catchment runoff processes. It is recognised in *Australian Rainfall and Runoff – A Guideline to Flood Estimation* (*1987*), as one of the available tools for use in flood routing within Australian catchments.

RAFTS was chosen for this investigation because it has the following attributes:

- It can account for spatial and temporal variations in storm rainfall across a catchment.
- It can accommodate variations in catchment characteristics.
- It can accommodate man-made controls such as Glennies Creek Dam.
- It can be used to estimate discharge hydrographs at any location within a catchment.

The RAFTS model was developed considering the physical characteristics of the catchment including catchment area, slope, percentage impervious area and vegetation. The model was implemented to generate discharge hydrographs at Glennies Creek near the SEOC site, which were used to determine the flood behaviour at the SEOC site.

CATCHMENT CONFIGURATION

The Glennies Creek catchment was divided into 15 sub-catchments encompassing an area of approximately 515 km^2. The sub-catchments were differentiated on the basis of the alignment of major watercourses and watershed boundaries, as well as the vegetation, land-use and topography. The adopted sub-catchment configuration is presented in **Figure 3**.

GLENNIES CREEK DAM

As discussed in **Section 3.3**, the Glennies Creek Dam would moderate flood flows, resulting in a major reduction in both the peak flow rate and total flood volume. The degree of attenuation would depend on the level of the dam at the beginning of the storm. If the dam was less than 100% full at the beginning of the storm, part or all of the inflow hydrograph would be impounded behind the dam wall, resulting in reduced discharge downstream of the dam. Significant discharge would only occur when the dam is full and the spillway overflows. As discharge over the spillway is proportional to the height of water above the spillway invert, the water level in the dam must raise for the spillway discharge to increase. Considering the dam, when full, has a surface area of 10.8 km^2, a significant volume of inflow is required to raise the water level, as well as a significant time lag delay prior to discharge occurring from the dam. Hence, the dam would significantly attenuate a flood hydrograph, even if it is 100% full at the beginning of the storm event. The dam was modelled as a detention basin node in RAFTS, for which the following parameters were adopted:

- The dam has a total storage volume of 283,000 ML and a surface area of 10.8 km^2
- The spillway rating curve provided by NSW State Water was adopted in the model. The adopted rating curve is detailed in **Appendix B.**

A sensitivity analysis was conducted to determine the effect of the antecedent dam level at the beginning of the storm. Both 85% full and 100% full scenarios were assessed. Results from this sensitivity assessment are discussed in **Section 4.1.3**.

Establishing Model Parameters

Once the subcatchment delineation was complete, rainfall runoff parameters such as initial and continuing losses, subcatchment roughness and subcatchment lag times were determined. As these parameters are defined by the physical properties of the catchment, survey information and aerial photographs were used to initially estimate these parameters. Some parameters were subsequently adjusted during the calibration phase of the model development. The methodology applied to estimate each of the rainfall runoff parameters is discussed below.

Catchment Slope

The weighted average catchment slope for each subcatchment was estimating through analysis of a 1:100,000 topographic map of the catchment area.

Impervious Percentage

The land use within the Glennies Creek catchment is predominantly either rural or naturally vegetated. Therefore, it was assumed that the entire catchment was 100% pervious.

Catchment Roughness

Catchment roughness values were selected to reflect the vegetation in each sub-catchment using a combination of aerial photograph, field observations of vegetation types, the level of vegetation cover, and soil types and standard guidelines of roughness values from literature. The following values were initially adopted for the model:

Rural – Grass Land	0.06
Forest – Sparse	0.06
Forest – Dense vegetation	0.10

These values were subsequently adjusted during model calibration.

Initial and Continuing Losses

In a typical storm event, not all of the rainfall that falls onto the catchment is converted to runoff. Depending on the prevailing "wetness conditions" of the catchment at the commencement of the storm (*i.e., antecedent wetness conditions*), some of the rainfall may be lost to the groundwater system through infiltration into the soil, or may be intercepted by vegetation and stored. This component of the overall rainfall is considered to be "lost" from the system and does not contribute to the estimated catchment runoff.

To account for rainfall losses of this nature, a rainfall loss model can be included within the RAFTS model. For this study, the Initial-Continuing Loss Model was used to simulate rainfall losses across the catchment. This model assumes that a specified amount of rainfall (*eg.10 mm*) is lost from the system initially, and that further losses occur at a specified rate per hour (*eg., 1.5 mm/hr*). These rainfall losses are effectively deducted from the total rainfall over the catchment, thereby leaving the remaining rainfall to be distributed through the watershed as runoff.

As no definitive loss rate data is available for the Glennies Creek catchment, rainfall loss rates used in the modelling were initially based on recommendations outlined in the RAFTS User Manual and documented in *Australian Rainfall and Runoff* (*IEAust, 1987*). The initial and continuing losses adopted in this model for the Glennies Creek Catchment were 25mm and 2.6 mm/hour respectively. These values were subsequently adjusted during model calibration.

Catchment Lagtime

The lag time between subcatchments is a function of the flow path length and the average velocity through the creek drainage corridor. Flow path distances were measures using a GIS package and the average velocity was estimated based on the average channel slope along the flow path.

The resulting calculations and adopted lag times are outlined in **Appendix B.**

4.1.2 Model Calibration

Runoff routing models such as RAFTS should be calibrated and verified using available historical rainfall and stream flow data. For this model, historic records from four local rain gauges and two stream flow gauging stations were assessed for calibration. Historic stream flows from the following State Water operated stream gauges was obtained from the State Water database:

- Middle Fal brook (*210044*) – is located at the confluence with Middle Fal brook, approximately 6km upstream of the Camberwell village. This is the most downstream stream gauge installed.
- Carrow Brook (*210114*) - is located at the confluence with Carrow Brook, which is immediately upstream of the Glennies Creek Dam Pondage.

Historic rainfall records at the BoM weather stations listed in **Section 3.2.2** were assessed for suitable calibration data.

Both the gauged stream flows and rainfall data have been recorded in daily time steps. The stream flows were recorded in increments of daily discharge volume (*i.e. ML/day*) and the rainfall records were recorded in a total rainfall depth over a 24 hour period (*i.e mm/day*). This data resolution does not accurately define flood peaks or rainfall burst which are required to accurately calibrate the catchment response time parameters (*i.e catchment roughness and lag times*). However, the calibration data is useful in providing an estimation of the runoff volume generated from a given rainfall depth. This is useful in determining the initial and continuing loss rates across the catchment.

The available data was assessed to determine the most adequate calibration events. Initial modelling indicated that the critical storm duration would be in the order of 36 to 48 hrs, so only significant rainfall events of similar duration were considered. The following two calibration events were identified as meeting the above criteria:

- **Calibration A** - A storm occurred on the 13th and 14th of May, 1962. During this storm over 150mm of rainfall was recorded at 3 rain gauges over a 48 hr period. Additionally, approximately 80mm of rainfall was recorded in the 3 days prior to the storm. This would have pre-wetted the catchment and filled the farm dams, resulting in a reduction to the initial loss rate (*which can be significant in rural catchment with many farm dams*) during the major storm. On the 14th of May the Middle Falbrook stream gauge recorded a daily discharge of 21,589 ML, which corresponds to an average discharge of nearly 250m^3/s. It is likely that the peak discharge would have been approximately twice the average discharge rate over the day.

- **Calibration B** - A storm occurring on the 29th and 30th of January, 1970. During this storm over 140mm of rainfall was recorded in the upper portion of the catchment and approximately 85mm in the lower portion of the catchment. Similarly to calibration event A, there was moderate rainfall recorded over the 3 days prior to the storm. On the 30th of January the Middle Falbrook stream gauge recorded a daily discharge of 14,441 ML, which corresponds to an average discharge of nearly 170m^3/s. It is likely that the peak discharge would have been approximately twice the average discharge rate over the day.

As the rainfall records were only available in daily rainfall depths, the total recorded rainfall total was applied to a 48 hr design storm hyetograph pattern in order to replicate realistic rainfall patterns. Similarly, the observed stream gauge data was used to estimate the downstream flood hydrograph, where a typical hydrograph for a 48 hr design storm derived from the RAFTS modelling was adjusted to achieve the observed stream flow volume.

Appendix B documents the calibration data used as well as the adopted rainfall hyetographs and downstream flood hydrographs.

Both calibration events were routed through the model and discharge hydrographs at the stream gauging locations were estimated. Calibration was completed by modifying model parameters until the simulated hydrographs matched the recorded stream flow values. In order to achieve this, the subcatchment roughness and initial and continuing losses required adjustment, for which the following values were adopted:

Catchment Roughness

Rural – Grass Land	0.08
Forest – Sparse	0.15
Forest – Dense vegetation	0.20

Catchment Losses

Initial Loss	20mm
Continuing Loss	3.6mm/hr

The resulting simulated hydrographs are plotted against the adopted calibration hydrographs in **Appendix B.**

It is noted that both calibration events took place before the Glennies Creek Dam was constructed. Hence, the influence of the dam was not applied in the calibration models. This was achieved by turning off the detention basin node which represents the dam in the hydrologic model. This is not likely to impact the accuracy of the calibration, as the impact of the dam can be accurately accounted for as the stage/storage proprieties of the dam storage and spillway rating curve have been provided by State Water.

4.1.3 Model Results

The calibrated RAFTS model was used to estimate discharge hydrographs for a range of design storm events. In order to account for the temporal variation over the catchment, separate design storms were applied to the upper and lower portions of the catchments. The corresponding IFD data for each design storm is attached in **Appendix B**.

Impact of Glennies Creek Dam

As discussed in **Section 4.1.1**, Glennies Creek Dam would significantly moderate flood flows in the upper section of Glennies Creek. The degree of moderation is a function of the storage level in the dam at the beginning of the storm. The calibrated RAFTS model predicted that during a 100 year ARI storm event, the total inflow in to Glennies Creek Dam would be approximately 40,000 ML. This volume was less than 15% of the total dam storage volume of approximately 283,000 ML. Hence, if the dam is less than 85% full at the beginning of a storm the entire 100 year flood hydrograph would be impounded, with no discharge downstream of the dam.

Table 4-1 presents the predicted peak discharge into and out of Glennies Creek Dam as well as the resulting peak discharge at the SEOC for modelling scenarios where the dam is 85% and 100% full at the beginning of a 100 year design storm event. Results from an additional scenario, where the dam is excluded from the model, are also included in **Table 4-1** to demonstrate the impact of the dam on the Glennies Creek Catchment flood hydrology.

Table 4-1 – *Impact of Glennies Creek Dam on catchment hydrology*

Dam level at the beginning of the Storm	100 year ARI Peak Discharge into Dam	100 year ARI Peak Discharge from dam	100 year ARI Peak Discharge at SEOC
	m^3/s		
No Dam	675	675	1145
Dam ≤ 85% full	675	0	784
Dam 100% full	675	180	834

Note: results reported for a 36 hr duration storm

With reference to **Table 4-1**, modelling indicates that the peak 100 year ARI discharge into the dam would be $675m^3/s$. As discussed above, if the dam is less than 85% full at the beginning of the storm, all of the arriving flow would be impounded. If the dam was 100% full, all flood water entering the dam would be discharged through the spillway. However, as discussed in **Section 4.1.1**, this would significantly attenuate the hydrograph. This was assessed in the RAFTS model which indicated that the peak outflow would be approximately $180m^3/s$. Additionally, the resulting peak flow would be delayed by approximately 12 hours which would further reduce peak flows downstream as flood hydrographs from catchments downstream of the dam would not be attenuated (*refer to* ***Appendix B*** *for inflow and outflow hydrographs*). This is why the peak discharge at the SEOC site only increases by 50 m^3/s, or 6.5% if the dam is full at the beginning of the storm. Hence, it can be concluded that the flood hydrology in Glennies Creek catchment is only marginally sensitive to the initial storage level in Glennies Creek Dam at the beginning of a major storm event. In order to be conservative, it was assumed that the dam is 100% full for all design storm events.

Modelling of the no dam scenario indicates that Glennies Creek Dam would reduce the peak 100 year ARI discharge at the SEOC by approximately 32% to 27% depending on the level of the dam at the beginning of a storm event.

Design Storm Estimation

Predicted peak flood hydrographs were determined at the SEOC site using the calibrated RAFTS hydrologic model. The 5, 20 and 100 year ARI storm events were assessed.

Table 4-2 presents the predicted peak discharge for a range of storm durations for the 5, 20 and 100 year ARI events.

Table 4-2- *Estimate Design Storm Peak Discharge*

ARI	Estimated Peak Discharge (m^3/s)			
	24 Hr	32 Hr	36 Hr	48 Hr
100 year	673.5	761.7	**834**	794.4
20 year	365.5	420.4	**459**	436.6
5 year	188.5	220.8	**237**	224.0

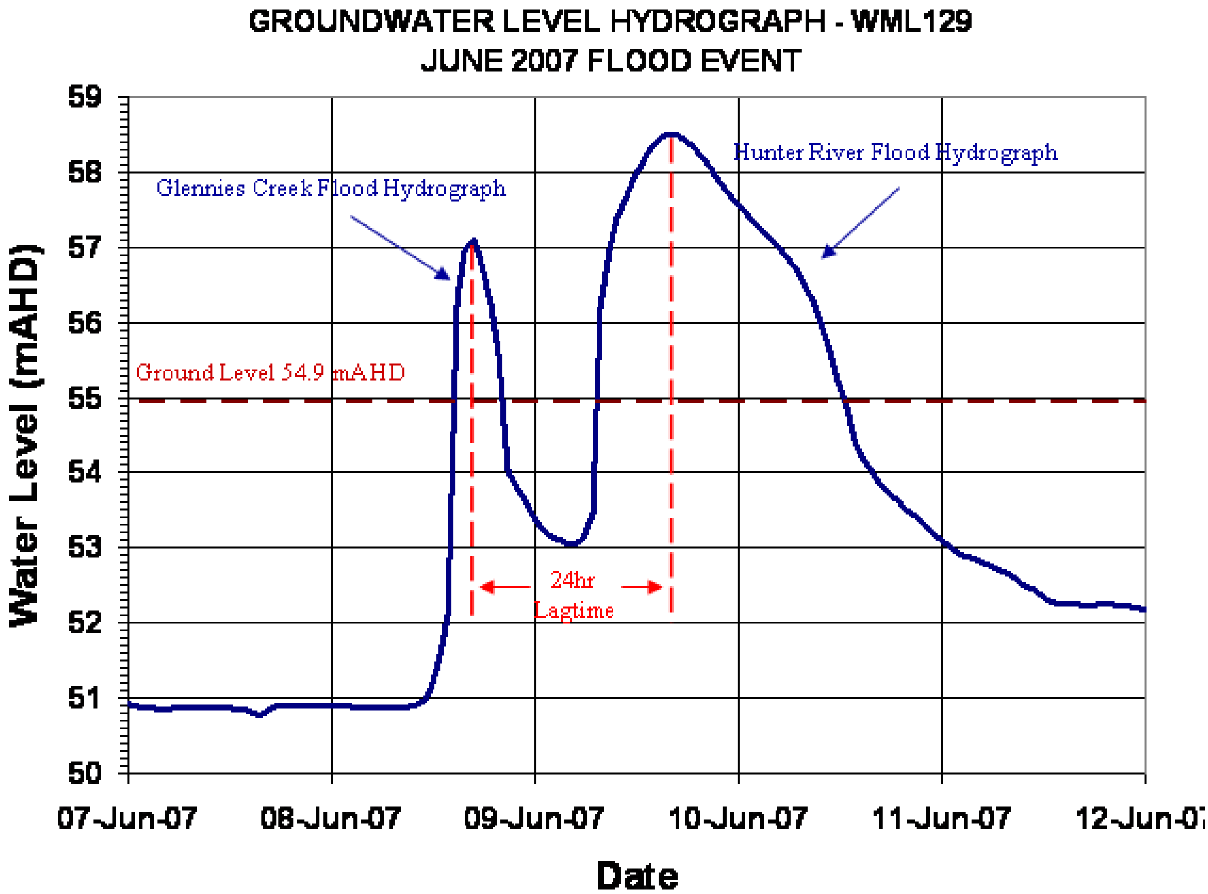
With reference to **Table 4-2** modelling indicated that the 36 hr storm event would be the critical storm duration for the catchment for the 5, 20 and 100 year ARI storm events. The reported peak discharges for this event are to be adopted in the flood hydraulics assessment, which is detailed in **Section 4.2**

4.2 Flood Hydraulics Assessment

The proposed SEOC site is adjacent to the Glennies Creek Channel, approximately 2km upstream of the confluence with the Hunter River. The western portion of the SEOC site is within the known flood extents from both river systems. Accordingly, an assessment was undertaken to determine the flood extents resulting from both Glennies Creek and Hunter River flood events. The following sections discuss in detail the assessment methodologies and results.

Discussion

The Hunter River Catchment upstream of the SEOC site has a significantly larger area than the Glennies Creek Catchment. Hence, it is expected that the Hunter River Catchment hydrology would have a longer time to peak than the Glennies Creek Catchment. Therefore, it would be expected that a Glennies Creek flood event would occur prior to a Hunter River Flood. This implies that flood events in the Hunter River and Glennies Creek would occur reasonably independent of one another. Observations during the June 2007 flood event support this assumption. An automated groundwater monitoring well located adjacent to the SEOC site recorded the June 2007 flood levels. The resulting flood stage curves are presented in **Plate 4-1**.



Note: Flood Levels provided by *The Department of Water and Energy*

Groundwater level hydrograph provided by Aquaterra

Plate 4-1 – *Recorded flood levels for the June 2007 event*

As indicated in the above image, the Glennies Creek flood hydrograph peaked approximately 24 hours prior to the Hunter River flood hydrograph. These recorded flood levels support the assumption that flooding in Glennies Creek and the Hunter River are likely to occur relatively independently. The sensitivity of this assumption is discussed in the following section.

4.3 Floodplain Features

The Glennies Creek floodplain is characterised by a meandering main channel, residual alluvial flats and is flanked by steep geological boundaries. The majority of the floodplain has been cleared for agricultural purposes. The Glennies Creek channel is moderately vegetated with a mixture of native and exotic plant species, while the floodplain generally consists of cleared land.

Survey information indicates that the average channel grade is approximately 0.1% in the section of Glennies Creek adjacent to and upstream of the SEOC site. Downstream of the SEOC site, the channel grade flattens to approximately 0.05% before the confluence with the Hunter River.

The New England Highway crossing to the north of the SEOC site has been identified as a key hydraulic control, primarily because of the natural contraction in the floodplain at the bridge location. In addition, the bridge and associated piers potentially create blockages during high flow events. Downstream of the bridge, the floodplain expands in the vicinity of the SEOC site near Tributary 4. A natural constriction in the floodplain occurs downstream of the SEOC site (*approximately cross-section CH689.06*).

4.3.1 Glennies Creek Flooding

A hydraulic model was developed to assess the Glennies Creek flood behaviour in the vicinity of the SEOC site. The model extends from the confluence with the Hunter River to approximately 500m upstream of Camberwell Village.

Hydraulic Model Development

A hydraulic model simulates the movement of a flood wave through a river and its floodplain. The hydraulic model incorporates channel slope, roughness, and structures such as bridges and embankments. The hydraulic model is used to determine flood levels and velocities along the river.

The HEC-RAS software package was used to develop a hydraulic model of the Glennies Creek Floodplain. HEC-RAS is an integrated software package designed to enable one-dimensional river modelling using steady-flow, based on a single geometric representation of the stream network. It is the successor to the steady-flow *HEC-2 Water Surface Profiles* software, which has been used widely to simulate flood behaviour in river and channel systems, particularly where structures constrain free surface flow. In its simplest application (*steady-flow simulations*), it automates the well known and respected *Standard Step Method* for backwater analysis.

Survey Data

A hydraulic model is based on the topographic representation of a water courses channel and floodplain. As discussed in **Section 1.3.1,** aerial survey data of the Glennies Creek floodplain within the model extents was provided by ACOL. Additionally, a recent high resolution aerial photograph of the site was also available. This data was assessed in conjunction with a series of site inspections to determine the most suitable locations for cross-sections extracted for the hydraulic model.

The HEC-RAS model was developed using the 12D CAD software. 12D was used to generate model cross-sections from the land surface model which is informed by the aerial survey data. 12D accurately determines the geometry of each cross-section as well as cross section chainage. The selected cross-section locations are presented in **Figure 9**.

Model Parameters

Manning's 'n' values are used to represent friction between water and a channel or floodplain. Generally, higher Manning's 'n' values imply increased friction and higher flood levels. As discussed in **Section 4.3**, the Glennies Creek Channel is moderately vegetated with riparian vegetation. The floodplain areas within the model extent are predominantly cleared pasture or cultivated fields. As there was little variance in the vegetation coverage over the modelled area, channel and overbank roughness were generically applied to all model cross-sections. Manning's 'n' values were conservatively adopted based on standard guidelines for channel types and vegetation density outlined in guideline literature (*HEC-RAS User Manual*). Adopted Manning's 'n' roughness for the channel and floodplain areas are presented in ***Table 4-3***.

***Table 4-3** – Adopted Channel and floodplain Roughness*

Description	Adopted Mannings 'n'
Glennies Creek Channel (*moderately vegetated with riparian vegetation*)	0.05
Glennies Creek Flood Plain (*predominately pasture*)	0.04

Contraction and expansion coefficients (*for evaluating creek transition losses*) of 0.1 and 0.3 were adopted for gradual contraction and expansion respectively. Higher coefficients of 0.3 and 0.5 were adopted for cross-section upstream and downstream of the New England Highway bridge crossing, in accordance with guideline literature (*HEC-RAS User Manual*).

Model Boundary Conditions

Upstream boundary conditions were estimated by applying normal depth conditions for the average channel grade in the upper reaches of each tributary. The downstream boundary conditions would be governed by the water level in the Hunter River. As discussed above, it is likely that a Glennies Creek flood event would occur relatively independently to a Hunter River flood event. Accordingly, the estimated 5 year ARI tail water level for the Hunter River was adopted for the 100 year ARI flood scenario. Tailwater levels for the 20 and 5 year ARI Glennies Creek Floods were progressively reduced by 1m from the 100 year ARI tailwater level. In the absence of more accurate information, these assumptions are considered conservative in terms of predicted flood levels in the SEOC project area. The adopted tailwater levels for all ARI floods assessed are presented in **Table 4-4**.

Table 4-4 – *Adopted tailwater levels for Glennies Creek Hydrodynamic model*

Average Recurrence Interval (ARI)	Adopted Tailwater Level
5 yr	56.6m AHD
20 yr	57.6m AHD
100 yr	58.6m AHD

Model simulations adopting a normal depth boundary conditions (*i.e assume there is no influence from the Hunter River*) predicted flood levels 0.5m to 1m lower in the lower section of the Glennies Creek Floodplain.

A sensitivity analysis was undertaken to determine the impact of a higher tailwater level on Glennies Creek flooding. The peak Hunter River 100 year ARI flood level (*62.73m AHD*) was applied as a tailwater condition to the peak 100 year discharge from Glennies Creek. Modelling indicated that the peak water level at the New England Highway Bridge (*nearly 5km upstream of the Hunter River*) was less than 0.2m above the adopted tailwater level. This implies that the significant increase in flow area induced by the higher tailwater level would significantly reduce the flood velocities, which would translate to lower energy losses. Therefore, modelling indicates that under high tailwater conditions, the flood levels at the SEOC site are not overly sensitive to the discharge in Glennies Creek.

As the higher tailwater scenarios are considered to Hunter River flood events (*which are discussed below*), and that it is probable that some minor flooding would occur in Hunter River when Glennies Creek is at its peak, the tailwater levels specified in **Table 4-4** are considered appropriate.

Glennies Creek Flood Results

The results from the Glennies Creek flood assessment is presented jointly with the Hunter River flood assessment results in **Section 4.3.3**.

4.3.2 Hunter River Flooding

The Hunter River drains the largest coastal catchment in New South Wales, covering some 22,000 km^2. Tributaries of the Hunter River include the Pages River, the Goulburn River, Wollombi Brook, Glennies Creek, Black Creek, the Williams River and the Paterson River. The Hunter River has a history of substantial flooding. Historically, the Hunter Valley floods of 1955 are regarded as the worst flood on record, and are typically described as being a 100 to 200 year ARI event, depending on the location along the River. The *Department of Water and Energy* (*DWE*) has provided historical Hunter River 1955 flood levels in the vicinity of the Glennies Creek Confluence. These are presented in **Plate 4-2**. In order to be conservative, locally recorded flood levels during this event have been adopted as the 100 year flood event.

Note: Flood Levels provided by *The Department of Water and Energy*

Plate 4-2 - *Recorded February 1955 Hunter River Flood Levels near Glennies Creek*

In addition to the 1955 flood records the design flood levels reported for the 5, 20 and 100 year ARI flood events at Singleton and Muswellbrook were interpolated to estimate the design flood levels at the SEOC for corresponding ARI flood events. The following graphical representation (*refer **Plate 4-3***) compares the interpolated flood levels to the observed 1955 and 2007 flood levels. It is noted that interpolated flood levels would not define any local variations in flood levels resulting from variations to the river grade or local hydraulic controls (*such as constrictions*). Hence, the interpolated values should only be used for comparative purposes in which case the potential inaccuracies should be considered.

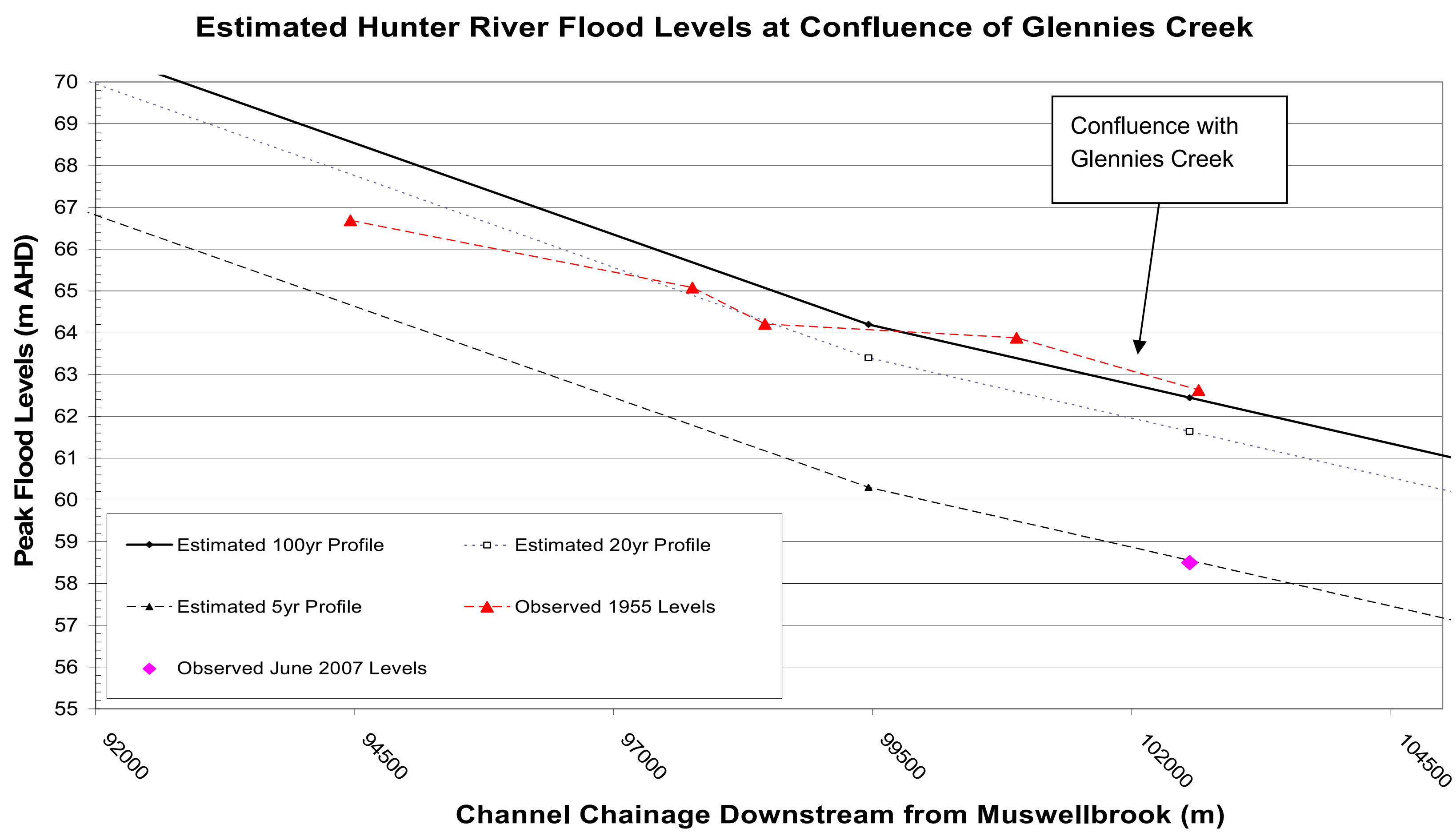


Plate 4-3– *Derivation of Hunter River Flood Levels at Confluence with Glennies Creek for the 5,20 and 100 year ARIs*

With reference to **Plate 4-3**, the recorded peak water level during the June 2007 flood corresponds to an estimated 5 year ARI flood level. The observed 1955 levels slightly exceed the interpolated 100 year flood levels at the Glennies Creek Confluence. However, it is noted that the interpolated 100 year flood level is moderately higher than the observed 1955 flood levels upstream of the Glennies Creek Confluence. In the absence of any detailed flood study of the Hunter River in the vicinity of the SEOC, the observed 1955 levels are considered the most reliable indication of the potential 100 year ARI flood levels at the SEOC. Accordingly, the 100 year Hunter River flood level adopted for the SEOC is **62.7m AHD**. The results from the flood assessment are further discussed in **Section 4.3.3**

4.3.3 Flood Assessment Results

Key flood results from the Glennies Creek and Hunter River flood assessment are presented in **Table 4-5**. The estimated key flood extents and cross-section locations are spatially presented in **Figure 9** (*5 year ARI*), **Figure 10** (*20 year ARI*) and **Figure 11** (*100 year ARI*). **Figure 14** presents the longitudinal water surface profiles for all reported flood events.

Table 4-5 – *Flood Assessment Results and Recommendations*

Average Recurrence Interval	Glennies Creek Upstream Cross Section CH 4725	Glennies Creek Downstream Cross Section CH 1786	Hunter River (backwater flooding)	Governing Flood Level
	Peak Flood Level (m AHD)			
5 year	57.9	56.7	58.6 (interpolated level)	58.6
20 year	59.4	57.8	61.6 (interpolated level)	61.6
100 year	60.7	58.8	62.7	**62.7**
Flood Planning Level	A flood planning level of **64 m AHD** will be adopted for the SEOC. This provides **1.3m freeboard** from the estimated 100 year Flood Level.			

With reference to **Table 4-5**, the flood assessment concluded that backwater flooding from a Hunter River flood event will govern flooding in the vicinity of the SEOC for ARIs ranging from 5 year to 100 years. This conclusion is supported by the observed flood levels during the June 2007 storm event (*refer to **Plate 4-1***) which recorded a peak Hunter River Flood level of 58.5m AHD, 1.5m above the Glennies Creek peak level of 57m AHD.

The resulting 100 year ARI flood level at the site is 62.7m AHD. As this flood level would occur from backwater flooding, there would be negligible variation in the flood level across the SEOC site. As discussed in **Section 4.3.2**, the Hunter River flood levels are based on historical observations, not a detailed flood assessment. Hence, a conservative flood planning level of 64m AHD is to be adopted for the SEOC. This flood planning level applies an additional 1.3m freeboard to the predicted 100 year level. This conservative freeboard was selected in recognition of the potential that flood events greater than the 100 year flood event could occur.

4.4 Probable Maximum Flood Assessment

Probable Maximum Precipitation (*PMP*) is defined by the World Meteorological Organisation (*1986*) as *'the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year'*. Calculation of the PMP allows estimation of the Probable Maximum Flood (*PMF*), which in turn is used to determine appropriate land uses on a risk management basis.

The presence of Glennies Creek Dam upstream from the site introduces the possibility of a dam breach, which would result in a flood greater than a PMF occurring through direct precipitation alone. Accordingly, the following assessments were undertaken to determine the PMF risk at the SEOC:

- A PMP storm event centred approximately 2km upstream of the SEOC. This would estimate the flood extents resulting from a locally occurring PMP storm event, which could potentially inundate the SEOC site in a relatively short period of time.

- PMF flood coinciding with a Glennies Creek Dam breach. This would estimate the largest flood probable in Glennies Creek at the SEOC site.

The above assessments are discussed in detail below.

PMP Storm

The PMP storm was estimated using the Generalised Short Duration Method (*GDSM*) which was published by the Australian Bureau of Meteorology in *June 2003*. The GDSM method is suitable for storm durations of up to 6 hours in catchments less than 1000 km^2. As the dam breach scenario would result in the greatest flood discharges, the PMP storm was centred approximately 2km upstream of the SEOC. This was undertaken to assess the flood hydrograph timing and flood behaviour from a PMP event occurring locally to the SEOC. The resulting information would be used to formulate the flood evacuation procedures for the SEOC. The adopted spatial distribution of a PMP storm is indicated in **Figure 7**.

A full range of PMP storm hyetographs and spatial distributions were determined using the GDSM method. Associated calculations are attached in **Appendix B**. The resulting PMP hyetographs were applied to the RAFTS model to determine the flood hydrographs at the SEOC site. The key results are presented in the proceeding results section.

Glennies Creek Dam Breach

The presence of Glennies Creek Dam upstream from the SEOC site introduces the potential for a flood greater then a PMF to occur through a possible dam breach. NSW State Water was contacted on this matter and advised they are currently in the process of revising their assessment of the potential flood implications resulting from a dam breach scenario. As the current assessment is ongoing, State Water provided a flood hydrograph at Camberwell village from the previous assessment, which is currently being revised. The hydrograph provided was from a PMF induced dam break scenario, which would be the worst case flood event possible in the Glennies Creek Catchment. As no superior information is available, the peak flow from this flood hydrograph was used to approximate the potential flood extents resulting from a dam breach.

Results

The HEC-RAS model developed for assessment of the design storm events was modified to facilitate the larger PMF discharges. The key modifications included:

- Removal of some cross sections to allow for expansion and contraction of flood flows to fully develop between cross-sections.
- Increasing the cross-section extents to allow for increased inundation depths and extents.
- Revising the left and right bank overland flow paths to accommodate the larger flood discharges.

The cross-sections adopted for the PMF model are displayed in **Figure 8**.

Key results from the PMF assessment, including peak flow, estimated time to peak and predicted flood levels at the SEOC site are presented in **Table 4-6**. Additionally, predicted PMF extents are spatially presented in **Figure 12**.

Table 4-6– *PMF Flood Assessment Results*

PMF Storm Scenario	Peak Flow (m^3/s)	Time to Peak (hours)	Peak Flood Level (m AHD)	
A PMP Storm Cell Located 2km Upstream of the SEOC			Upstream Cross Section CH 4725	Downstream Cross Section CH 1786
0.5 hr PMP Storm Duration	1,346	Approximately 12-18hrs from the beginning of the PMP storm	62.38	58.84
1 hr PMP Storm Duration	1,782		63.09	59.53
2 hr PMP Storm Duration	2,257		63.77	60.22
3 hr PMP Storm Duration	2,312		63.83	60.28
4 hr PMP Storm Duration	**2,319**		**63.84**	**60.28**
5 hr PMP Storm Duration	2,299		63.82	60.26
6 hr PMP Storm Duration	2,197		63.70	60.17
A PMF including Glennies Creek Dam Breach^	57,986	Approximately 3hrs from the dam breach occurring	79.47	73.19

^ Dam Breach hydrographs were provided by NSW State Water from a study which is currently being revised. Accordingly, State Water advised that extreme flood hydrology is not an exact science and State Water provides no warranty as to the accuracy of the information and accepts no liability with respect to decisions taken on the basis of this information.

With reference to **Table 4-6**, the PMF resulting from a dam breach is clearly the most significant flood event, with estimated inundation levels over 15m above the 100 year ARI flood levels. While a flood of this nature is an unlikely occurrence, emergency evacuation procedures are required to minimise the risk to personnel located at the SEOC. Information provided by State Water estimates that the peak flood level would occur approximately 3 hrs after the dam breach initiated. Emergency and evacuation procedures are discussed in **Section 8.1.3**.

Modelling indicates that a PMP storm centred locally to the SEOC would generate a peak discharge of 2,319 m^3/s, which is roughly three times the 100 year ARI peak Glennies Creek flood discharge. Hydraulic modelling indicates that the resulting peak flood levels would be 63.84 mAHD at the upstream extent of the SEOC. This is roughly 1m higher than the predicted Hunter River peak 100 ARI year flood level at the site (*62.7 m AHD*). It is estimated that the peak flood level would occur between 12 to 18 hours from the beginning of the storm.

A Hunter River PMF event would significantly inundate the SEOC. However, there has been no quantitative assessment of such a flood event as it is expected that highest possible flood level at the site would be governed by a Glennies Creek Dam breach scenario. Additionally, the short time to peak resulting from a PMP storm occurring locally to the SEOC would govern the timing of evacuation procedures for the SEOC proposed operation.

5. SURFACE WATER MANAGEMENT

5.1 Definitions

For the purposes of reporting, surface water within the site has been divided into the following categories:

- **Clean Water** – refers to surface water runoff from catchments which are undisturbed, relatively undisturbed or fully rehabilitated following disturbance. Clean water can be discharged from the site with no treatment.
- **Sediment Laden Water** – refers to surface water runoff from catchments which are disturbed but are currently being rehabilitated. Sediment laden water is likely to contain elevated suspended sediment levels and requires sedimentation treatment prior to discharge.
- **Mine Water –** refers to water with elevated concentrations of salts and sediment. Mine water includes surface water accumulated in the bottom of the pit and surface runoff from any areas where coal is transported or processed (*i.e haul roads, and stockpile areas*). Mine water is likely to contain elevated levels of salts, sediment and may be mildly acidic.
- **Wastewater –** refers to wastewater generated from the onsite facilities such as toilets and showers. Wastewater contains human waste and associated pathogens.
- **Potable Water –** refers to water suitable for drinking.

5.2 Surface Water Management Objectives

The principle objectives of this Surface Water Management Plan (*SWMP*) are as follows:

- Minimise the disturbance area throughout the life of the mine.
- Where practical, separate clean water (*i.e runoff from undisturbed areas*), sediment laden water and mine water circuits within the mine site.
- Harvest clean water runoff from the upper portion of Tributary 4 and 5 catchments which drain through the site.
- Provide sedimentation treatment for all runoff from disturbed areas.

- Store and re-use all mine water generated from the mine operation.
- Undertake monitoring to confirm the SWMP is operating in accordance with its design objectives.
- Provide erosion control measures such as drop structures and channel armouring to protect channel stability.
- Develop a drainage solution that is consistent with the design objects of the staged and final landform of the mine.

5.3 Surface Water Management Strategy

This section details the adopted surface water management strategy for each surface water category discussed in **Section 5.1**. This section should be read in conjunction with the staged life of mine stormwater management plans (*SWMPs*) detailed in **Figure 17** through to **Figure 22**. These plans are discussed in detail in **Section 5.4**.

5.3.1 Summary of Geochemistry

Geochemical testing undertaken by *Environmental Geochemistry International Pty Ltd* indicates that the overburden and pit floor materials are likely to be non acid forming materials. In addition, the washery wastes from both the SEOC and the underground operation are expected to be non acid forming overall.

Salinity levels of the overburden material appear to be generally low, with some samples returning moderate salinity levels.

Refer to the report titled *Ashton Coal ARD Assessment, South Eastern Open Cut Project* (*2009*) for further information on the geochemistry of the proposed mining material.

5.3.2 Clean Water

Clean water is surface water runoff from undisturbed and rehabilitated areas. Clean water can be discharged into Glennies Creek without any treatment. A network of clean water drains would be established to collect and convey clean water runoff around the proposed disturbed areas. The clean water diversions will limit the volumes of mine and sediment laden water as well as minimise the volume of runoff captured by the mining operation.

With reference to the SWMPs, the upper portions of the Tributary 4 and 5 catchments will drain through the SEOC project area. These catchments have a collective area of approximately 218ha. It is proposed to construct two clean water dams to capture runoff from these catchments. The dams are functions are to:

- Provide flood mitigation by capturing flood flows. The dams are to be sized to capture all runoff during a 1 in 20 year 12 hour storm event. Associated calculations are detailed in **Appendix B**.
- Provide 100ML of clean water storage in CW 1. The lower portion of CW1 would be dedicated to clean water storage that will be filled through a combination of pumped licensed extraction from Glennies Creek and harvesting of surface runoff from the upstream catchments. Runoff collected in CW2 will be pumped into CW1. The 100ML storage would be retained as a contingency supply for use during dry periods. Water harvesting is further discussed in **Section 6**. Any water in the dam in excess of the permanent water storage would be pumped directly into Glennies Creek.

Refer to the life of mine SWMPs (*refer to **Section 5.4***) for the proposed location of the clean water drains and dams. All clean water drains would be designed to convey the peak 100 year ARI flow.

5.3.3 Sediment Laden Water

Runoff from disturbed areas is likely to have elevated levels of suspended sediments. Suspended sediments are the result of an increase in soil loss rates from exposed or partially exposed areas of the catchment. Sediment laden water catchment areas are classified as any disturbed area outside of mine water catchments. This generally consists of shaped overburden areas as well as the proposed infrastructure area.

Soil loss rates are generally highest in the initial years while the rehabilitation is establishing. Once established, the vegetated surfaces would result in significantly reduced soil loss rates. ACOL are committed to commencing rehabilitation of overburden areas as soon as practically possible. In addition to rehabilitation measures such as revegetation, soil loss rates can be controlled through drainage design, which would employ measures to limit the flow path lengths and break up steep slopes.

Soil loss can also occur from channel erosion. Accordingly, all sediment catchment drains are to be designed to convey a 100 year peak flow rate. Appropriate scour protection (*i.e. jute mesh or rock armouring, depending on the velocities*) would be provided as required.

Sediment dams are required as interim measure to protect receiving waters from sediment laden runoff from disturbed areas. Sediment laden water can be treated using gravity settlement using a holding dam. All sediment dams have been sized to capture a 1 in 20 year ARI 12 hour design storm. Associated calculations are attached in **Appendix B**. An additional sediment storage volume equal to half the runoff retention volume is provided in the total storage volume. Once the contributing catchments are fully rehabilitated, the sediment dam can be removed to allow the catchment runoff to discharge into the receiving waters.

It is proposed to re-use water captured within the sediment dams for either dust suppression or process water for the Coal Processing Plant. However, during extended periods of rainfall or during a significant storm event (*i.e greater than a 20 year ARI storm*), some overflow from the dams may occur. If overflow does occur, the sediment dams would facilitate the removal of the majority of the coarse sediment through gravity settlement.

5.3.4 Mine Water

Mine water is considered to be the most contaminated water on a mine site. The primary contaminant is elevated salt levels, which arise from contact with both coal and saline overburden material. Mine water can also be acidic (*low pH*), however, as discussed in **Section 5.3.1**, the pit floor, overburden and washery rejects are expected to be non acid forming overall.

In recognition of the potential environmental impacts of mine water the EPA has established the *Hunter River Salinity Trading Scheme* to regulate the discharge of mine water into the Hunter River and its tributaries. ACOL are not participants in the salinity trading scheme, and therefore, do not have a license to discharge mine water. Accordingly, all mine water is to be stored and re-used on-site.

Mine water catchments are principally all catchment areas draining to the open pit, as well as all haul roads and ROM storage areas. As the pit is the lowest point on the site, all groundwater inflow and seepage through the overburden dump would discharge into the pit through subsurface flow. In addition, any sediment laden water or clean water catchments which discharge into mine water drains are also classified as mine water catchments.

Mine water will also generated from the workshop facilities that will include vehicle wash down and maintenance areas, as well as fuel storage and refuelling areas. Runoff from the workshop facilities will be treated in an appropriately sized sedimentation chamber and an oil and grease separator prior to being either recycled or discharged into the mine water circuit.

It is proposed to use all mine water within the mining operation, principally for dust suppression and process water for the Coal Processing Plant. In addition, some mine water would be lost through evaporation. During major storm events, excess mine water would be pumped to the final void of the Barrett Pit that will provide over 2,000ML of contingency storage.

5.3.5 Wastewater

Wastewater would be generated from the proposed on-site amenities, which include showers, bathroom facilities and washrooms. All wastewater generated would be treated using an Envirocycle or equivalent waste water treatment system (*WWTS*). Treatment would be by an aerated wastewater treatment system (*AWTS*) as well as UV disinfection or equivalent (*removes pathogens and other potentially harmful organism*s). The WWTS is commonly used for commercial wastewater applications and is approved by relevant health authorities throughout Australia. Treated effluent would be disposed through irrigation of landscaped areas surrounding the infrastructure area. The treatment plant would provide holding tank sized to retain up to 5 days of effluent production to allay the need to irrigate during rainfall periods.

Information provided by ACOL was used to determine the peak and average daily wastewater loads, which were estimated to be 7.7 l/s and 23.6 KL/day respectively. Detailed calculations are attached in **Appendix E**. The estimated wastewater loads were used to indicatively size the WWTS and disposal system.

A 20KL balancing tank would be required upstream of the WWTS to attenuate the peak flows, allowing for the WWTS to operate at the average waste water loading rate. Treated effluent would be disposed through spray irrigation of landscaped areas surrounding the infrastructure area. Refer to the life of mine plans (*discussed in* ***Section 5.4***) for an indicative irrigation area. Minimum disposal areas have been calculated based on hydraulic capability of the land to accept effluent and its associated nutrients. Soil testing was undertaken by *The Department of Lands* to determine the capacity of the onsite soils to absorb nutrients. The resulting test results are attached in **Appendix E**.

Based on methodologies detailed in *On-site Sewage Management for Single Households* (*Environment and Health Protection Guidelines,1998*), a recommended land area of approximately 1.8 ha would be required to dispose of all wastewater generated by the SEOC operation. Phosphorus was determined to be the limiting nutrient. Detailed calculations are attached in **Appendix E**.

5.3.6 Potable Water

It is proposed to import all potable water from external sources. Potable water will be stored onsite and distributed through an isolated network.

5.4 Life of Mine Surface Water Management Plans

Life of mine Surface Water Management Plans (*SWMPs*) are detailed in **Figure 17** through to **Figure 22**. The underlying principles of the life of mine SWMPs are discussed in **Section 5.3**. These principles were practically applied to the proposed mining plan with consideration given to the following identified site constraints:

- A fibre optic cable is aligned parallel to the New England Highway and crosses the north eastern portion of the SEOC project area.
- Existing native vegetation areas exist to the north and east of the project area.

In addition to the above constraints, one of the key objectives of the design of the SEOC project is to minimise the project footprint, especially in the Glennies Creek Floodplain.

The following sections discuss each of the life of mine SWMPs in detail. Refer to **Appendix B** for calculations for all dam sizes.

Water Management Plan – Year 1

The initial stage of the SEOC proposal incorporates the construction of the ROM stockpile pad, dump station and conveyor system, the northern section of the levee, the infrastructure area and the initial box cut. The initial material excavated will be used to establish a visual screen adjacent to the New England Highway.

A 180ML minewater storage dam (*MW1*) would be located to the east of the levee. MW1 is sized to retain all runoff during a 1 in 100 year 72 hr design storm from the contributing disturbance areas (*SC MW1*). MW1 would be the key mine water holding dam until the pit moves to the south, adjacent to the levee. At this time the surface drainage would be directed into the pit and MW1 would be decommissioned. This is expected to occur in year 2. Sediment dams SD1, SD2a and SD3 would be constructed to provide sediment treatment for runoff from the overburden emplacement and infrastructure areas.

A 190 ML clean water dam (*CW 1*) would be constructed to provide water storage and emergency flood mitigation storage. The initial 100ML is intended to provide cleanwater storage, and the remaining 90 ML is proposed to be used for emergency flood storage and is sized to retain all runoff during a 12hr duration 20 year ARI storm. This will reduce the risk of floodwater entering the SEOC operation area.

The Tributary 4 (*T4*) channel will remain a clean water system until approximately year 2. The Tributary 5 (*T5*) catchment will be relatively undisturbed until year 4.

WATER MANAGEMENT PLAN – YEAR 3

In the second year of the operation, the middle section (*or stage 2*) of the levee would be constructed as well as sediment dam SD2b. This dam will be built in series with SD2a to provide additional retention required as the contributing catchment area (*SD2*) increases. Sediment dams SD2a and SD2b have been separated to avoid disturbing an underlying fibre optic cable.

In the third year, the landform in catchments SD2 and SD3 would be shaped with varying stages of rehabilitation underway. An additional overburden catchment area, SD4, would be in the early stages of rehabilitation. Runoff from this area will be directed into the active pit to avoid constructing a sediment dam to the west of the levee in the Glennies Creek Floodplain. The open pit would continue to capture all runoff from the ROM pad, haul road and active mining area.

The Tributary T5 catchment would remain outside of the disturbance area, and all surface flow would be discharged as clean water.

WATER MANAGEMENT PLAN – YEAR 5

By the fifth year of operation, the final (*southern*) portion of the levee would have been constructed. The mining operation would encroach into the T5 catchment. Accordingly, a clean water dam, sized to capture a 20 year ARI flood would be constructed to the east of the final void. The open pit would capture all runoff from the ROM pad, haul road and SD4 catchment.

WATER MANAGEMENT PLAN – YEAR 7

The 6th and 7th year of operation would incorporate a similar SWMP to the 5th year, with the open pit capturing all runoff from the ROM pad, haul road and catchment SD4. Year 7 will be the final year of mining. The initial stage of the proposed re-establishment of Tributary 4 would be implemented. The rehabilitation strategy for this creek is discussed in more detail in **Section 7.2**.

WATER MANAGEMENT PLAN – YEAR 9

In year 9, the mining operation would have ceased. However, tailings from the underground operation would continue to be disposed in the final void. The year 7 SWMP would still be applied. However, the rehabilitation of the northern emplacement areas would be advanced, and the potential for removing SD2a, SD2b and SD3 and reinstating Tributary 2 could be considered. However, this will depend on the state of the rehabilitation and the resulting water quality in the sediment dams. Refer to **Section 5.5** for guidelines for sediment dam closures.

Water management Plan – Final Landform

The proposed mine closure plan would incorporate the following rehabilitation measures:

- Filling and capping of the final void, once final tailings have been placed.
- Removal of the ROM pad. The removed material would be placed between the levee and overburden dump, to facilitate a natural draining landform.
- Re-establishment of Tributaries 2, 3 and 4 (*as indicated in **Figure 22***). The preliminary design measures for the re-establishment of these watercourses are discussed in more detail in **Section 7.2**.
- Removal or significantly reduce the size of all dams to facilitate the reinstatement of more natural flow regimes.

As discussed above, the closure of dams and re-instatement of water courses would be undertaken as soon as the contributing catchment is rehabilitated. Refer to **Section 5.5** for guidelines for sediment dam closures.

5.5 Guidelines for Dam Closures

It is proposed to either fully remove or significantly reduce in size all proposed dams as part of the mine rehabilitation plan. Large online dams present barriers for sediment and aquatic habitat movement as well as capturing a significant portion of the catchment runoff yield, which is subsequently lost to evaporation. Large dams also present an ongoing maintenance and safety liability. Removing dams will enhance the long term environmental functions of the re-established water courses and facilitate the return of stream flows to existing levels. However, it is important that dams are not removed until the upstream catchment areas are fully rehabilitated stabilised. Accordingly, the following guidelines would be used to determine if a dam is ready to be removed:

- Inspection of the contributing catchment to ensure the rehabilitation is well established and there is no evidence of significant sheet, rill or channel erosion.
- Inspection of the upstream drainage network to ensure there is no significant channel erosion such as bed or bank scouring.

- Inspection of the receiving watercourse, to ensure that removing the dams will not result in erosion of downstream waterways.

6. SITE WATER BALANCE

A site water balance was undertaken to assess both the drought security of the proposed ACOL operation as well as the capacity to manage surface water runoff volumes during periods of high and extreme rainfall. This section discusses the modelling methodologies, model assumptions, calibration techniques as well as the water balance results.

6.1 Modelling Objectives

The objectives of the water balance are:

- To gain an understanding of the predicted water sources, demands and water movements within the proposed ACOL operation.
- Demonstrate the ability of the proposed stormwater management measures to manage surface water runoff during periods of extended wet weather.
- Assess the drought security of the proposed ACOL operation.
- Estimate the reduction in surface water runoff to receiving waters expected as a result of the SEOC development.
- Assist in the determination of water licensing requirements for the proposed ACOL operation.

6.2 Modelling Methodology

The water balance modelling was undertaken using a scripted water balance model that has been developed over the past 24 months to examine the water management strategy at the existing ACOL operation. This model was calibrated using data collected by ACOL over an 18 month period. Following calibration, the model was expanded to incorporate the SEOC proposal that includes additional catchment areas, storages and water demands. The resulting model facilitates the integrated assessment of the water management strategy for the proposed ACOL operation. This includes the existing underground mine, the Coal Processing Plant (CPP) and the proposed SEOC open cut mine.

6.2.1 Water Balance Model

The water balance model was developed as a continuous simulation model that simulates the various model inputs, outputs and storages on a daily time step. The key features of the water balance model are described below:

- A simplified SIMHYD rainfall runoff model was adopted to model the rainfall runoff relationship of the identified catchments within the mine site. SIMHYD is a conceptual daily rainfall-runoff model which simulates both surface and base flow runoff from a given catchment. When used in continuous simulation, the SIMHYD model tracks the soil moisture content, which is the key variable in determining the volumetric runoff from a particular rainfall event.

- Water demands and sources can be applied at constant rates or through the use of custom functions. Time series data can also be applied when known or observed data is available.

- Water transfers between storages, demands and sources can be controlled using transfer rules that are based on storage levels, demand requirements and/or source availability. This function can be used to ensure elements of the water management strategy, such as maintaining low levels in flood mitigation storages, can be captured in the water balance simulation.

- The water balance runs on a daily time step and requires daily rainfall and evaporation rates as model inputs. The model results are available on a daily timestep, but are reported as monthly averages to simplify the model results.

6.3 Model Structure

Water movements around a mine site are complex and often vary over time as the operation progresses through the mining plan. Accordingly, the water balance model has been simplified to capture the key water sources, water demands and storages. The adopted model structure is presented in **Figure 15**. A schematic, which locates the features detailed in **Figure 15**, is presented in **Figure 16**. The key demands, sources and storages are discussed in detail in the following sections.

6.3.1 Model Inputs

ACOL commenced monitoring key water flows within the existing operation in July 2007. A comprehensive data set is available for the period between 25/9/2007 to 31/3/2009. The observed water movements over this 18 month period were used to gain an understanding of the water movements (*i.e supply and demand*) through the existing operation and subsequently calibrate the water balance model. This period is referred to as the calibration period in the remainder of this report.

Observed rainfall depths during the calibration period were provided by ACOL. This data set was compared to the rainfall data from BoM station at *Jerrys Plains Post Office* (*BoM station 061086*) which is located 16km to the west of the SEOC. Comparison of the rainfall depths indicated that the two sites are very similar. However, the ACOL data did not include data during some of the higher rainfall events. Hence, the rainfall time series from *BoM station 061086* was considered to be the most suitable for use in the water balance model as it was comparable, but also a more complete set.

6.3.2 Water Demands and Losses

The following water demands have been identified.

Coal Processing Plant (CPP)

ROM product is processed on-site prior to exporting the final product off-site. With reference to **Figure 16**, the Coal Processing Plant (CPP) is located adjacent to the Process Water Dam (PWD). ROM product is washed in the CPP, using water sourced from the PWD. The washing process separates the product from the non-product components of the ROM. The non-product component consists of coarse and fine rejects. Fine rejects are pumped as slurry to tailings dams, where a settling agent (*floc*) is added to assist in settlement of the fine reject. Excess water is decanted from the tailings dam and returned to the process water dam to complete the cycle.

The cycle described above results in a net loss of water through various means. ACOL have installed flow meters, which measures the inflow into the CPP, the flow from the CPP to the tailings dam, and the flow decanted from the tailings dam and returned to the PWD. The net loss through the total process was observed to vary from 0.5 to 5.5ML/day, with an average net loss of 3.1ML/day. The variation is the result of varying levels of throughput, variation in the percentage of product in ROM, CPP down time and other factors.

It is proposed to increase the CPP processing capacity from 5.2Mtpa of ROM Coal to a maximum annual rate of 8.6Mtpa. ACOL estimates this will increase the net water loss from the existing 3.1ML/day to 4.5ML/day. As this EA seeks approval for the increased processing rate, the higher net water loss has been adopted for the water balance calculations (*excluding the model calibration which is based on observed data*).

Dust Suppression

Dust suppression is required on non-rainy days to mitigate the dust levels produced from the operation. The key dust suppression measure is water sprayed from water trucks over the active haul roads. Information supplied by ACOL defines an average daily water demand for dust suppression to be 1.3 ML/day. This is based on a 38KL truck making 2 runs per hour for an equivalent of 18 hours a day (*2 trucks running for 6 hours per day and one truck running for 6 hours*). This calculation assumes there are 12 rainy days per year when dust suppression is not required. ACOL anticipate that the dust suppression requirements for the SEOC would be similar to the existing open cut operation, for which the above water usage rates are sourced from.

Water usage for dust suppression of product stockpiles and conveyors is accounted for in the overall CPP water demand.

Evaporation losses

Evaporation/evapotranspiration losses are applied to both the open water bodies as well as the onsite soils for which the average monthly values specified in **Table 3-2** were adopted. The evaporation from the open water bodies is calculated based on the storage levels and estimated surface area (*which is based on survey data*). Evapotranspiration losses from the onsite catchments are integrated into the simplified SIMHYD rainfall runoff model, which is described in **Section 6.4**.

6.3.3 Water Sources

Licensed Extraction

ACOL currently have access licences to extract surface water from both Glennies Creek and the Hunter River. The licences details are summarised in **Table 6-1**.

Table 6-1– *Existing surface water extraction licences*

Stream	Sub Category	Total Allocation (*ML/year*)
Glennies Creek	High Security	91
	General Security	354
	Supplementary	4
Hunter River	High Security	3
	General Security	335
	Supplementary	15.5

The above licence allocations are administered by DWE, who regulates the extraction volumes based on water availability and stream flows. During extended dry periods, it is likely that the general and supplementary allocations are reduced. ACOL have provided flow meter readings for both Hunter River and Glennies Creek extraction locations from the past 18 months. Over this period, an average 1.4ML/day was extracted collectively from Glennies Creek and the Hunter River. This equates to approximately 64% of ACOL's total allocation.

ACOL advised that during the dry period observed during 2005, 2006 and 2007, the general and supplementary licence allocations were reduced to as low as 0% (*i.e no extraction allowed*). Accordingly, the potential for reductions in licence allocations has been captured in the water balance model by tracking the total rainfall depths over a 24 month period prior to each model timestep. In order to develop this algorithm, the storage level in Glenbawn and Glennies Creek Dams was compared to the total annual rainfall depths and the average annual allocation of General Security Licences. Both the dam storage levels and the General Security allocations were sourced from DWE's website. The resulting information from June 2004 to June 2008 is plotted in **Plate 6-1**.

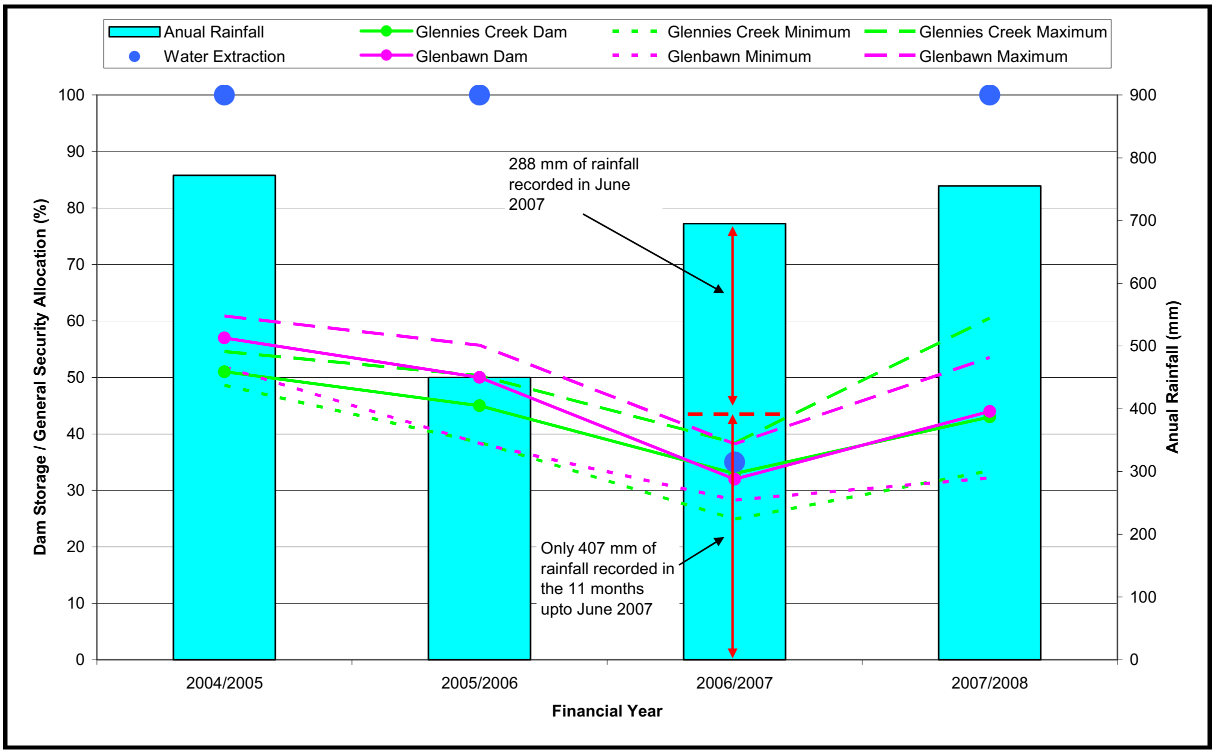


Plate 6-1 – *is a plot comparing Glennies Creek and Glenbawn Dam storage levels, observed rainfall and General Security licensed allocations.*

As indicated in **Plate 6-1**, the General Security allocation was only reduced during the 2006/2007 Financial Year. As indicated on the diagram, rainfall total during the 2006/2007 was significantly increased by the June 2007 long weekend storms. Rainfall for the month of June totalled 288mm, which effectively broke the drought. Prior to June, 2007, there were approximately 2 consecutive years of 10th percentile rainfall. This resulted in the dam levels in both Glennies Creek and Glenbawn Dam dropping below 30%. As a result the General Security license allocation was reduced to an average of 30% during the 2006/2007 Financial Year. As discussed above, ACOL advised that it was reduced to 0% for a short period of time.

As indicated in **Table 6-1**, ACOL currently has an 689 ML/year allocation under a General Security licences. Hence, the risk of this licence allocations being reduced must be captured in the water balance calculations. Accordingly, license allocations in the SEOC water balance model are weighted based on the 24 month cumulative rainfall totals adopting the algorithm outlined in **Table 6-2**.

Table 6-2 – *24 month rainfall to General Security Allocation*

24 month cumulative rainfall Total	Assumed General Security Allocation	Assumed Permissible ACOL extraction (ML/year)
Greater than 1100mm	100%	689 ML/year
Less than 1100mm	75%	517 ML/year
Less than 1000mm	50%	345 ML/year
Less than 900mm	30%	207 ML/year

It is noted that, the algorithm recalculates the allocation on a daily basis. Hence, it assumes the allocation would quickly be adjusted following significant rainfall events, such as the storms observed in June 2007.

Catchment Runoff

Surface water runoff volumes are dependent of rainfall patterns and can be highly variable. During dry periods, it is expected that next to no surface runoff would occur. Conversely, during wet periods significant volumes of surface runoff are likely. The key soil variable defining rainfall runoff relationships for water balance calculations is the Soil Moisture Storage Capacity (*SMSC*). If dry, soils can absorb relatively large volumes of water prior to generating runoff. As the soil becomes partially saturated, the ratio of runoff to rainfall increases. This soil absorption capacity is referred to as the Soil Moisture Storage Capacity (*SMSC*). SMSC is generally higher in cohesive soils, with moderate to high organic components and lower in soils which are either compacted and/or barren and contain little cohesive material. Accordingly, the following soil types have been identified in the ACOL study area:

- **Undisturbed Soils –** refers to areas which are relatively undisturbed such as the clean water catchment upstream of the SEOC. The native soils in the area generally have a moderate clay component, which would result in moderate to high SMSC.
- **Rehabilitated Overburden Soils –** refers to areas of the overburdened which are fully rehabilitated. The rehabilitation would have resulted in the development of healthy topsoil encompassing moderate organic components, and therefore moderate SMSC.

- **Barren Overburden Soils** – refers to areas of active pit or unshaped and/or untreated overburden. The associated soil is basically the parent rock, which generally has a limited SMSC. The uncompacted nature of the overburden would facilitate the deep infiltration of the majority of excess runoff.

- **Compacted Mine Working Areas**. – refers to areas of the mining operation where machinery frequently operates. Generally, this refers to haul roads, stockpile areas and other general working areas. The continual compaction of machinery would substantially reduce the SMSC, resulting in increase runoff to rainfall ratios similar to impervious surfaces. In addition, infrastructure areas also generally incorporate impervious areas such as car parks, hardstand areas and large structures.

As discussed above, a SIMHYD rainfall runoff model has been used to estimate the rainfall runoff relationship of the above soil types. This is further discussed in **Section 6.4**.

Water from Other Mines

ACOL have an ongoing arrangement with the operators of Glennies Creek Underground Mine to receive mine water from the underground operation. ACOL have indicated that received flows are in the order of 1 to 1.2 ML/day. ACOL is not required to receive water during wet weather periods.

Underground Operation

The existing underground operation produces a net surplus of water. Clean source water is required to assist in the mining operation. This water is collected within the mine, along with seepage from the local groundwater storages and returned to either Arties Sump or the PWD. The flow rates into and out of the underground mining operation have been metered for approximately 18 months. Over this period, a net water surplus ranging from less than 0.1 ML/day to over 0.6 ML/day was observed. The average daily surplus was 0.4ML/day.

Seepage into Pit

ACOL have monitored the pump out volumes from the existing open cut pit for approximately 18 months. The pump out volume represents the combined inflow from surface runoff (*i.e from rainfall over the pit*), as well as seepage inflow from external sources. Observed pump out rates range from 0.3 to 1.4 ML/day, with an average volume of 0.6ML/day. ACOL estimate that 0.35 ML/day of this inflow is attributed to seepage, or subsurface flow into the pit.

With reference to the Hydrological Impact Assessment (*Aquaterra, 2009*), the anticipated average seepage inflow into the SEOC pit is estimated to range from 0.15ML/day to 0.23 ML/day.

6.3.4 Onsite Storages

Figure 16 locates the numerous storages, and associated capacities, located within the existing and proposed SEOC operation. ACOL has provided detailed survey information for all existing dams allowing the stage/storage relationship to be accurately modelled. The proposed stage/storage relationships for the proposed dams at the SEOC were indicatively determined based on standard mine dams.

6.4 Model Calibration

The data collected during the calibration period was used to define average daily water movement time series for the following flows:

- Water pumped out of the Barrett pit.
- Water movements through the CPP and tailings storage facilities.
- Extraction from both Glennies Creek and the Hunter River.
- Water flows into and out of the underground operation.
- Water movements between the various storages.

These water flow time series were integrated into the water balance model as known data. Other unmetered water movements, such as flows received from the Glennies Creek Mine and the water usage for dust suppression were applied to the model based on information provide by ACOL (*as documented in **Section 6.3***). In addition, ACOL provided survey dam levels (*for which the dam storage volumes can be estimated*) at four dates within the calibration periods. Additional survey dam levels were also available at the start of the calibration period and were adopted as initial conditions in the water balance model.

All of the above information was integrated into the water balance model. Using the known and assumed data, the water balance model was calibrated by adjusting the SIMHYD model parameters to achieve a reasonable correlation between the simulated water storages and the surveyed dam levels. The resulting model results are summarised in **Plate 6-2** that graphs the observed water used and sourced, the simulated storage and runoff volumes and the survey dam storage levels on a monthly scale over the calibration period.

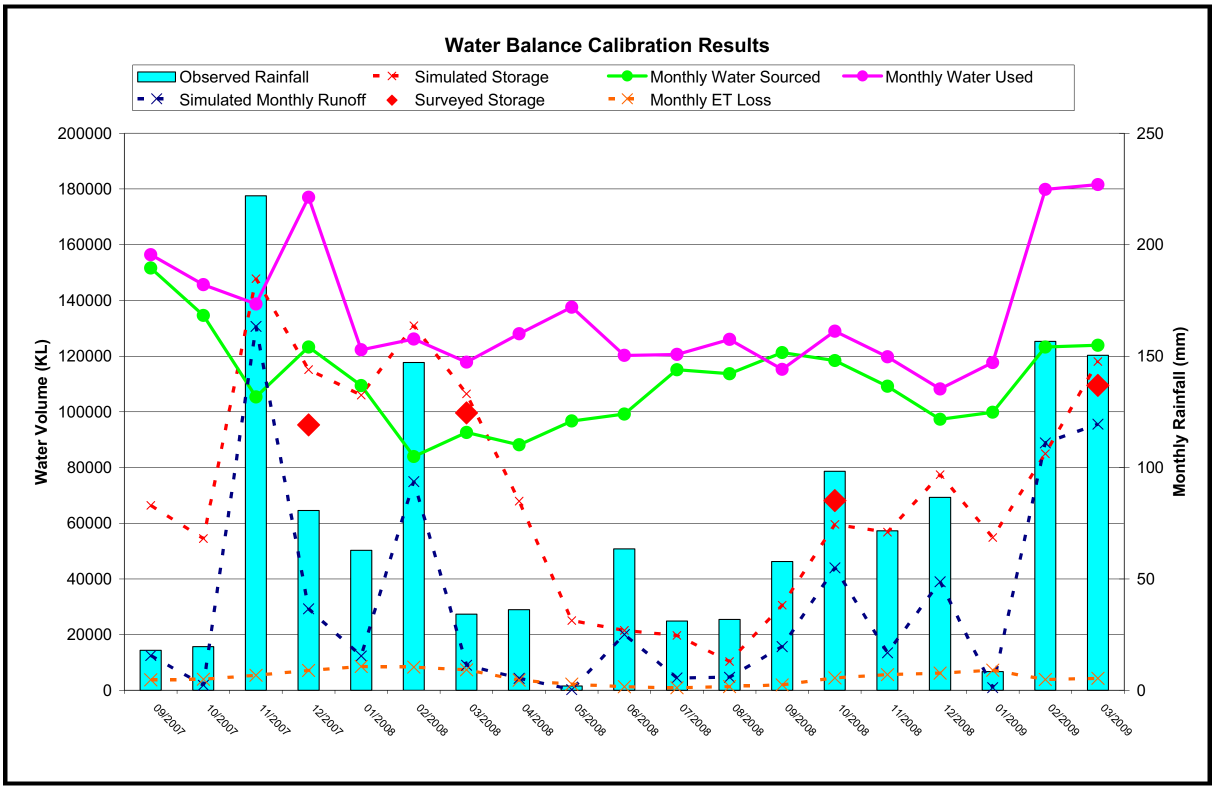


Plate 6-2 – *Water balance model calibration results*

As demonstrated in **Plate 6-2**, the simulated storage levels are reasonably well correlated with the survey dam storage levels indicating the model calibration is reasonably accurate. The calibration periods included periods of high rainfall in November 2007, February 2008 and February and March 2009. During each of these months, the estimated surface water runoff volumes ranged between 80ML to 130ML. During moderate rainfall months (*i.e total rainfall depths between 50mm and 100mm*), the monthly surface water volumes ranged between 15 and 50ML. There was negligible runoff during months with minimal rainfall.

As indicated in **Plate 6-2**, the storage levels were high during the initial month of the calibration period. This is the result of above average rainfall over this period. The storage levels were progressively reduced between March and May of 2008. This resulted in an increased requirement for source water to meet demand.

In summary, the key water movements during the calibration periods are presented in **Table 6-3**.

Table 6-3 – *Key water movements during calibration periods*

	Average Annual Flow (ML)	Average Daily Flow (ML/day)
Water Demands		
CPP (net Demand)	1123	3.1
Dust Suppression	474	1.3
Evaporation Loss	71	0.2
Total Demand	**1668**	**4.6**
Water Sources		
Flow from underground mine (Net)	147	0.4
Flow from Glennies Creek mine	438	1.2
Glennies Creek Extraction	224	0.6
Hunter River Extraction	267	0.7
Pump out from Barrett pit	224	0.6
Surface Runoff (Estimate)	402	1.1
Total Source	**1702**	**4.6**
Balance^	**34**	**0.0**

^ Difference between Storage levels at the first and last model time step

6.4.1 Calibration of SIMHYD Parameters

As discussed above, the calibration of the water balance required adjustment of the SIMHYD rainfall runoff parameters. The calibration model incorporated three of the four soil types discussed in **Section 6.3**. However, the bare overburden soil type was excluded from the calibration model as the pump out from the open cut pit was a known water movement. In addition, there are insufficient areas of natural catchment in the existing operation to facilitate the accurate calibration of the undisturbed soil type. Hence, the following methodology was used to calibrate these soil types:

- **Barren Overburden –** the observed pumpout rates from the existing pit were used to calibrate the SIMHYD model. However, some of the pump out volume is attributed to seepage into the pit from external sources, and must be considered in the calibration. ACOL estimates that seepage into the Barrett Pit is 0.35ML/day. This volume was subtracted from the total pumpout volume to achieve a volume for calibration. It is noted that this calibration volume would incorporate the evaporation losses occurring from any standing water in the pit.

- **Undisturbed Catchments** – in the absence of any calibration data, the SIMHYD parameters were calibrated to achieve a runoff coefficient of 0.125, which is equivalent to 80mm of runoff in an average year. This figure is commonly used in Hunter Valley for undisturbed catchments.

The resulting key adopted SIMHYD model parameters and results are presented in **Table 6-4**.

Table 6-4 – *SIMHYD rainfall runoff parameters.*

Soil type	SIMHYD Parameters					Rainfall Runoff Results		
	Initial Loss	SMSC	Maximum Infiltration Rate	Surface Runoff exponent	Base flow exponent	Runoff Coefficient	Surface Runoff	Base Flow
	mm	mm	mm\day	Unit-less		% of total Rainfall	% of total runoff	
Undisturbed Soils	5	200	50	0.7	0.10	0.12	88%	12%
Rehabilitated Overburden Soils	5	150	50	0.6	0.15	0.15	17%	83%
Barren Overburden Soils	5	120	100	0.4	1.00	0.14	85%	15%
Compacted Mine Working Areas	5	70	25	1.0	0.00	0.60	100%	0%

The SIMHYD parameters listed in **Table 6-4** were applied to the water balance model used to assess the proposed water management strategy for the SEOC.

6.5 SEOC- Water Balance

The calibrated water balance model developed for the existing operation was expanded to include the SEOC proposal. This required the inclusion of the additional water sources, water demands, catchment areas, storages and transfer systems associated with the SEOC development proposal.

Refer to **Figure 15** for the adopted water balance schematic and **Figure 16** for a plan view of the water balance framework.

6.5.1 Assessment Method

In order to facilitate a comprehensive assessment, a 105 year simulation period was used to assess the site water balance. This simulation period applied the observed rainfall time series recorded at *BoM Station 061086* between 1904 and 2009. The recorded data prior to 1904 was incomplete, and therefore was not considered suitable for continuous simulation. The application of a 105 year modelling period facilitates the assessment of a diverse range of short and long term rainfall trends.

6.5.2 Model Scenarios

The water balance model was applied to the Year 3, Year 7 and the post SEOC surface water management plans. The key difference between Year 3 and Year 7 is the increase in catchment area as the mining operation progresses to the south (*refer to life of mine SWMPs*). This will effectively add more surface runoff to the system. When the SEOC operation concludes, the water usage requirements would be reduced as dust suppression will no longer be required and the CPP would be operating on lower throughput as a result of reduced ROM production. The adopted water balance input parameters for each of the above scenarios are presented in **Table 6-5**.

It is noted that the Year 1 and Year 5 SWMPs are very similar to the respective Year 3 and Year 7 SWMPs and as such have not been included in the water balance assessment.

Table 6-5 – *Adopted Water Balance Input Parameters*

	SEOC Year 3	SEOC Year 7	Post SEOC (Year 9)^
Water Demands			
Dust Suppression	1.3 ML/day		0 ML/day^^
CPP	4.5 ML/day		3.0 ML/day
Total Demand	5.8 ML/day		3.0 ML/day
Water Sources			
Net water make from underground mine	0.4 ML/day		
Water received from Glennies Creek mine	1.2 ML/day		
Licensed Extraction	Up to 802 ML/year		
Seepage into SEOC^^	Approximately 0.2ML/day over the life of the mine.		
Total Water Sources	1.8 ML/day and up to 712 ML/year	1.8 ML/day and up to 712 ML/year	
Surface Runoff – Contributing Catchment Areas			
Existing operation	233ha (*refer to **Figure 16***)		
SEOC	378 ha (*refer to **Figure 18***)	512 ha (*refer to **Figure 20***)	
Total Contributing Catchment Area	611ha	745 ha	

^ Post SEOC refers to the period between the finalisation of open cut mining at the SEOC operation (2017) and the finalisation of the underground operation (2023).

^^ Dust suppression for the conveyor and stockpile areas is included in the CPP demands.

^^^Predicted pit inflows provided by Aquaterra

Each of the scenarios detailed in **Table 6-5** was applied to the water balance model from which the key results are presented in the following sections.

6.5.3 Drought Security

It is anticipated that the total ACOL operation will have an average daily water demand of approximately 5.8 ML/day. As detailed in **Table 6-5** approximately 1.8ML/day of water is received from sources such as pit seepage, water received from Glennies Creek Mine and surplus water from the underground. The remaining 4ML/day is to be sourced from rainfall dependant sources, such as harvesting surface water runoff and licensed extraction from Glennies Creek and the Hunter River. The water balance model was used to determine the drought security of the proposed ACOL over the 105 year simulation period. The adopted rainfall runoff parameters and methodology for accounting for reduced licensed extraction availability during dry periods is detailed in **Section 6.3**.

The drought security for each of the scenarios detailed in **Table 6-5** was assessed using the water balance model. For each scenario, the percentage of months where demand is fully satisfied, as well as the 50th, 70th and 90th percentile demand deficits (*i.e the volume of demand not met*) are reported in **Table 6-6**.

Table 6-6 – *Drought Security Assessment*

Year of Mining Operation	Year 3		Year 7		Post SEOC - Year 9	
Percentage of months demand is fully satisfied	35%		41%		97%	
Monthly Demand (*ML/month*)	180		180		93	
Estimated Demand Deficit	Demand Deficit (*ML/month*)	Percentage of Total Demand	Demand Deficit (*ML/month*)	Percentage of Total Demand	Demand Deficit (*ML/month*)	Percentage of Total Demand
50th Percentile	14	7%	5	3%	0	0%
70th Percentile	58	32%	44	25%	0	0%
90th Percentile	104	58%	99	55%	0	0%

With reference to **Table 6-6**, the water balance model estimates that the ACOL operation would have sufficient water to fully meet the estimated monthly demand in approximately 35% of months in the Year 3 scenario and 41% of months in the Year 7 scenario. The increase is the result of an increased catchment area as the SEOC pit progresses to the south (*refer to life of mine SWMP's*). In the post SEOC scenario, the water demand is reduced and the estimated percentage of months where demand is fully satisfied increases to 97%. The estimated magnitude of the predicted water deficits ranges from 58% of total demand in the 90th percentile case to 7% of total demand in the 50th percentile case.

Periods of water deficit are generally associated with extended dry spells, where the license extraction allocations are reduced and no significant surface runoff is collected. As such, the water availability over the 7 year SEOC mining period would be governed by the rainfall patterns over the life of the mine, and could potentially vary to the results presented in **Table 6-6** that are based on 105 years of rainfall data. In conclusion, the ACOL operation is likely to have sufficient water during above average rainfall years, possible minor water shortages during average rainfall years and is likely to experience shortages of varying levels of severity during below average rainfall years.

In the event of operational water shortages, ACOL could implement the following measures:

- Reduce the throughput through the CPP, which accounts for approximately 70% of the water usage.
- Obtain additional water extraction licenses.

6.5.4 Mine Water Containment

As discussed in **Section 5.4**, it is proposed to direct all mine water from the SEOC area into the operation pit. As the pit will provide a very large storage volume, there is no risk that there would be insufficient capacity to capture mine water during any conceivable rainfall event. Water accumulated in the SEOC pit would be pumped to the final Barrett Pit void (*existing open cut operation*) that would store the water until it can be used in the mining operation. The mine closure plans for the existing open cut operation indicate the final Barrett Pit void would have a storage volume in excess of 2,000 ML.

The key risk with the mine water containment strategy is an operational risk, as large volumes of water in the pit could possibly impact the mining operation. Over the past 100 years, there were four major storm events which would have caused significant flooding in the SEOC pit. These events and the estimated volume of pit flooding are summarised in **Table 6-7**.

Table 6-7 – *SEOC flooding during major storm events*

Date	Monthly Rainfall	Estimated runoff into SEOC Pit^
May 1913	310mm with 200mm in 2 days	520 ML
June 1930	271mm with 250mm in 3 days	400 ML
February 1955	340mm with 244mm in 3 days	400 ML
June 2007	286mm with 222mm in 3 days	280 ML

^ The estimated pit runoff was calculated using the Year 7 Scenario, which has the greatest contributing catchment area. Accordingly, runoff volumes would be reduced in the Year 3 scenario.

A 100 year 72 hour design storm at the SEOC has a total rainfall depth of 239mm over a 3 day period. Hence, each of the storm events presented in **Table 6-7** are similar to a 100 year ARI design storm event. The estimated volume of runoff into the pit is sensitive to the antecedent conditions, which governs the initial *Soil Moisture Storage Capacity* (*SMSC*) as well as the stored volume of water in the clean water dams (*CW 1 and CW 2*) that overflow into the SEOC pit. For example, approximately 80mm of rain was recorded in the week prior to the May 1913 storm. While the June 2007 storm proceeded an extended dry period, whereby the clean water dams upstream of pit would have been empty.

The depth and extent of inundation would depend on the pit geometry at the time of the flooding. Accumulated mine water would be transferred to the final Barrett Pit void at a rate of approximately 20ML/day. Therefore, it is expected that the SEOC pit floor would be inundated for approximately 15 to 25 days following a major storm event.

Water balance modelling indicates that the final Barrett Pit void has sufficient storage volume to contain all runoff during a major storm event. The peak simulated storage was slightly less than 1,000ML which occurred in June 1913, following the May 1913 storm event (*note: excess water from both the SEOC and the existing operations would be pumped into the Barrett Pit*). As the final Barrett Pit void provides over 2,000 ML of storage, it is highly unlikely that there would be insufficient mine water storage capacity.

It is noted that during wet periods, ACOL have the capacity to significantly reduce source water through temporarily suspending licensed extractions and the receipt of water from the Glennies Creek Mine. This would facilitate a drawn down rate of up to 5ML/day minus any additional runoff from continuing rainfall. Water balance modelling indicated that the water accumulated during the May 1913 storm would have taken approximately 8 months to drawdown.

6.5.5 Predicted Changes to Stream Flow

They key impact on stream flows would arise from the temporary reduction in runoff from the SEOC project area during the operational and rehabilitation phases of the project. The SEOC project will have an estimated ultimate footprint of approximately 294 ha. Runoff from the project area will collected in sediment and mine water holding dams and re-used within the ACOL operation. In addition, it is proposed to harvest runoff from the upstream catchment areas which are not to be disturbed by the SEOC project. These upstream catchment areas (*designated as CW 1 and CW 2*) have a collective area of 218ha (*refer to **Figure 20***). Runoff from catchments CW 1 and CW 2 would be stored in clean water dams and used in the mining operation. During and after periods of heavy rain, some clean water would be pumped directly into Glennies Creek to maintain the flood retention capacity in the clean water dams.

During the initial mining period from Year 1 to Year 4, the southern portion of the project area would remain undisturbed, and the collective harvesting and disturbance areas would be approximately 378ha (*refer to **Figure 18***). From Year 5 to the final rehabilitation phase (*Year 13 or 2023*), the collective harvesting and disturbance areas would be approximately 512ha. The resulting estimated changes to annual flows in average, 10th, 50th and 90th percentile rainfall years are presented in **Table 6-8**. These values are compared to the Glennies Creek stream gauging data collected at Middle Fal Brook. It is noted that the Middle Fal Brook stream gauge is approximately 9km upstream of the site. Accordingly, the contributing Glennies Creek catchment area at the SEOC is approximately 15% larger than the catchment contributing to the Middle Fal Brook stream gauge.

Table 6-8 – *Predicted changes to stream flows*

Annual Rainfall Depth		Estimated Annual Flows Existing Conditions	Estimated Reduction in Annual Flows			Observed Glennies Creek Flows	
			Years 1 to 4	Years 5 to 13	Final Landform	Annual Flows	Maximum Reduction
		ML/Year	*ML/Year*	*ML/Year*	*ML/Year*	*ML/Year*	*%*
Average		451	331	451	33	55,240	0.8%
Percentile	10th	117	86	117	8	30,570	0.4%
Percentile	50th	352	258	352	25	46,670	0.8%
Percentile	90th	909	667	909	65	85,990	1.1%

With reference to **Table 6-8**, the predicted average annual loss in Glennies Creek stream flow will be approximately 330 ML/year during the initial 4 years of mining and 450 ML/year during the final 3 years of mining and the 6 year rehabilitation period. A reduction of 450 ML/year is equivalent to 0.8% of the average annual Glennies Creek flow at the subject site. The reduction is stream flow as a percentage is lower in dry years and higher in wet years as a result of the moderating effect of Glennies Creek Dam on the Glennies Creek flow regime.

As indicated in **Figure 22**, the final void would encompass an estimated 37ha area that would not be free draining, and therefore result in a minor permanent loss in stream flow. It is estimated that this would be 33ML/year in an average year and is not considered to be significant considering the Glennies Creek average annual discharge is over 55,000 ML/year.

It is noted that the estimated loss in stream flow only considers surface runoff. The estimated loss of subsurface discharge is documented separately in the *Hydrological Impact Assessment* (*Aquaterra, 2009*).

7. PRELIMINARY DESIGN MEASURES

7.1 Flood Containment Levee

It is proposed to construct a flood containment levee to protect the SEOC operation from potential inundation from flooding within the Glennies Creek Floodplain. As discussed in **Section 4**, the levee would be constructed to 64m AHD and would provide 1.3m freeboard from the estimated 100 year ARI Hunter River flood level (*62.7m AHD*). The levee design is outside of the scope of this investigation. However, a preliminary assessment was undertaken by others which included the following features:

- The levee would be constructed in stages and would incorporate a 40m wide crest to accommodate a haul road. The extent of the levee at various stages of the mine life is documented in the life of mine plans which are presented in **Figure 17** through to **Figure 22**.
- Batters on the Glennies Creek side (*western side*) would be 1V to 3H and 1V to 2H on the mine side (*eastern side*).
- The levee would form part of the final landform.

A detailed design of the levee will be undertaken based on extensive geotechnical field testing at the detailed design phase.

7.2 Watercourse Re-establishment

With reference to **Figure 22**, it is proposed to reinstate Tributaries 2, 3 and 4 as part of the final landform rehabilitation. The following sections discuss the rehabilitation measures for each of the above tributaries.

7.2.1 Guidelines for Watercourse Re-establishment

The following principles will be applied, where practical, to all proposed watercourse reinstatements.

CHANNEL CONSTRUCTION

Where practical, the watercourse would incorporate a channel which meanders through a broader overbank region. The channel would have the capacity to convey the 1 to 2 year ARI flow, with higher flows conveyed as out of channel flow. A pool and riffle sequence would be incorporated into the reinstated channels. The pool and riffle sequence will allow the channels to mimic a more 'natural' creek regime while also reducing average channel bed slopes and thereby reducing peak flow velocities. The pools will also create opportunities for aquatic habitat.

It is anticipated that adequate channel stabilisation would be provided by riparian vegetation, however, engineered structures such as rock riffles would be considered at the detailed design stage.

Establishment of Vegetation

It is proposed revegetate all watercourses within the project area with native riparian vegetation, such as the Hunter Valley River Oak Forest. Planting on the reinstated watercourses will generally increase the riparian species diversity above the current diversity, which has been depleted by former land use practices (*i.e. clearing, cattle grazing and trampling*). A combination of native shrubs, herbs, native grasses and tree species specially selected, will be determined as part of the detail design. Examples of vegetation species that could be used (*but not limited to*) to create an appropriate varietal habitat within the reinstated watercourses, are listed in **Table 7-1**.

Table 7-1 – *Examples of vegetation species used in watercourse rehabilitation works*

Location	Species
Lower Banks	*Lomandra longifolia* *Phragmites Austraus* *Juncus Usitatus* Water Couch (*Paspalum distichum*) Swamp She-Oak (*Casuarina Glauca)* River She-Oak (*Casuarina cunninghamiana*)
Mid Banks	Prickle Leaved Paperbark (*Melaleuca styphelioides*) *Melaleuca thymifolia* *Melaleuca decora* Rough-barked Apple (*Angophora floribunda*) Acacia Floribunda *Shorthair Plumegrass* (*Dichelachne micrantha*)
Upper Banks	River Red Gum (*Eucalyptus camaldulensis*) *Eucalyptus Amplifolia*

A range of native grasses and trees are proposed for the in-channel bench and channel side-slopes (*refer **Figure 23***). The potential for erosion along the in-channel terrace is to be mitigated through the use of dense copse of deep-rooted tree species with soil binding characteristics. Dense tree coverage increases the thickness of the boundary layer over the bank, thereby reducing shear stresses acting on the surface of the bank during high flows. In addition, the trees would shade the watercourse, which is recognised as an effective means of controlling weeds such as blackberry, lantana and duck-weed.

MONITORING

Monitoring of each watercourse would be undertaken to assess the channel stability and the progress of the vegetation rehabilitation.

7.2.2 Tributary 2

With reference to **Figure 22**, the overburden emplacement area has been intentionally located to the south of the lower section of Tributary 2. However, the upper section would be disturbed by the construction of sediment dams SD2a and SD2b and will be reinstated once the dams are removed. Tributary 2 will drain catchment RH 3 (*53ha*), which will comprise rehabilitated overburden. The reinstatement of Tributary 2, will require the following measures:

- Inspection of the lower section of Tributary 2 to determine if any rehabilitation or channel improvement works are required.
- Removal of Sediment Dams SD 2a and SD 2b.
- Construction of up to 400m of creekline, which will be aligned adjacent to the overburden extent.
- Rehabilitation of the riparian corridor with native riparian vegetation.

7.2.3 Tributary 3

It is proposed to remove the ROM stockpile pad, dump station and conveyor as part of the mine closure plans. The ROM pad material will be used to fill the mine water drain located to the west of the levee. As a result, the eastern portion of the rehabilitated overburden area would drain into the remnant Tributary 3 channel, which would require reconstruction between the levee and the western extent of the ROM pad.

The reinstated Tributary 3 would have a contributing catchment area of approximately 71ha (*RH 2*), which would comprise rehabilitated overburden.

The reinstatement of Tributary 3 would require the levee to be lowered to prevent water ponding over the remnant pit shell.

7.2.4 Tributaries 4 & 5

One of the key elements of the final landform design is the re-establishment of a naturally draining overland flow path through the mining area. This is required to allow runoff from the upstream catchments (*CW1 and CW 2*) to freely discharge into Glennies Creek at the end of the mine life. The reinstatement of Tributaries 4 and 5 will require the following measures:

- Removal or significant size reductions of clean water dams CW1 and CW 2 as well as Sediment Dam SD1.
- Construction of approximately 600m of creek channel from clean water dam (CW1) to the edge of the eastern extent of the overburden emplacement area.
- Construction of approximately 600m of creek channel to divert Tributary 5 into Tributary 4, upstream of the overburden emplacement area. This would consolidate the creekline over the overburden stockpile to a single alignment, thus allowing for a more successful treatment in a more localised area.
- Construction of approximately 1300m of channel through the remnant mining area. This will require the construction of a creek channel across mine backfill, which is up to 110m deep in places. The proposed methodology is discussed in detail below in **Section 7.3**. Careful consideration of the proposed mitigation measures will be critical to the successful completion of this creekline reinstatement.
- Rehabilitation of all riparian corridors with native riparian vegetation.

Figure 22 locates the rehabilitation measures described above.

7.3 Settlement Assessment and Mitigation Measures

As outlined above, it is proposed to reinstate Tributary 4 across the mine backfill. The key risks in reinstating a creek across mine backfill are the potential for:

- settlement to lower the western end of the creek to below the natural surface of the land to the west of the pit.
- differential settlement to reverse the grade of the creek in some sections.
- settlement induced damage of the integrity of any low permeability liner that would subsequently limit the water holding capacity of the creek.

It is proposed to shape the reinstated channel during year 5 (2015) of the mining operation, but defer the construction of the creek until approximately 2020 to 2021. This will allow for a 2 to 3 year rehabilitation period prior to the mine closure. This staged construction methodology would allow approximately 5 to 6 years for the initial settlement to occur prior to the creekline construction. During this period, the settlement will be monitored on an annual basis to determine the rate of settlement and assist in the prediction of the long term settlement profile. As discussed above, the creek reinstatement would be undertaken approximately 2 to 3 years before mine closure to allow the rehabilitation to be established at the time of mine closure.

This section discusses the estimated potential range in vertical settlement of the mine backfill as well as mitigation and design measures that could be adopted to minimise the potential impact of settlement on the creek reinstatement.

7.3.1 Estimated Vertical Settlement

Figure 23 presents a longitudinal section of the proposed creek alignment, which indicates that the fill depth increases from negligible thickness on the eastern side of the pit shell to approximately 115m on the western side of the mine. As such, there will be a sharp transition between deep fill and unfilled areas on the western side of the pit shell.

It is assumed that the mine backfill will comprise primarily of silt, sand, gravel with some cobble and occasional boulders. Therefore primarily settlement of the fill under its own self weight would be expected to take place during construction. The three identified sources of settlement that could potentially occur subsequent to back filling are:

- Creep settlement of the main backfill under self weight due to particles getting closer together over time.
- Settlement of the fill due to water loading (*occurs when the water first flows down creek*).
- Collapse settlement of the fill due to water inundation or vibrations such as earthquakes or nearby blasting.

Details of the calculations of the above settling mechanisms were undertaken and are attached in **Appendix F**. The estimated minimum, maximum and expected settlements at the location of the deepest fill are summarised in **Table 7-2**. Estimates of settlement where fill is shallower have been made by proportioning settlement according to fill depth relative to maximum filled depth (*assumed 115m for calculations*). **Figure 23** plots the estimated maximum and expected profiles against the creek long section.

Table 7-2 - *Estimated settlements and possible mitigation measures*

Settlement Source*	Estimated Settlement**		
	Min.	Max.	Expected
Creep Settlement	1m	7m	2m
Creep Settlement after 6 years***	0.4m	3.1m	0.8m
Settlement of fill under water loading	0.1m	5m	2m
Collapse settlement[1]	0m	10m	7m

* Settlement likely to occur in localised areas

** Estimated settlement at location of deepest fill. Estimates of settlement where fill is less deep could be made by proportioning settlement according to fill depth relative to maximum filled depth (*assumed 115m for calculations*).

*** Linearly interpolated from the 8 year settlement calculations attached in **Appendix F**. This is considered conservative as the settlement has an exponential relationship to time (*i.e the rate of settlement reduces over time*).

LIMITATIONS

The above settlement calculations were undertaken to assess the feasibility of the reconstruction of the creek over the backfilled mine and allow incorporation of some of the features required into the concept design. The calculations were based on very limited geotechnical information and preliminary designs. Field tests should be undertaken, the assumptions checked and the calculations revised as part of subsequent design phases.

In particular, the calculations assumed that the mine backfill material comprises siltstones and sandstones, sand, silts and gravel with some cobble and occasional boulders and so it was assumed that the material will behave as a non-plastic fill. If there is significant clay in the backfill material, the calculations will need to be reviewed.

Settlement calculations are always an estimate and settlement of fill is very much case study based, so although the calculations can be refined when more accurate data is available, there is a risk that the actual settlements will vary from those calculated.

[1] Case study of colliery spoil in J A Charles and K S Watts, Building on fill: geotechnical aspects, BRE Centre of Ground Engineering and Remediation, 2nd ed. 2001, p50

7.3.2 Proposed Mitigation Measures

Settlement of the mine backfill is likely to be significant at the site. However, adoption of mitigation measures and amalgamation of design allowances for the settlement will significantly reduce the risk of settlement on the successful reinstatement of Tributary 4. Accordingly, the following mitigation measures will be considered at the detailed design stage:

- Settlement occurs as a function of time. With reference to **Table 7-2**, it is estimated that 60% of creep settlement would occur within six years from the fill being placed (*between 2015 and 2021*). Hence, the proposal to postpone full construction of the creek is likely to reduce the settlement impacts on the constructed creek.
- Construction of a haul road along the proposed alignment of the creek. If this option is adopted, the haul road alignment should be carefully surveyed so that it consistently follows the proposed creek alignment. If the haul road underlies only part of the creek alignment, differential settlements could occur between well compacted and poorly compacted areas.
- Providing a well compacted layer, such as a haul road, beneath the creek should form a 'bridging layer' to reduce the likelihood that small near-surface settlements would occur at the surface in the creek. However deeper larger settlements, particularly collapse settlements, may still result in larger areas of localised surface settlement. It is therefore suggested that the steeper creek grading is maintained to provide contingency for some localised settlement to occur without reversing the creek grade. In particular, at the western end of the creek there will be a transition between the deepest fill and unfilled areas and therefore there would be a greater risk of significant differential settlement affecting creek grade in this area. Consideration should therefore be given to steep grades in the creek in this area with the creek appropriately protected against scour.
- Consideration could be given to allowing the creek to flow prior to the earthworks being finalised (*e.g. gravity discharge from the clean water dams for extended periods to allow for water induced surface settlements to occur, prior to final working of the area, and compaction of the surface layer and liner*). This is likely to preload the area as well as remove some of the risk of collapse settlement due to infiltration. It should be noted that this should <u>not</u> be undertaken whilst the mining operation is ongoing without a thorough assessment of the potential impacts on pit stability. It is unpredictable where the infiltrated water could flow and the presence of water could result in instability of ongoing pit excavations.
- Carry out additional filling as settlement and depressions occur in the backfill. The additional filling should be compacted in layers as described above. Ideally, problem areas should have a thicker area of well compacted material prior to creek construction being finalised.

Other measures exist for deep fill improvement such as dynamic compaction or deep soil mixing with cement and lime. These measures could be considered if field testing indicates that settlements of the fill are too large to be designed out, but at this stage they are not recommended or considered further as it is expected that the cost would outweigh the benefit.

It is considered that with the mitigation measures listed above that the largest risk of settlement that is likely to remain is associated with collapse settlement due to vibration or water inundation, which could be triggered by an earthquake or blasting nearby. Collapse settlements may be able to be designed around or else some maintenance of the creek should be anticipated, particularly in the event of an earthquake.

In order to assess the settlement rate, it is recommended to survey the creek alignment on a yearly basis to develop an understanding of the actual settlement rates, as well as the change in settlement rate over time.

When Tributary 4 is reinstated in 2020 (*after approximately 5-6 years of settlement*), the following design measures are recommended:

- If required, reshape the creek alignment to amened any variation in landform resulting from settlement over the 6 year period. Depending on the degree of settlement, this may require substantial earthworks. Any filled material should be compacted using standard methods.
- Compact the upper 2m layer of the creek channel, and overbank area. It is expected that compaction could be achieved by placing fill in layers, moisture conditioning and compacting to minimum 95% Standard dry density ratio with moisture in the range of 85% to 115% of the standard optimum moisture content. Alternatively it is expected that an impact roller (*heavy roller with hexagonal or other straight-side wheel*) could create a 2m thick bridging layer from the surface.
- The creek should have a low permeability ‘liner’ directly underneath it to minimise surface infiltration of water which could result in collapse settlement. Ideally the liner would have a coefficient of permeability ‘k’ of not greater than 1 x 10^{-9}m/s commensurate with the EPA’s normal requirements for liners. However it is considered that a coefficient of permeability of close to this value (*i.e. 5 x 10^{-8}m/s*) would also be appropriate. It is possible that the mine backfill material, with boulders selectively removed, may be able to be compacted to meet this permeability requirement, subject to testing. Otherwise imported select clayey material would be suitable for a liner.

An indicative cross section of the reconstructed Tributary 4 is provided in **Figure 23**.

7.4 Dam Design

Proposed dam locations have been selected based on topographical trends and identified site constraints such as services, and environmental and heritage protection areas. In addition, the guiding strategy of the SWMP is to minimise the environmental footprint, especially within the Glennies Creek Floodplain. At the detailed design stage, each dam would be designed by a suitably qualified engineer (*e.g. hydrologic / hydraulic, geotechnical / structural*) in accordance with the relevant standards.

7.5 Surface Drainage

The surface drainage layout detailed in the life of mine SWMPs is an indicative design based on current best management practice. All surface drains would be constructed to safely convey a 100 year ARI design storm in accordance with best management practice.

8. SURFACE WATER IMPACTS AND MANAGEMENT METHODS

8.1 Flood Impacts

This section discusses the predicted flood impacts of the SEOC on both Glennies Creek and the Hunter River flood behaviour. This section should be read in conjunction with **Figure 13**, which identifies the predicted reduction in flood extents under developed conditions. It is noted that the identified flood impacts are the result of filling in the floodplain (*through the creation of a levee and a raised final landform*). Hence, the impacts would be considered permanent. However, it is noted that the ROM pad will be removed during the final rehabilitation stage of the SEOC project. This will partially mitigate the permanent displacement of flood water.

8.1.1 Flood Conveyance

As discussed in **Section 4**, the governing flood levels at the SEOC site are from backwater flooding during a Hunter River flood event. The back water flooding occurs because the Hunter River flood level is higher than the Glennies Creek Floodplain, resulting in water backing up into the Glennies Creek Floodplain. It is important to note that apart from Glennies Creek flow, there would be no Hunter River flow conveyance through the Glennies Creek Floodplain. Hence, the SEOC project is not expected to impact the Hunter River flood conveyance.

As indicated in **Figure 13,** the existing Glennies Creek 100 year ARI flood extent generally only infringes on the SEOC area at the inlets to the existing tributaries (*refer to the purple shading in **Figure 13***). The impact of the SEOC project on Glennies Creek flood conveyance was assessed using the HEC-RAS model that is discussed in detail in **Section 4**. The HEC-RAS model was modified by applying blockages at the extent of the proposed levee. Modelling predicted a maximum increase in flood levels of 30mm during a 100 year ARI Glennies Creek flood event. This minor increase is less than 100mm, which is recommended in the *Flood Plain Development Manual* as the threshold for defining an impact on flood conveyance. HEC-RAS results for the above model are attached in **Appendix C**. Accordingly, the SEOC pit is unlikely to impact the flood conveyance of Glennies Creek.

As the SEOC project will not impact the flood conveyance of Glennies Creek, the project will not adversely increase flood levels of flood velocities in the Township of Camberwell, and other upstream properties.

8.1.2 Flood Storage

Flood storage is classified as areas which are outside of the floodway (*area of significant flood conveyance*) and provide temporary storage of floodwaters during the passage of a flood. Flood storage areas are often aligned with floodplains and are usually characterised by deep and slow moving floodwater. Displacement of flood storage results in the loss of the natural attenuation capacity of the floodplain, which can result in a redistribution of floodwaters, an increase in flood levels or an increase in peak flows downstream of the site.

With reference to **Figure 13**, the SEOC development proposal requires the construction of a levee to the east of the Glennies Creek Channel. The levee would prevent floodwater from entering the SEOC area, which under existing conditions, would be inundated. This would result in a loss in flood storage. The volume of flood storage lost was estimated by calculating the volume under the displaced flood water using 12 CAD based software. The resulting displaced flood storage volumes for each Hunter River and Glennies Creek flood event are presented in **Table 8-1**. This is compared to the total flood storage in the Glennies Creek Floodplain for each flood event.

Table 8-1 – *Estimated loss of flood storage for the Glennies Creek and Hunter River flood events.*

Flood Event	Existing Flood Storage in Glennies Creek Floodplain* (ML)	Loss of Flood Storage (ML)	Loss of Flood Storage in the Glennies Creek Floodplain* (%)
Hunter River 100 Year	15,600	1,157	7.5%
Hunter River 20 Year	12,200	702	5.8%
Hunter River 5 Year	5,200	62	1.2%
Glennies Creek 100 Year	6,200	63	1.0%
Glennies Creek 20 Year	4,200	18	Less than 0.5%
Glennies Creek 5 Year	2,400	4	Less than 0.2%

* The term Glennies Creek Floodplain refers to the lower section of the floodplain represented in the HEC-RAS model (refer to **Figure 8**). This is extends from upstream of the Township of Camberwell to the confluence with the Hunter River.

As shown in **Table 8-1**, the SEOC would result in the loss of up to 7.5% of flood storage in the Glennies Creek floodplain during a 100 year ARI Hunter River flood event. The loss of flood storage, as a percentage of the total storage in the Glennies Creek floodplain, is reduced for the lower ARI events, as well as the Glennies Creek flood events. As discussed above, the ROM pad will be removed during the final rehabilitation stage of the SEOC project. This will reduce the permanent displacement of flood storage by approximately 200 ML during a 100 year ARI Hunter River flood event.

It is noted that the Glennies Creek Floodplain contributes only a small fraction of the total flood storage in the greater Hunter River Floodplain, which includes the over bank regions of the Hunter River as well as the lower flood plains of other tributaries such as Bowmans Creek. Hence, the loss of flood storage in the greater Hunter River Floodplain will be a fraction of a percent. Accordingly, the impact of the displaced flood storage on the flood behaviour of the Hunter River is likely to be insignificant.

8.1.3 Flood Evacuation Plan

In the case of a flood event occurring in either the Hunter River or Glennies Creek, the following emergency evacuation procedures would be implemented:

- Mining operations would be temporarily ceased if flood levels in either the Hunter River or Glennies Creek are expected to meet or exceed a safe water level. The safe water level will be determined as part of the detailed design of the levee system.
- In the event of an extreme flood, all personnel would evacuate to the infrastructure area, which is located above the estimated Glennies Creek Dam break flood level.

The levee system is to be thoroughly inspected and certified as adequate by a qualified engineer after any flood event prior to mining operations recommencing.

8.1.4 Impact of Climate Change

The two major anticipated flood impacts as a result of climate change are the rise in sea levels and an increase in rainfall intensities. Considering the project locality, the impacts from sea level rise would not influence flooding within the SEOC site. The anticipated increase in rainfall intensities are also not considered applicable to the flood assessment as operations are expected to be complete by 2023, which is before the effects of climate change are likely to be realised.

8.2 Water Quality

8.2.1 Sediment

The construction and operation of the SEOC project has the potential to impact on water quality within Glennies Creek and the Hunter River through export of sediment from the site. Accordingly, a range of sediment and erosion controls are proposed as part of the Surface Water Management Plan (*refer to **Section 5***) to address this potential impact.

All sediment control ponds within the site have been sized to retain a 20 year ARI, 12 hour storm volume. Runoff collected in the dams would generally be re-used in the mining operation. Hence, overflow from the dams would only occur during extended periods of heavy rainfall, such as events greater than 20 year ARI, 12 hour storm duration.

It is considered that with the proposed sediment control measures in place, the SEOC project is unlikely to adversely impact the water quality in Glennies Creek and downstream systems.

8.2.2 Salinity

All mine water collected in the bottom of the pit and from surface runoff from any areas where coal is transported or processed (*i.e haul roads, and stockpile areas*) is likely to contain elevated levels of salts. Accordingly, it is proposed to store and reuse all mine water generated on site. The water balance modelling documented in **Section 6**, demonstrated that there would be no mine water discharge from the site. It is therefore unlikely that the SEOC will adversely impact the salt levels in Glennies Creek and downstream systems.

8.2.3 Watercourse Impacts

An assessment of the existing environment identified six tributaries to Glennies Creek within the study area. The existing state of these watercourses is documented in **Section 3.3.3**. The following sections outline the anticipated impacts on the six tributaries in medium term (*i.e during mining operations*) and the long term (*i.e post rehabilitation*).

Tributary 1

Tributary 1 is located to the north of the disturbance area and as such, would not be directly impacted by the SEOC operation.

Tributary 2

The SEOC footprint was intentionally positioned to avoid direct disturbance of the lower portion of Tributary 2. However, the upper section of Tributary 2 would be disturbed in the initial year of the mining operation. Sediment Dams SD2a and SD2b would be constructed online and would capture the majority of the catchment runoff. When the contributing catchment is rehabilitated, SD2a and SD2b would be removed, and the creek channel would be reinstated. The reinstated channel would be designed to mimic a typical ephemeral watercourse and would include the rehabilitation of native riparian vegetation.

Considering the existing tributary is currently disturbed by cattle grazing, and has little riparian vegetation, the long term impact of the disturbance of Tributary 2 is expected to be minimal.

Tributary 3

Tributary 3 would be disturbed in the initial year of mining by the construction of the ROM pad, levee as well as the open pit. With reference to **Figure 22**, the western portion of the rehabilitated overburden will drain into the existing Tributary 3 channel. During the mining operation, a diversion drain will direct all flow from this catchment into the open pit. When the ROM pad is decommissioned as part of the mine closure, the levee would be lowered and overland flow will be returned to the Tributary 3 channel. The area disturbed by the ROM pad will be fully rehabilitated, and the lower section of Tributary 3 will be reinstated. The reinstated channel would be designed to mimic a typical ephemeral watercourse, including pool and rifle sequences and the rehabilitation of native riparian vegetation.

Given the level of disturbance, it is unlikely that the upper section of Tributary 3 can be reinstated to its existing condition. However, the lower section of Tributary 3 (*downstream of the levee*) will be reinstated to form a natural creek. Considering the existing water course is currently disturbed by cattle grazing and has little riparian vegetation, it is likely that the rehabilitated lower section of Tributary 3 will be an improvement to the existing watercourse.

Tributary 4

Tributary 4 is the largest watercourse (*apart from Glennies Creek*) in the study area. As discussed in **Section 3.3.3**, the upper and middle portions of the watercourse are currently in good condition, with established riparian vegetation and good channel integrity. The lower section of Tributary 4 is moderately degraded with little riparian vegetation and a moderately incised channel.

The SEOC project will disturb the middle and lower sections of Tributary 4. The upper section will be largely undisturbed. The key impacts will be the construction of a clean water dam and other infrastructure in the middle section, and the open cut pit in the lower section. As part of the rehabilitation plans, the middle section would be rehabilitated by removing or reducing the size of the clean water and sediment dams, and reinstating a naturalised channel. The reconstructed channel would be designed to mimic a typical ephemeral watercourse, including pool and rifle sequences and the rehabilitation of native riparian vegetation.

The lower portion of the creek would be required to traverse the mine backfill area. As discussed in **Section 7.3**, the possible settlement of the mine backfill creates a risk that the reinstated creek will not hold water as well as the possibility of differential settlement may result in a negative grade in some sections. As such, the creek reconstruction will be delayed until the final rehabilitation stage, which will facilitate 5 to 6 years of pre-settlement to occur. However, a temporary channel will be constructed when the overburden is shaped in Year 6. Other mitigation measures recommended in **Section 7.3** would further reduce the risks.

The provision of a naturally draining flow path through the rehabilitated overburden area would be considered a desirable outcome as it would allow stream flows from both Tributary 4 and 5 catchments to naturally discharge into Glennies Creek. The reinstated Tributary 4 channel will include a fully vegetated riparian corridor and constructed channel designed to withstand moderate levels of long-term settlement. As such, it is likely that the resulting watercourse will have a similar, if not improved, environmental function to the existing lower section of Tributary 4 that is considered to be moderately degraded.

Tributary 5

Similarly to Tributary 4, the lower and middle section of Tributary 5 would be disturbed by the mining operation in approximately year 4. In order to reduce the length of creek line over the overburden material, it is proposed to permanently divert Tributary 5 channel into the proposed reinstated Tributary 4 channel, upstream of the pit shell. This will reduce the risks associated with the establishing creeks over overburden material and allow the rehabilitation efforts to focus on the Tributary 4 alignment.

The section of Tributary 5 upstream of the pit, and the proposed diversion, would be fully rehabilitated. However, it is difficult to construct a naturalised creek system (*i.e with both channel and overbank flow*) in a diversion drain which is not aligned in the bottom of a valley.

As Tributary 5 will not be fully restored, there would be a permanent loss of part of a watercourse.

Tributary 6

Tributary 6 is located to the south of the disturbance area and as such, would not be directly impacted by the SEOC operation.

Glennies Creek

The impact of the on the Glennies Creek Channel and alluvium, is documented separately the Geomorphology Assessment (*WorleyParsons, 2009*).

8.3 Predicted Changes to Streamflow

The water balance modelling documented in **Section 6** estimated the anticipated changes in stream flows as a result of the proposed development. The predicted changes to annual stream flow in Year 3, Year 7 and the post mining period for average and 10th, 50th and 90th percentile rainfall years are presented in **Table 6-8**. This data is compared to the observed stream flows in Glennies Creek recorded at Middle Fal Brook stream gauge. As detailed in **Table 6-8** the predicted temporary changes to stream flow are in the order of 0.8% of the total flow in Glennies Creek in an average rainfall year. As such, this small reduction is not expected to adversely affect any downstream license holder or the ecological function of Glennies Creek or the Hunter River.

It is proposed to seek licences to harvest water from the undisturbed catchments upstream of the site and any additional water extraction requirements. It is understood that the collection and re-use of surface runoff from the proposed disturbance area is exempt from licensing under the *Water Management Act* as the intent of the surface water management plan is to prevent the contamination of a water source.

9. CUMULATIVE IMPACTS

The key potential cumulative surface water impacts of the SEOC project are:

- The overall demand for water in the Hunter River and Glennies Creek systems.
- The potential for landuse practises to result in greater sediment generation and deposition in the Hunter River and Glennies Creek.
- The potential for increased salt loads in the Hunter River and Glennies Creek.

The water required to meet operational needs of the project will be sourced from collecting runoff from within the mining operation area as well as licensed harvesting of runoff from undisturbed areas draining into the SEOC project area. Additional water will be sourced through licensed extraction from the Hunter River and Glennies Creek. The licensing framework and water sharing plans regulate the overall water demands in the both the Hunter River and Glennies Creek and as such address the cumulative impacts of the various water demands. Accordingly, compliance with the license conditions would ensure that the cumulative impacts of water extraction and harvesting are adequately managed.

With reference to **Section 3.4**, the baseline water quality monitoring undertaken by ACOL indicates that TSS levels are within the normal range expected in a healthy river system, with average TSS levels less than 20mg/l (*Australian Runoff Quality, IEAust, 2005*). In addition, the baseline water quality indicates that the salinity levels in Glennies Creek are similar to those observed at the NSW State Water stream gauge at Middle Fal Brook and are within the target salinity levels outlined in *The Integrated Catchment Management Plan for the Hunter River*. There are currently two mining operations between the ACOL sampling locations and the Middle Fal Brook stream gauge. These are the Integra mining complex (*which incorporates both open pit and underground mining operations*) and the existing ACOL open cut mine. The monitoring results presented in **Section 3** of this report indicate that there is no obvious increase in salinity levels as a result of these mining operations. This indicates that the surface water management methods employed at these mines are effective in mitigating the potential water quality impacts of mining. As such, the ACOL data indicates there is no definitive cumulative impact of mining operations on the water quality in Glennies Creek.

With consideration of the baseline monitoring results discussed above, and the proposed surface water management controls, it is likely that the SEOC project would not exacerbate the cumulative impact of land use practises on the water quality in Glennies Creek or its receiving water, the Hunter River.

10. MONITORING AND REPORTING PROCEDURES

10.1 Surface Water Monitoring

As discussed in **Section 3.4**, ACOL have an ongoing water quality monitoring programme. Monitoring commenced in September 2004 and is currently ongoing. To date, this monitoring programme has established a comprehensive data set of the baseline water quality trends in both Glennies Creek and the Hunter River. With reference to **Figure 5**, the existing monitoring programme incorporates fourteen (*14*) sampling locations, including three (*3*) within in Glennies Creek and five (*5*) in the Hunter River. The existing Glennies Creek sampling locations are upstream, adjacent and downstream of the SEOC. The downstream location is immediately upstream of the confluence of the Hunter River, approximately 2km downstream from the SEOC.

The existing monitoring program involves:

- Weekly sampling at Bowmans Creek monitoring stations (*SM1, SM2, SM3, SM4*) as well as the process water dam.
- Monthly sampling of all monitoring stations and onsite dams (*sediment dams and select clean water dams*).
- Monthly extended sampling of Bowmans Creek site SM4.
- Comprehensive sampling of both onsite dams and monitoring stations on an annual basis.

It is proposed to continue the current monitoring programme with an additional sampling location located immediately downstream of the SEOC (*refer* ***Figure 5***). **Table 10-1** details the proposed monitoring schedule, which is consistent with the existing schedule.

Table 10-1 - *Monitoring Schedule*

Parameter	Weekly (*Bowmans Creek Only^*)	Monthly (Onsite Dams only)	Monthly All Surface Water Stations (* = SM4 only)	Annual Comprehensive Testing
pH	✓	✓	✓	✓
Electrical Conductivity	✓	✓	✓	✓
Non-filterable Residue	✓	✓	✓	✓
Oil & Grease	✓		✓	✓
Total Dissolved Solids	✓	✓	✓	✓
Turbidity			✓*	✓
Hardness	✓	✓	✓	✓
Calcium			✓*	✓

Parameter	Weekly (*Bowmans Creek Only*^)	Monthly (Onsite Dams only)	Monthly All Surface Water Stations (* = SM4 only)	Annual Comprehensive Testing
Magnesium			✓*	✓
Sodium			✓*	✓
Potassium			✓*	✓
Sulphate			✓*	✓
Bicarbonate			✓*	✓
Carbonate			✓*	✓
Chloride			✓*	✓
Nitrates			✓*	✓
Ammonia			✓*	✓
Iron (total & dissolved)			✓*	✓
Manganese			✓*	✓
Arsenic			✓*	✓
Barium			✓*	✓
Boron			✓*	✓
Cadmium			✓*	✓
Chromium			✓*	✓
Copper			✓*	✓
Nickel			✓*	✓
Lead			✓*	✓
Zinc			✓*	✓
Mercury			✓*	✓
Selenium			✓*	✓
Fluoride			✓*	✓
Total Petroleum hydrocarbons			✓*	✓
Polycyclic Aromatic Hydrocarbons			✓*	✓

^ Weekly monitoring undertaken at SM1, SM2, SM3 and SM4

The monitoring and reporting program will be continued during both the construction, operational and rehabilitation phases of the SEOC project. All monitoring results will be reported annually in a written report that presents and analyses all results. All monitoring data will be retained in an appropriate database that will be available to relevant authorities at request.

In addition to water quality sampling, ACOL would continue to:

- Monitor all key water movements around the mine site. Monitoring will be recorded on a minimum monthly basis or following significant rainfall events.
- Monitor dam storage levels. Dam levels will be surveyed on a monthly basis and following significant rainfall events.
- Maintain and operate the ACOL weather station.

10.2 Operational Requirements

In addition to the monitoring requirements described above, the following routine inspections will be undertaken:

- Inspection of all dams, drains and culverts on a monthly basis and following significant rain.
- Inspection of rehabilitation areas on a monthly basis and following significant rain.

The following routine maintenance would be undertaken:

- Removal of accumulated sediment from dams and drains as required.
- Enhancement of underperforming rehabilitation areas as required.
- Repair and installation of erosion control measures as required.
- Inspection and maintenance of the wastewater management system.
- Inspection and maintenance of the sediment chamber and oil and grease trap treating runoff from the hardstand area.

10.3 Contingency Measures

If unforeseen or unacceptable levels of impact are identified, the following contingency measures would be implemented:

- Increased monitoring frequency and sampling points to identify and confirm the source of any suspected degradation to water quality.
- Review the SWMP in order to identify opportunities to improve or rectify any identified problem. The data collected as part of the monitoring programme will enable fully informed decisions to be made.
- If any component of the surface water management framework is identified as creating an unacceptable environmental impact, remedial actions will be established in close liaison with the relevant authority.

11. CONCLUSION

This report presents the results of the surface water assessment of the proposed South Eastern Open Cut (*SEOC*) Coal Mining Project. This assessment was undertaken by WorleyParsons on behalf of Ashton Coal Operations Pty Ltd (*ACOL*).

The SEOC site is located in the Hunter Valley approximately 15km north-west of Singleton and approximately 2.5km to the south-east of the existing Ashton Coal Mine. The New England Highway forms the north-eastern boundary of the site and Glennies Creek defines the western boundary.

The SEOC will produce up to 2.4 Million tonnes per annum (*Mtpa*) of coal product from a proposed annual extraction of 3.6Mtpa of Run of Mine (*ROM*) coal over a 7 year mine life. This will supplement the proposed 5Mtpa of ROM coal produced from the existing underground operation. ACOL seeks to modify the current approval to mine and process up to 5.2Mtpa of ROM Coal, to an annual rate of up to 8.6Mtpa.

The objective of this report is to provide sufficient information on the existing state of the surface water environment within the SEOC project area and the immediate surrounds, and to assess the potential impacts of the project on the surface water environment. The surface water assessment includes the following key components:

- **Flood Assessment**- Assessment of both the Glennies Creek and Hunter River flood behaviour at the subject site and the immediate surrounds.
- **Water Management Assessment** – Assessment of the existing water quality and quantity and the development of a surface water management plan for the life of the SEOC operation.
- **Watercourse Assessment** – An assessment of the existing watercourses within the SEOC project area and establishment of the watercourse rehabilitation requirements.

It is noted that stream geomorphology and hydrogeology assessments are documented in separate reports.

11.1 Flood Assessment

The SEOC site is located within historic flood extents of both Glennies Creek and the Hunter River. In order to determine the governing flood behaviour at the subject site, a detailed assessment of the Glennies Creek hydrology and floodplain hydraulics was undertaken. Historic flood levels observed during the 1955 Hunter River flood event were used to estimate the potential Hunter River flood levels at the SEOC site.

A hydrologic model of the Glennies Creek catchment was developed to predict discharge hydrographs adjacent to the SEOC over a range of storm events. The model was calibrated using recorded rainfall depths and stream gauging from two storm events. A sensitivity analysis was undertaken to determine the hydrologic impact of the Glennies Creek Dam. This assessment indicated that the dam would reduce the peak 100 year ARI discharge adjacent to the SEOC by approximately 27% to 32% depending on the level of the dam at the beginning of a storm event. Hydrologic modelling predicted that the peak discharges at the SEOC site for the 5 year, 20 year and 100 year Average Recurrence Interval (*ARI*) storm events would be 237m^3/s, 459 m^3/s and 834m^3/s respectively.

The SEOC site is affected by both Glennies Creek flooding and backwater flooding during Hunter River flood events. The Glennies Creek flooding was assessed using a flood hydraulics model (*HEC-RAS*). The model extended from the Township of Camberwell to the confluence with the Hunter River. Historic flood levels provided by *The Department of Water and Energy* at the Glennies Creek confluence during the 1955 flood event were adopted as the Hunter River 100 year ARI flood level.

The flood assessment concluded that Hunter River backwater flooding governs flood levels at the SEOC site. The resulting 100 year ARI flood level at the site is estimated to be 62.7m AHD. As this flood level would occur from backwater flooding, there would be negligible variation in the flood level across the SEOC site. A conservative flood planning level of 64m AHD is proposed for the SEOC. This flood planning level applies an additional 1.3m freeboard to the predicted 100 year ARI flood level.

It is proposed to construct a levee along the western extent of the SEOC project to prevent the ingress of floodwater into the mining operation. This levee would have a minimum crest elevation of 64m AHD.

11.2 Surface Water Management

A Surface Water Management Plan (SWMP) was developed for the life of the mine. The SWMP includes the following key features:

- Runoff from undisturbed catchment areas upstream of the SEOC will be collected in two clean water dams. The collected water will be used in the mining operations. Any excess clean water will be pumped directly into Glennies Creek.

- Sediment laden runoff from disturbed and rehabilitated areas will be collected in four sediment retention basins that will be sized to retain all runoff during a 20 year ARI, 12 hr duration storm event. All collected water will be used in the mining operation.

- Runoff from the open pit, haul roads, ROM storage areas and some rehabilitated overburden areas will be directed into the SEOC pit. Collected mine water will be reused in the mining operation. In the event of a major storm event, the SEOC pit is likely to be partially flooded. Following a major storm event, captured water would be pumped to the final void of the existing ACOL open cut pit which would provide temporary storage until the excess water can be used in the mining operation.

- All waste water generated onsite would be treated using an aerated wastewater treatment system. Treated effluent would be disposed through irrigation of landscaped areas surrounding the infrastructure area.

A site water balance was developed for the existing ACOL operation. The water balance was calibrated using 18 months of data collected by ACOL. The calibrated water balance was then expanded to include the SEOC proposal and assessed the proposed surface water management for the ACOL operation holistically (*i.e including both the existing operation and the SEOC project*). The water balance was used to assess the drought security of the operation and the capacity to manage large volumes of runoff during major storm events. The following key conclusions were derived:

- The ACOL operation is likely to have sufficient water during above average rainfall years, possible minor water shortages during average rainfall years and is likely to experience shortages of varying levels of severity during below average rainfall years.

- There is sufficient storage to contain all mine water generated during a major storm event such as a 100 year ARI event.

11.3 Watercourse Assessment

There are six (6) unnamed tributaries to Glennies Creek located within the project area. These water courses are all ephemeral and range in size from first order to second order streams. The upper sections of the watercourses are generally in good condition. The middle and lower sections are generally moderately degraded with limited riparian vegetation and evidence of channel erosion in places. Four of the watercourses will be disturbed by the mining operation.

The final landform will be free draining with the exception of the final void, which will have an estimated 37ha footprint. It is proposed to reinstate three watercourses within the project area. This will involve the establishment of naturalised creek channels and the revegetation of the riparian zone with native riparian vegetation.

In order to maintain a freely draining landform, one of the reinstated watercourses will be aligned across mine backfill, which will be up to 110m deep in places. Accordingly, there is a risk that settlement of the mine backfill could potentially alter the creeks design grades and reduce its water holding capacity. A range of mitigation measures are proposed to reduce this risk, these include:

- Delaying the final creek construction by approximately 5 to 6 years to allow for pre-settlement to occur. It is estimated that over 60% of total creep settlement would occur in this timeframe.
- Construction of a haul road along the proposed alignment of the creek to increase the level of compaction of the mine backfill in the vicinity of the proposed creek alignment.

11.4 Predicted Surface Water Impacts

The following key surface water impacts have been identified:

- The SEOC project would result in the loss of up to 7.5% of flood storage in the Glennies Creek Floodplain during a 100 year ARI Hunter River flood event. However, it is noted that the Glennies Creek Floodplain contributes only a small fraction of the total flood storage in the greater Hunter River Floodplain, which includes the over bank regions of the Hunter River as well as the lower flood plains of other tributaries such as Bowmans Creek. Hence, the loss of flood storage in the greater Hunter River Floodplain will be a fraction of a percent. Accordingly, the impact of the displaced flood storage on the flood behaviour of the Hunter River is likely to be insignificant.
- It is considered that with the proposed water management control measures in place, the SEOC project is unlikely to adversely impact the water quality in Glennies Creek and downstream systems.
- The SEOC project would temporarily disturb four identified watercourses, which are unnamed tributaries of Glennies Creek. The final landform will incorporate the reinstatement of three of these watercourses. Sections of watercourses reinstated outside of the overburden emplacement will be rehabilitated to form naturalised ephemeral watercourses. The provision of a naturally draining flow path through the rehabilitated overburden area is considered a desirable outcome as it would allow stream flows from upstream catchments to continue to naturally drain into Glennies Creek. The reinstated channel will include a fully vegetated riparian corridor and a constructed channel designed to withstand moderate levels of long-term settlement. Revegetation of the reinstated watercourses will generally increase the riparian species diversity above the current diversity, which has been depleted by former land-use practices (*i.e. clearing, cattle grazing and trampling*). As such, it is likely that the reinstated watercourse will have a similar, if not improved, net environmental function when compared to the existing watercourses.

- The predicted average annual loss in Glennies Creek stream flow will be approximately 330 ML/year during the initial 4 years of mining (*2010 to 2014*) and 450 ML/year during the final 3 years of mining and the 6 year rehabilitation period (*2015 to 2023*). A reduction of 450 ML/year is equivalent to 0.8% of the average annual Glennies Creek flow. The final void will encompass an estimated 37ha area which will not be free draining to Glennies Creek, and therefore will result in a minor permanent loss in stream flow that is estimated to be approximately 34ML in an average year. This is equivalent to approximately 0.06% of the average annual Glennies Creek stream flow.

11.5 Monitoring and Contingency Plans

ACOL have an ongoing water quality monitoring programme which commenced in September 2004. This monitoring programme incorporates 14 sampling locations, including three within Glennies Creek and 5 in the Hunter River. It is proposed to continue the existing monitoring programme and include an additional sampling location immediately downstream of the SEOC project area. Monitoring will be undertaken on a monthly basis. In addition ACOL will continue to monitor internal water quality and water movements.

If unforeseen or unacceptable levels of impact are identified, the following contingency measures would be implemented:

- Increased monitoring frequency and sampling points to identify and confirm the source of any suspected degradation to water quality.

- Review the SWMP in order to identify opportunities to improve or rectify any identified problem. The data collected as part of the monitoring programme will enable fully informed decisions to be made.

- If any component of the surface water management framework is identified as creating an unacceptable environmental impact, remedial actions will be established in close liaison with the relevant authority.

12. REFERENCES

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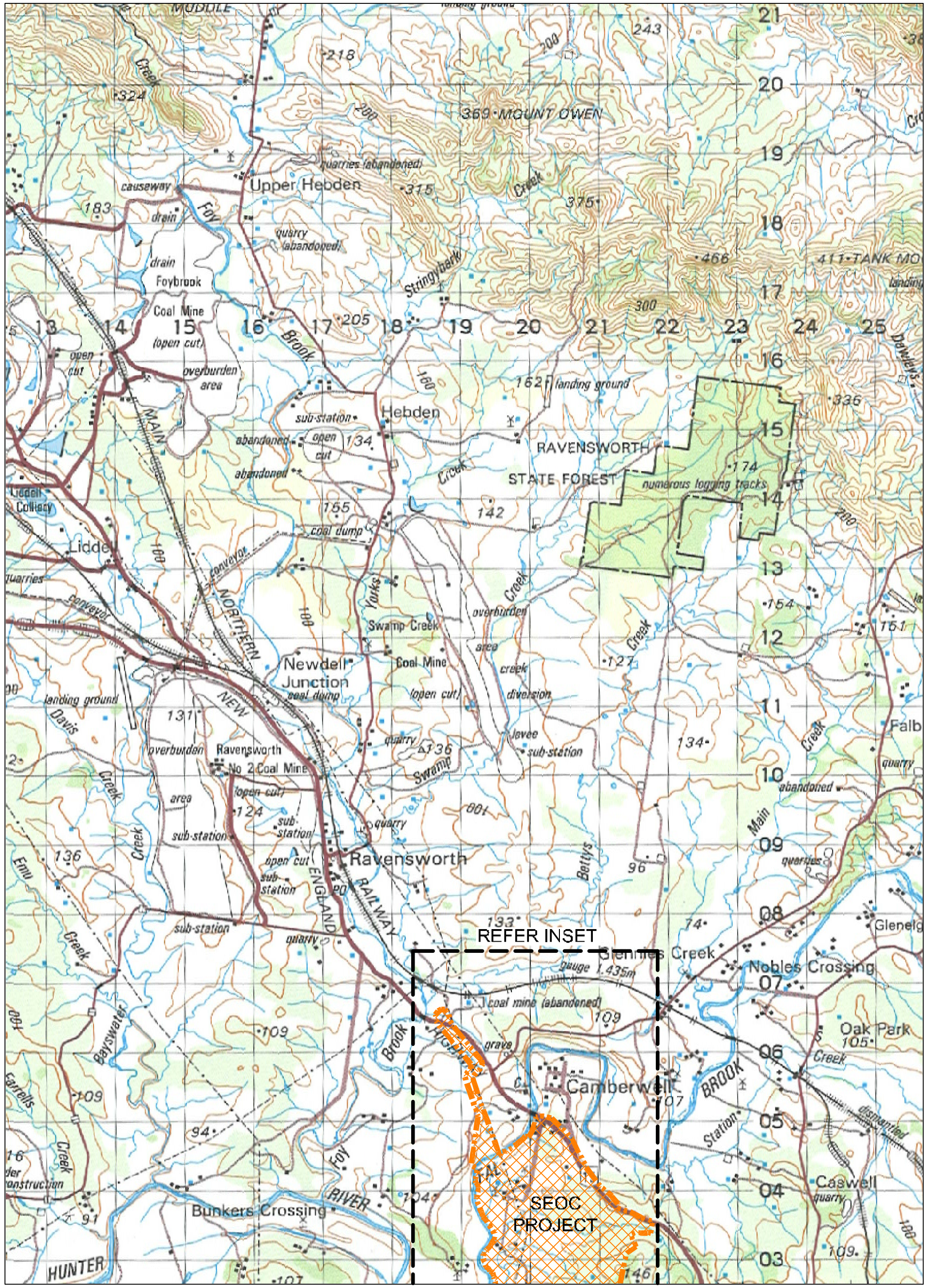
FIGURE 1



PLAN
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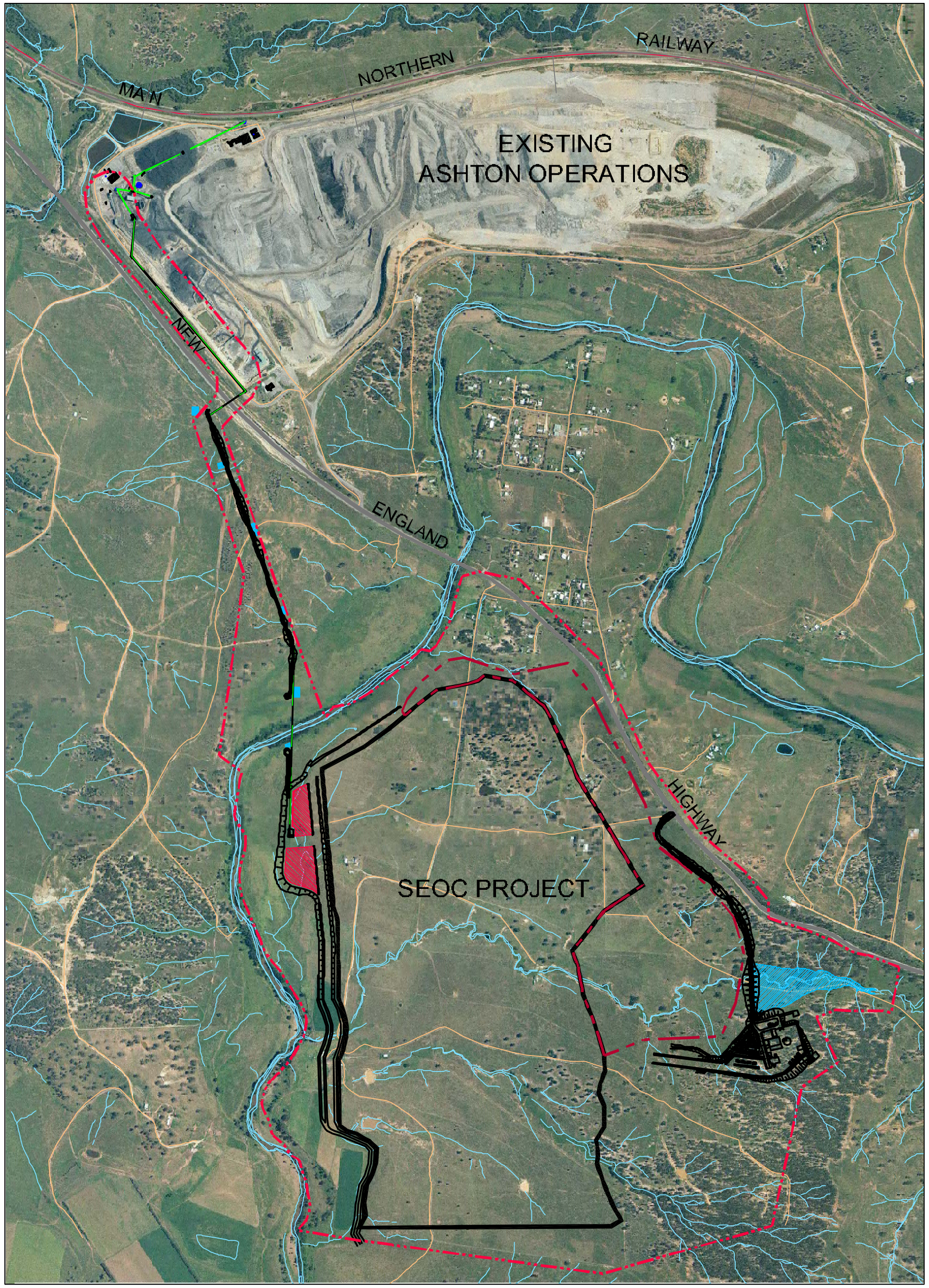

INSET
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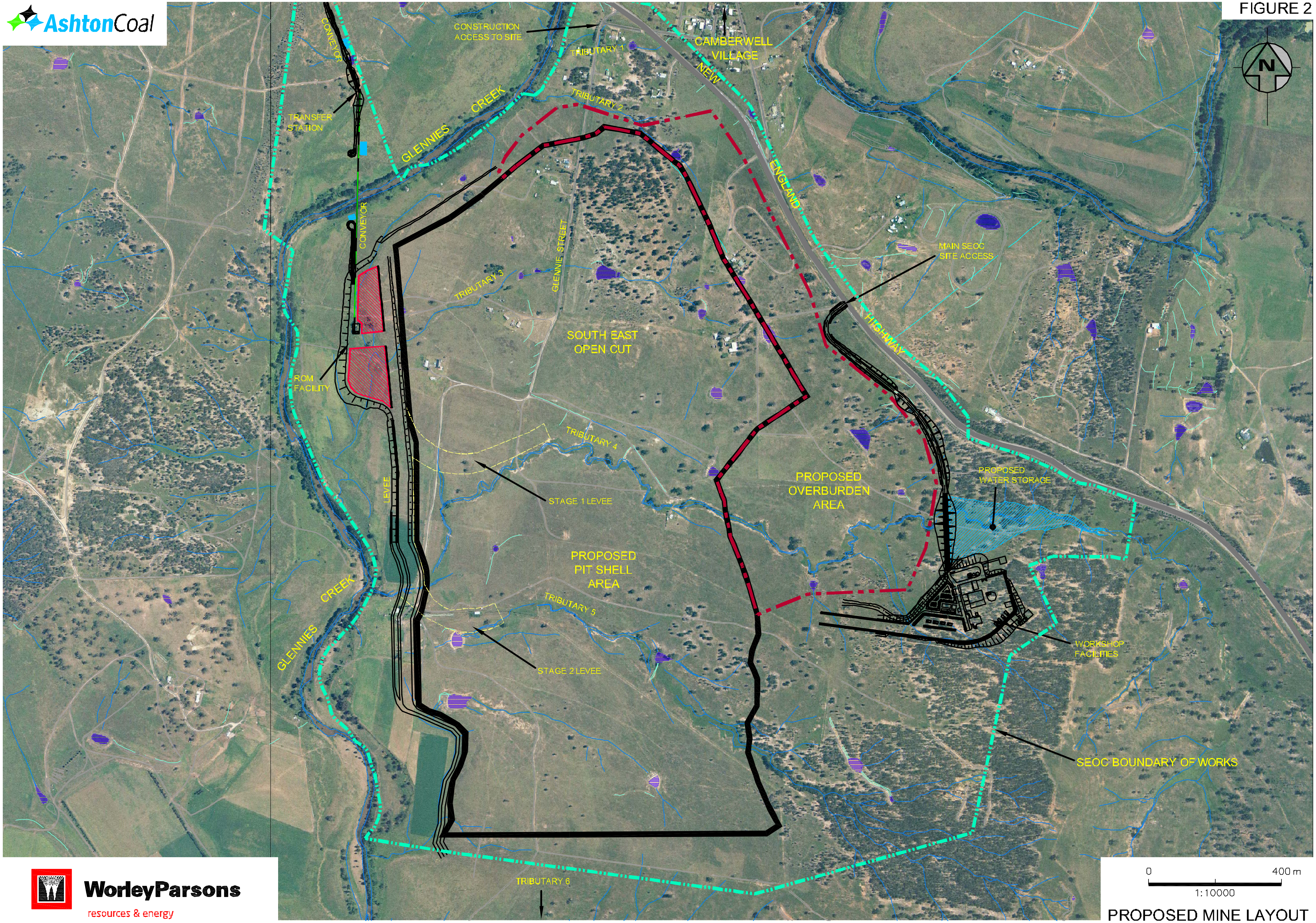
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 1 SITE LOCALITY.dwg 22/07/2009

SITE LOCALITY

FIGURE 2



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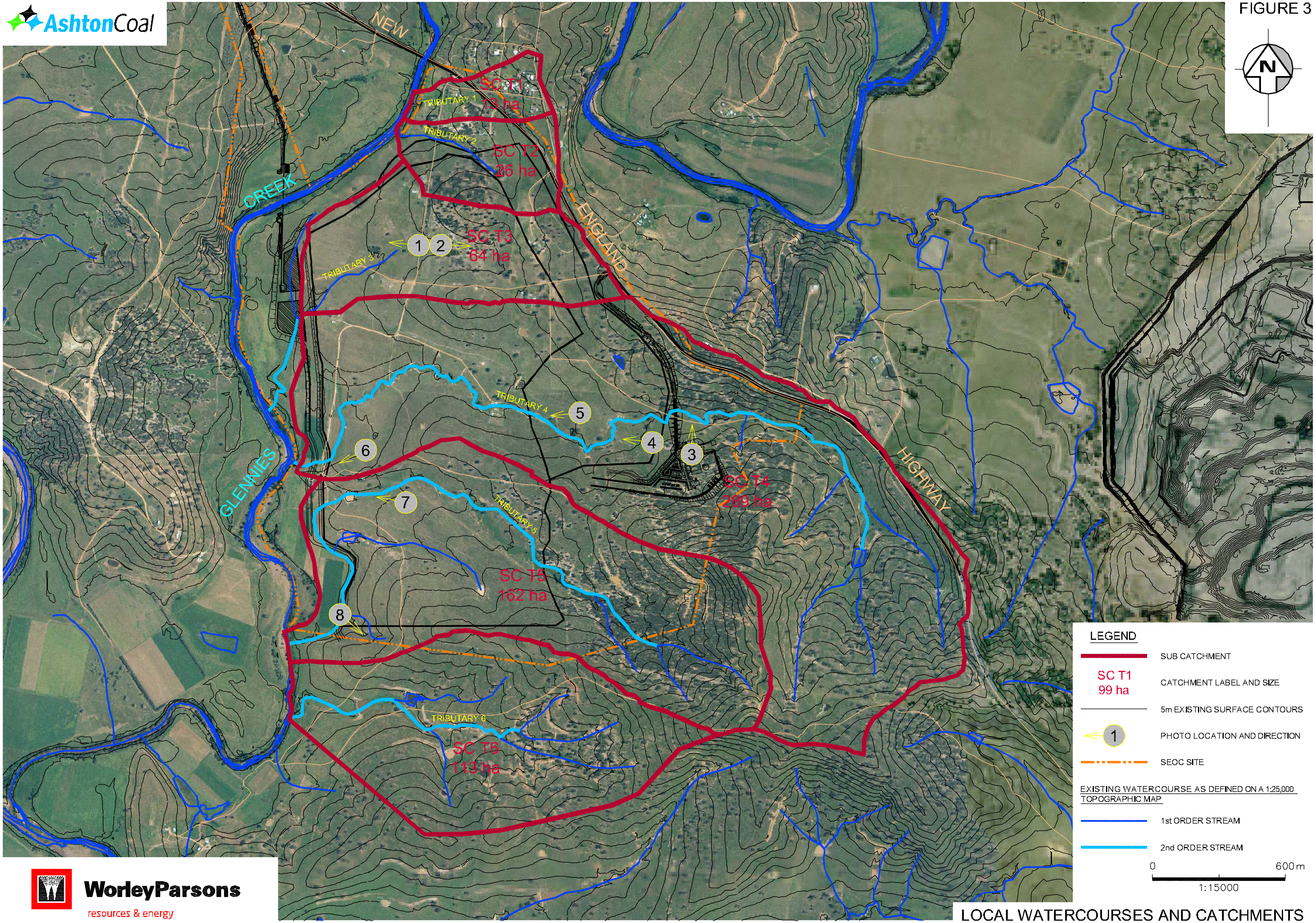
PROPOSED MINE LAYOUT

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 2 PROPOSED MINE LAYOUT.dwg 22/07/2009

FIGURE 3



LEGEND

	SUB CATCHMENT
SC T1 99 ha	CATCHMENT LABEL AND SIZE
	5m EXISTING SURFACE CONTOURS
1	PHOTO LOCATION AND DIRECTION
	SEOC SITE

EXISTING WATERCOURSE AS DEFINED ON A 1:25,000 TOPOGRAPHIC MAP

	1st ORDER STREAM
	2nd ORDER STREAM

0 600m
1:15000

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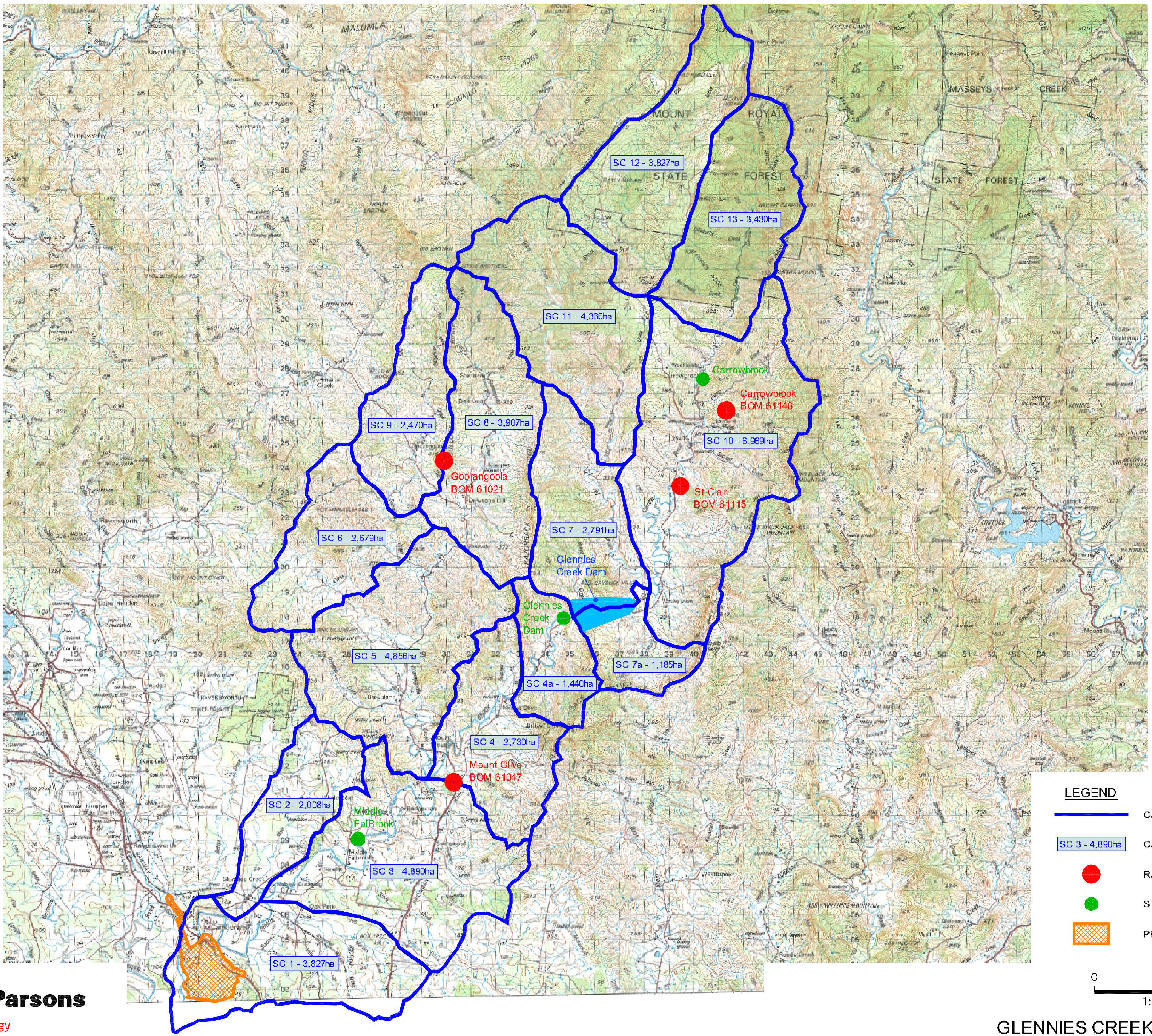
LOCAL WATERCOURSES AND CATCHMENTS

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 3 LOCAL WATERCOURSE AND CATCHMENTS.dwg 22/07/2009

FIGURE 4



GLENNIES CREEK CATCHMENTS

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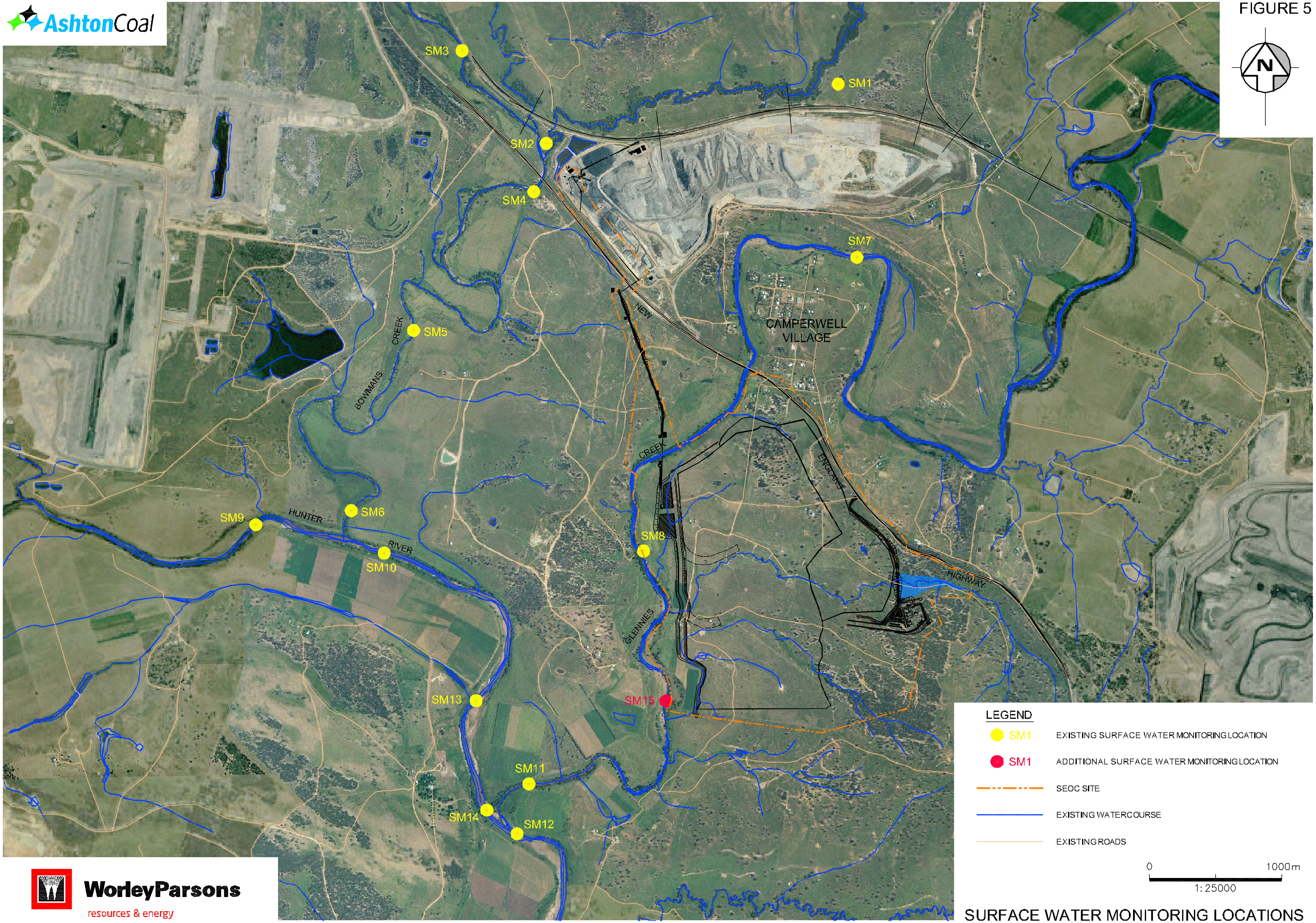
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 4 GLENNIES CREEK CATCHMENT.dwg 22/07/2009

FIGURE 5



LEGEND

- SM1 EXISTING SURFACE WATER MONITORING LOCATION
- SM1 ADDITIONAL SURFACE WATER MONITORING LOCATION
- SEOC SITE
- EXISTING WATERCOURSE
- EXISTING ROADS

0 1000m
1: 25000

SURFACE WATER MONITORING LOCATIONS

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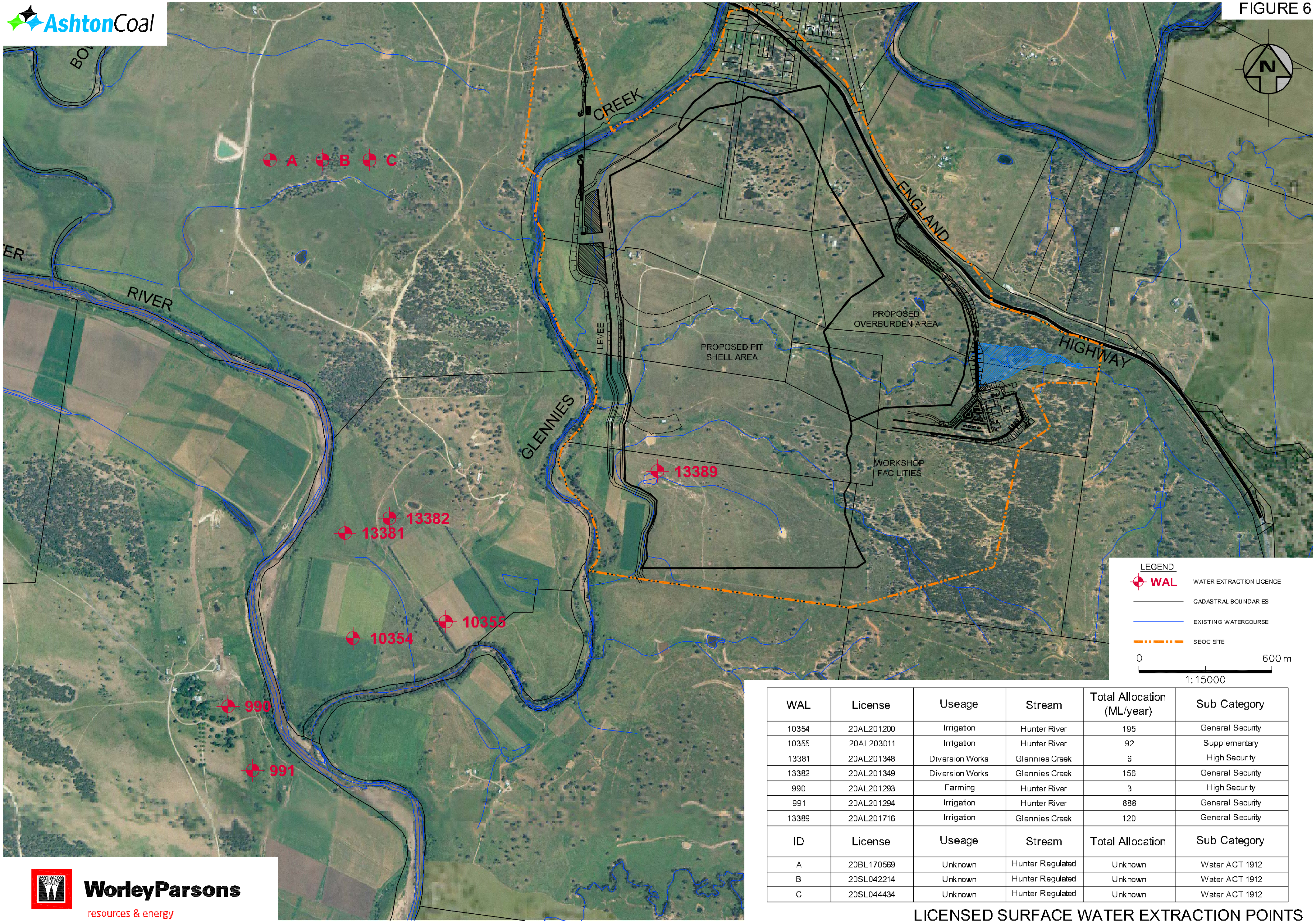
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 5 SURFACE WATER MONITORING LOCATIONS.dwg 22/07/2009

FIGURE 6



WAL	License	Useage	Stream	Total Allocation (ML/year)	Sub Category
10354	20AL201200	Irrigation	Hunter River	195	General Security
10355	20AL203011	Irrigation	Hunter River	92	Supplementary
13381	20AL201348	Diversion Works	Glennies Creek	6	High Security
13382	20AL201349	Diversion Works	Glennies Creek	156	General Security
990	20AL201293	Farming	Hunter River	3	High Security
991	20AL201294	Irrigation	Hunter River	888	General Security
13389	20AL201716	Irrigation	Glennies Creek	120	General Security
ID	**License**	**Useage**	**Stream**	**Total Allocation**	**Sub Category**
A	20BL170569	Unknown	Hunter Regulated	Unknown	Water ACT 1912
B	20SL042214	Unknown	Hunter Regulated	Unknown	Water ACT 1912
C	20SL044434	Unknown	Hunter Regulated	Unknown	Water ACT 1912

LICENSED SURFACE WATER EXTRACTION POINTS

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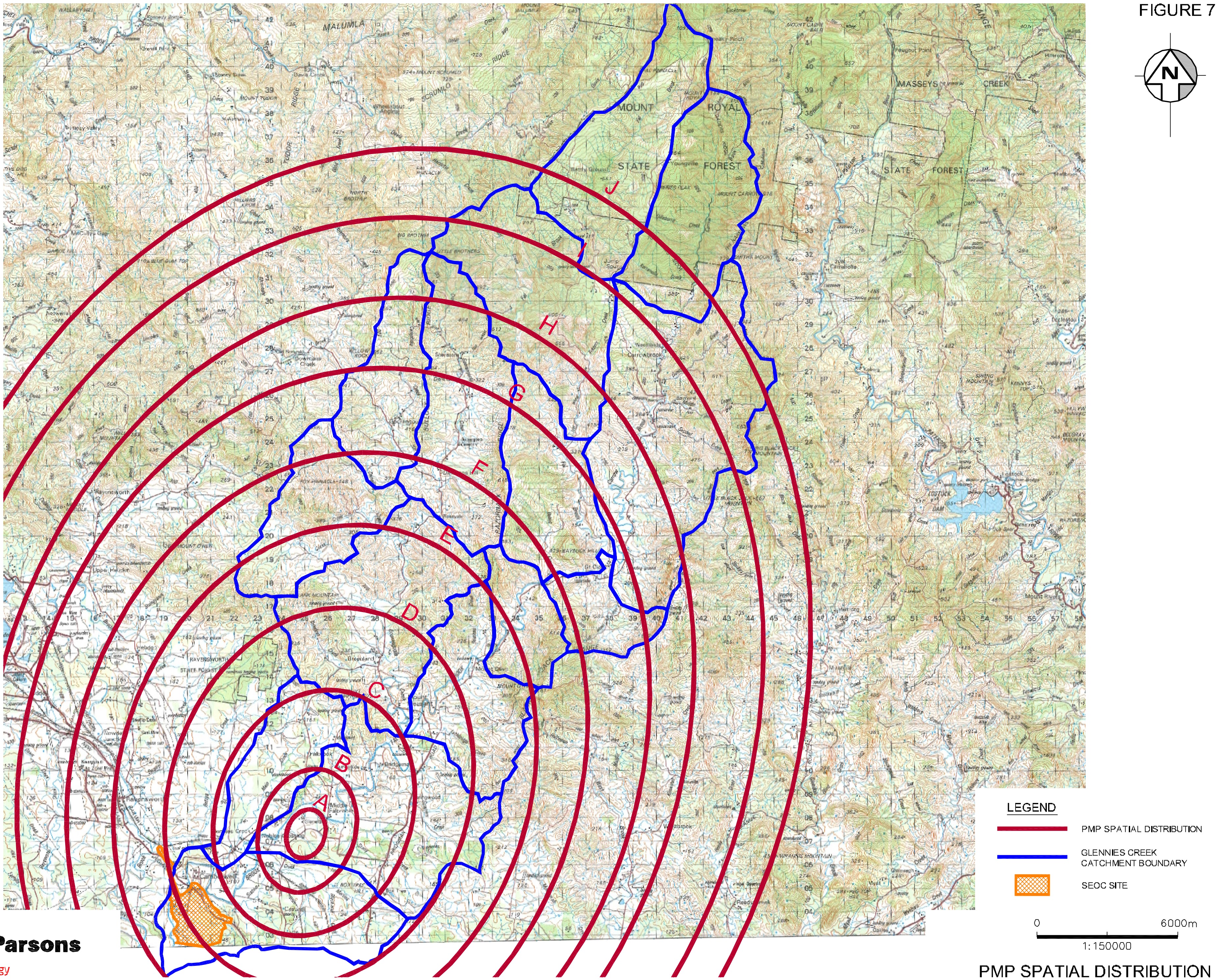
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 6 LICENSED SURFACE WATER EXTRACTION POINTS.dwg 22/07/2009

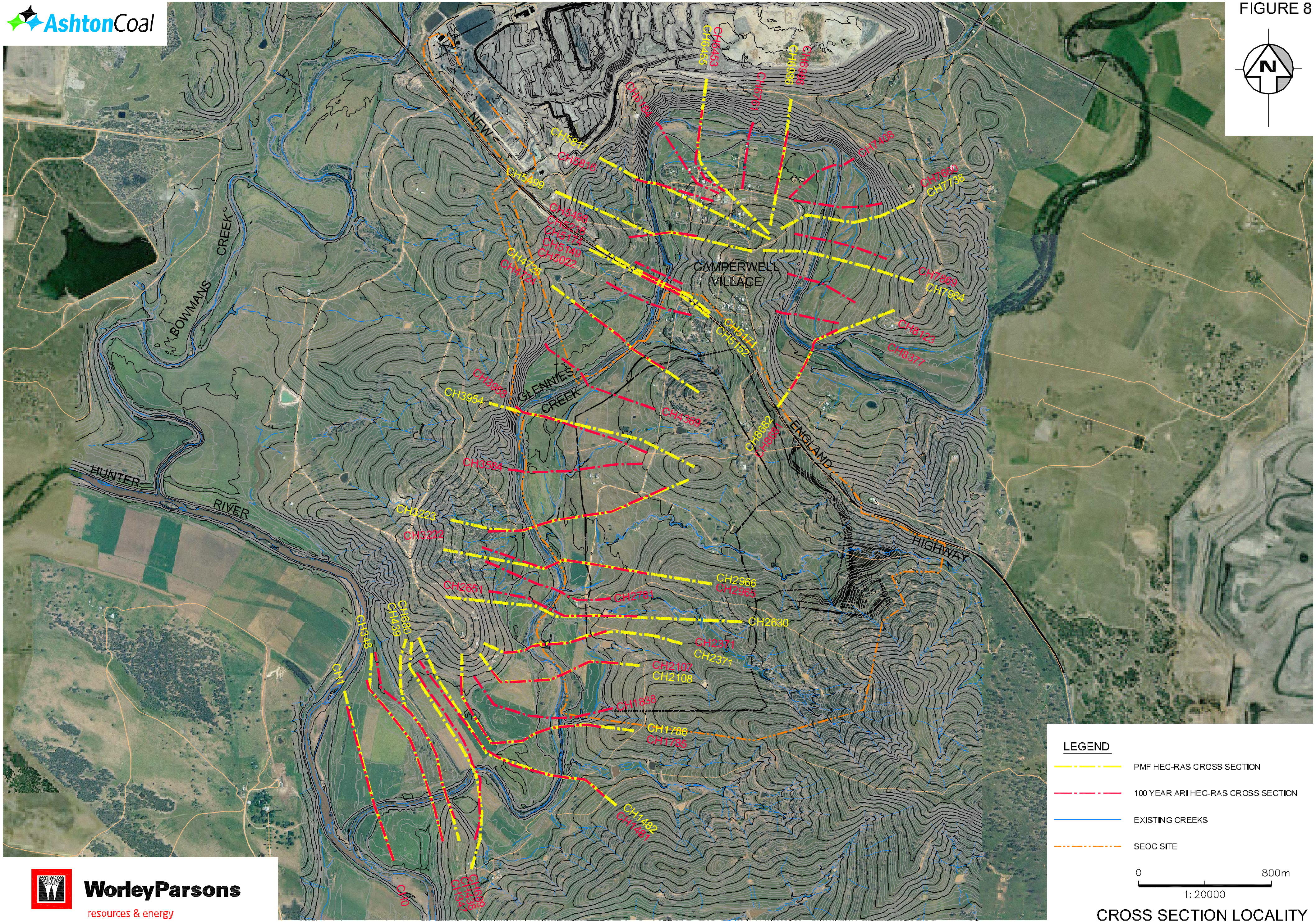
FIGURE 7



PMP SPATIAL DISTRIBUTION

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 7 PMP SPATIAL DISTRIBUTION.dwg 22/07/2009

FIGURE 8



LEGEND

- PMF HEC-RAS CROSS SECTION
- 100 YEAR ARI HEC-RAS CROSS SECTION
- EXISTING CREEKS
- SEOC SITE

0 — 800m
1:20000

CROSS SECTION LOCALITY

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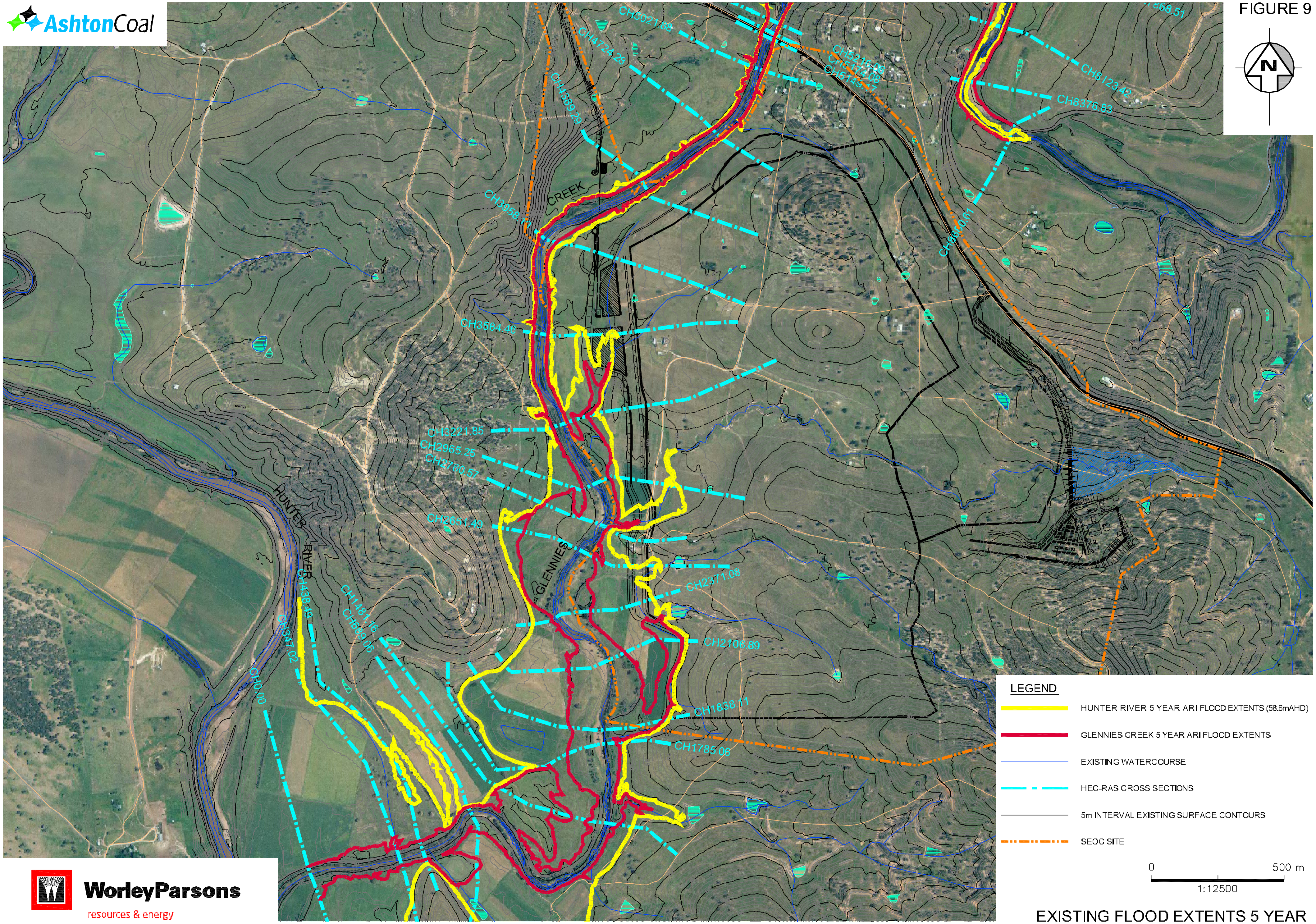
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 8 CROSS SECTION LOCALITY.dwg 22/07/2009

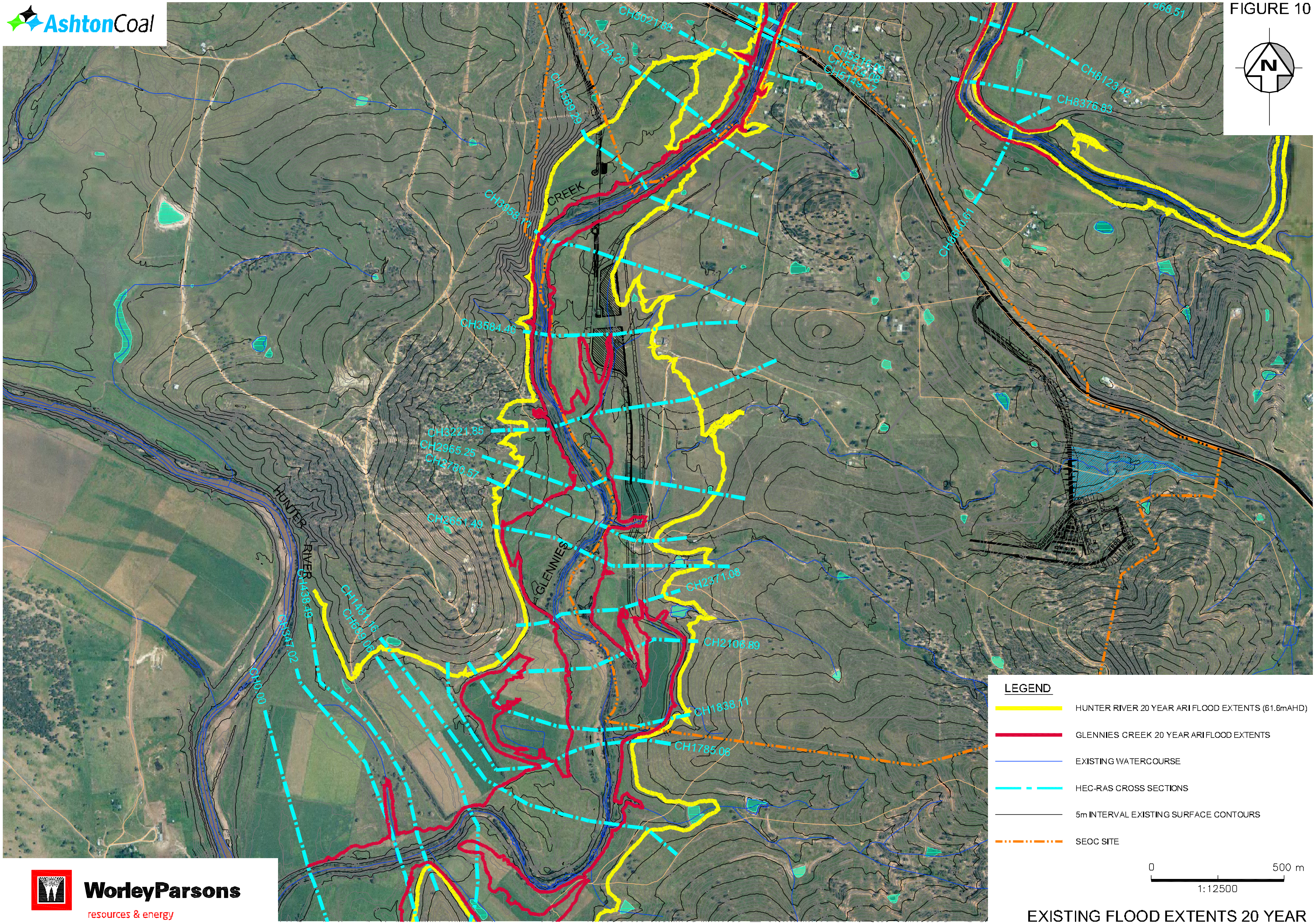
FIGURE 9



EXISTING FLOOD EXTENTS 5 YEAR

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 9 EXISTING FLOOD EXTENTS 5YR.dwg 22/07/2009

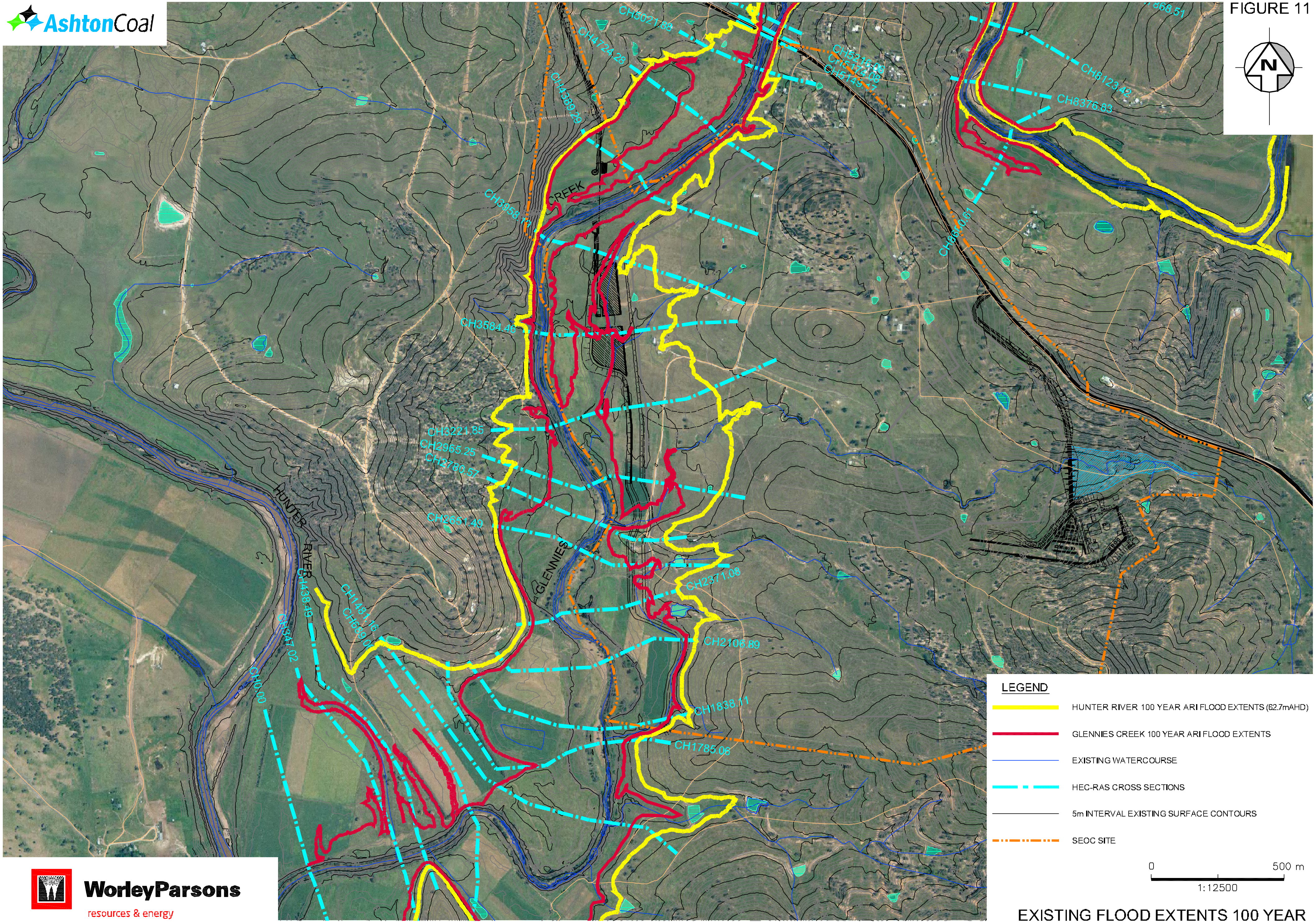
FIGURE 10



EXISTING FLOOD EXTENTS 20 YEAR

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 10 EXISTING FLOOD EXTENTS 20YR.dwg 22/07/2009

FIGURE 11



LEGEND

- HUNTER RIVER 100 YEAR ARI FLOOD EXTENTS (62.7mAHD)
- GLENNIES CREEK 100 YEAR ARI FLOOD EXTENTS
- EXISTING WATERCOURSE
- HEC-RAS CROSS SECTIONS
- 5m INTERVAL EXISTING SURFACE CONTOURS
- SEOC SITE

0 — 500 m
1:12500

EXISTING FLOOD EXTENTS 100 YEAR

AshtonCoal

WorleyParsons
resources & energy

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 11 EXISTING FLOOD EXTENTS 100YR.dwg 22/07/2009

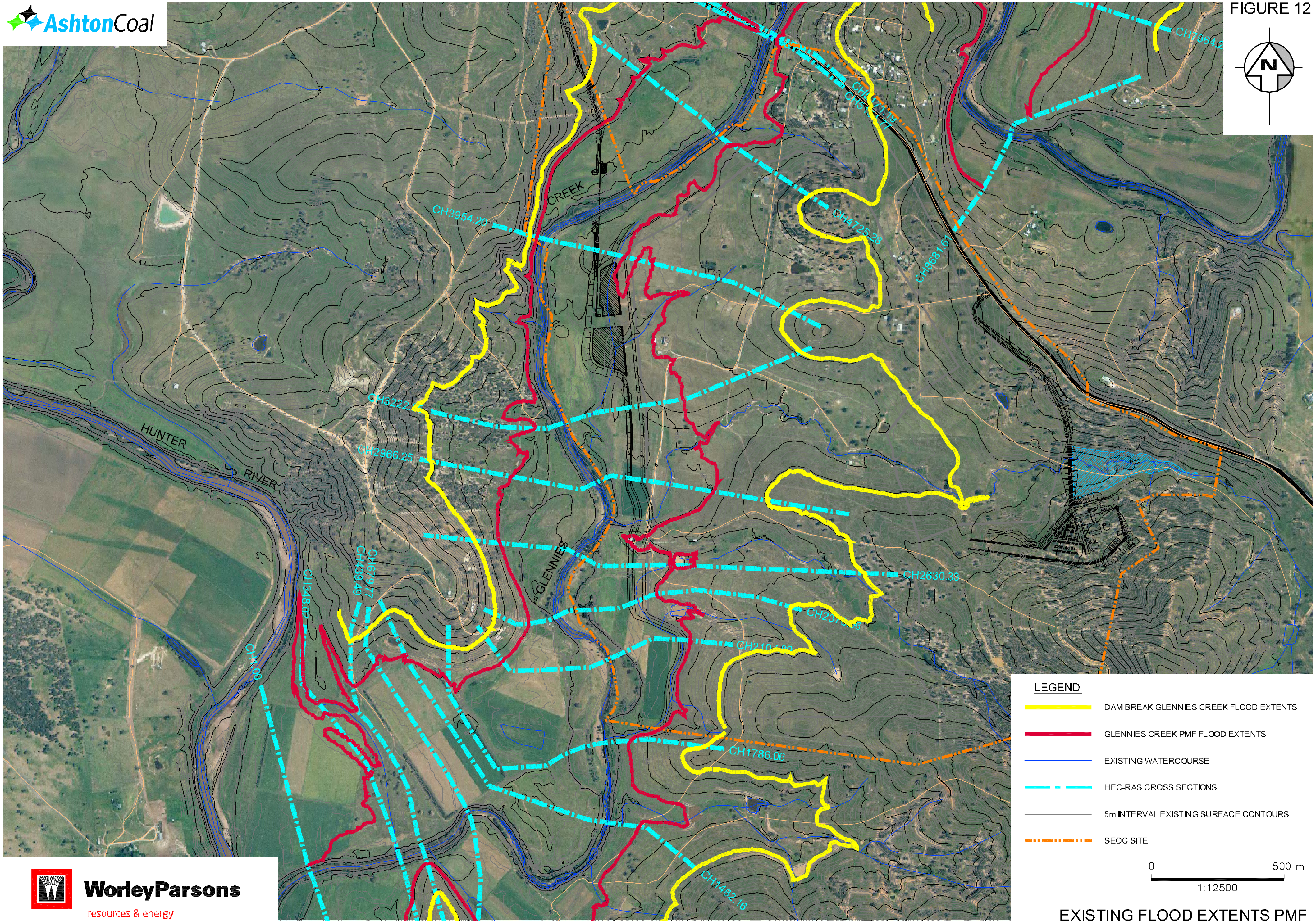


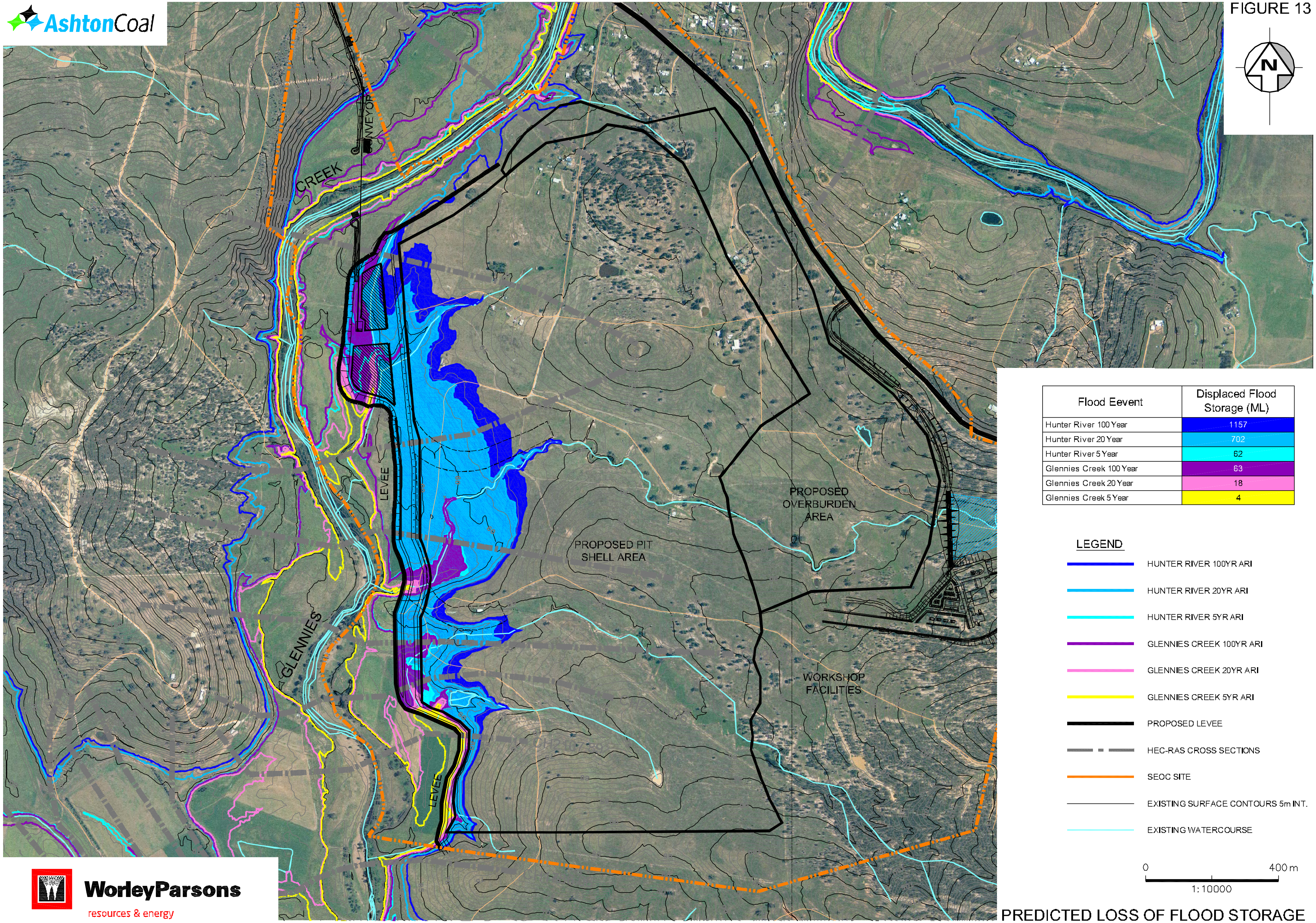
FIGURE 12

EXISTING FLOOD EXTENTS PMF

AshtonCoal

WorleyParsons resources & energy

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 12 EXISTING FLOOD EXTENTS PMF.dwg 22/07/2009



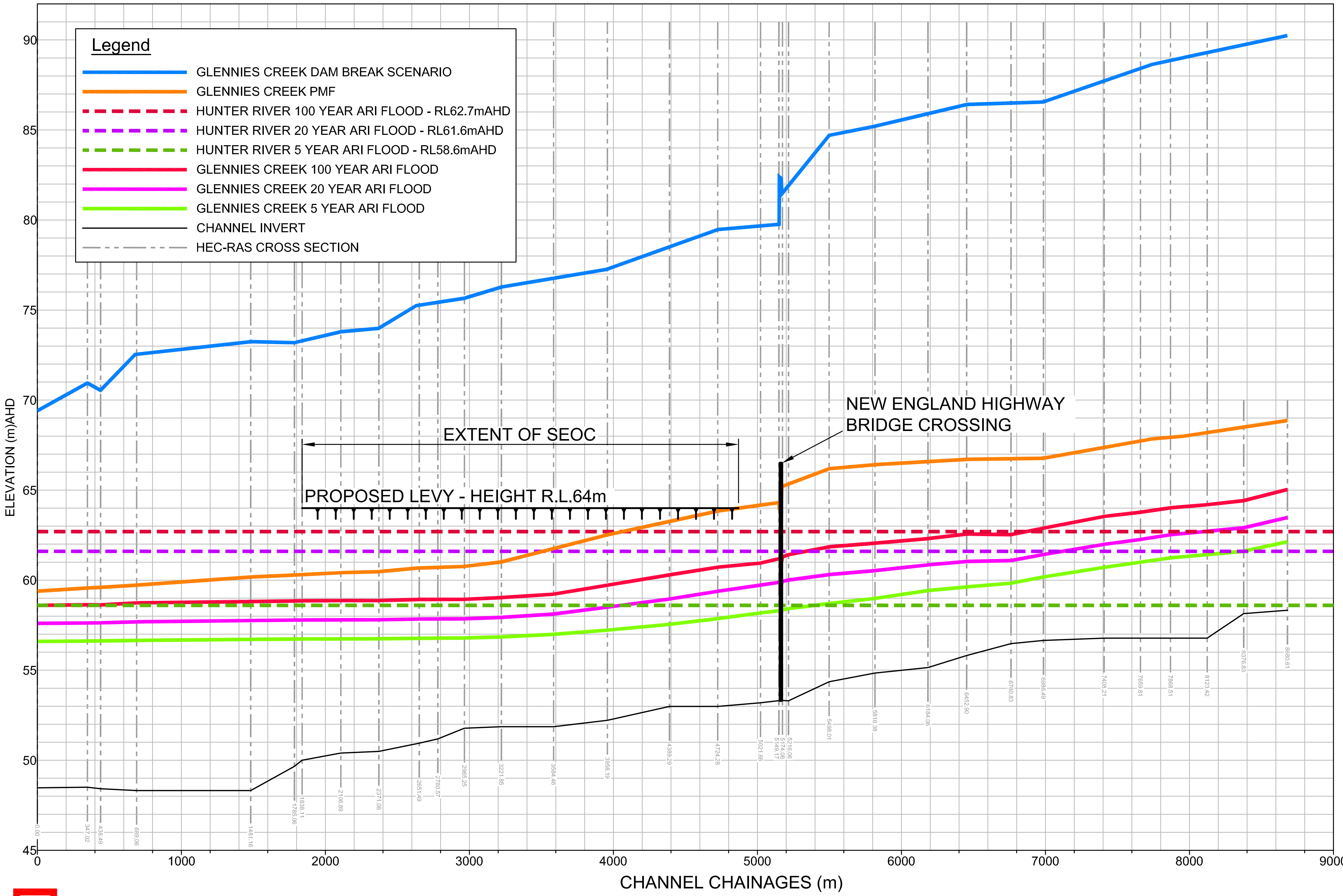
Flood Eevent	Displaced Flood Storage (ML)
Hunter River 100 Year	1157
Hunter River 20 Year	702
Hunter River 5 Year	62
Glennies Creek 100 Year	63
Glennies Creek 20 Year	18
Glennies Creek 5 Year	4

PREDICTED LOSS OF FLOOD STORAGE

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 13 DEVELOPED FLOOD EXTENTS.dwg 22/07/2009

FIGURE 14

EXISTING STATE WATER SURFACE PROFILES



WorleyParsons
resources & energy

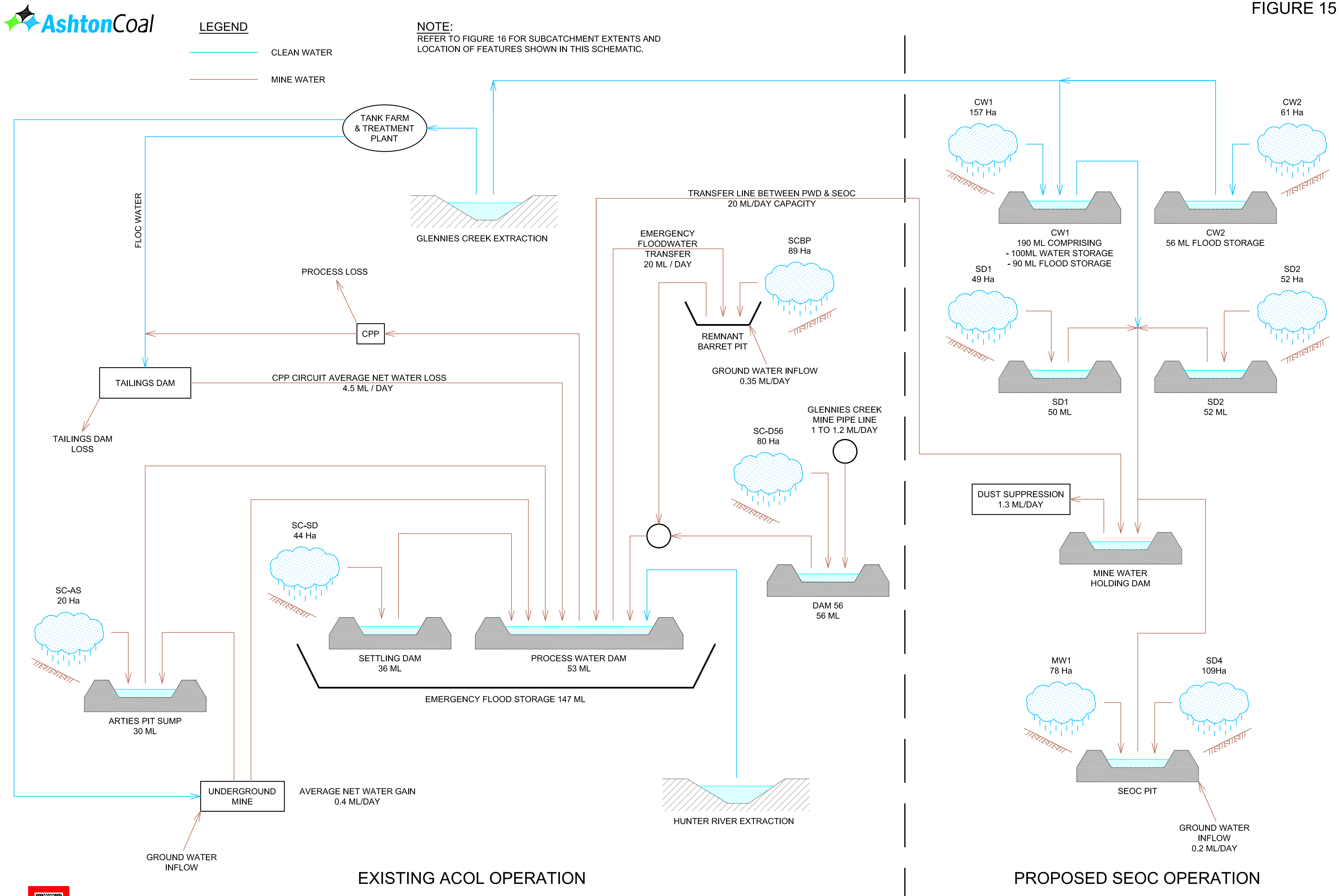
0 1000m
HORIZONTAL SCALE 1:25000

0 8 m
VERTICAL SCALE 1:200

EXISTING WATER SURFACE PROFILES - GLENNIES CREEK

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 14 EXISTING WATER SURFACE PROFILES.dwg 22/07/2009

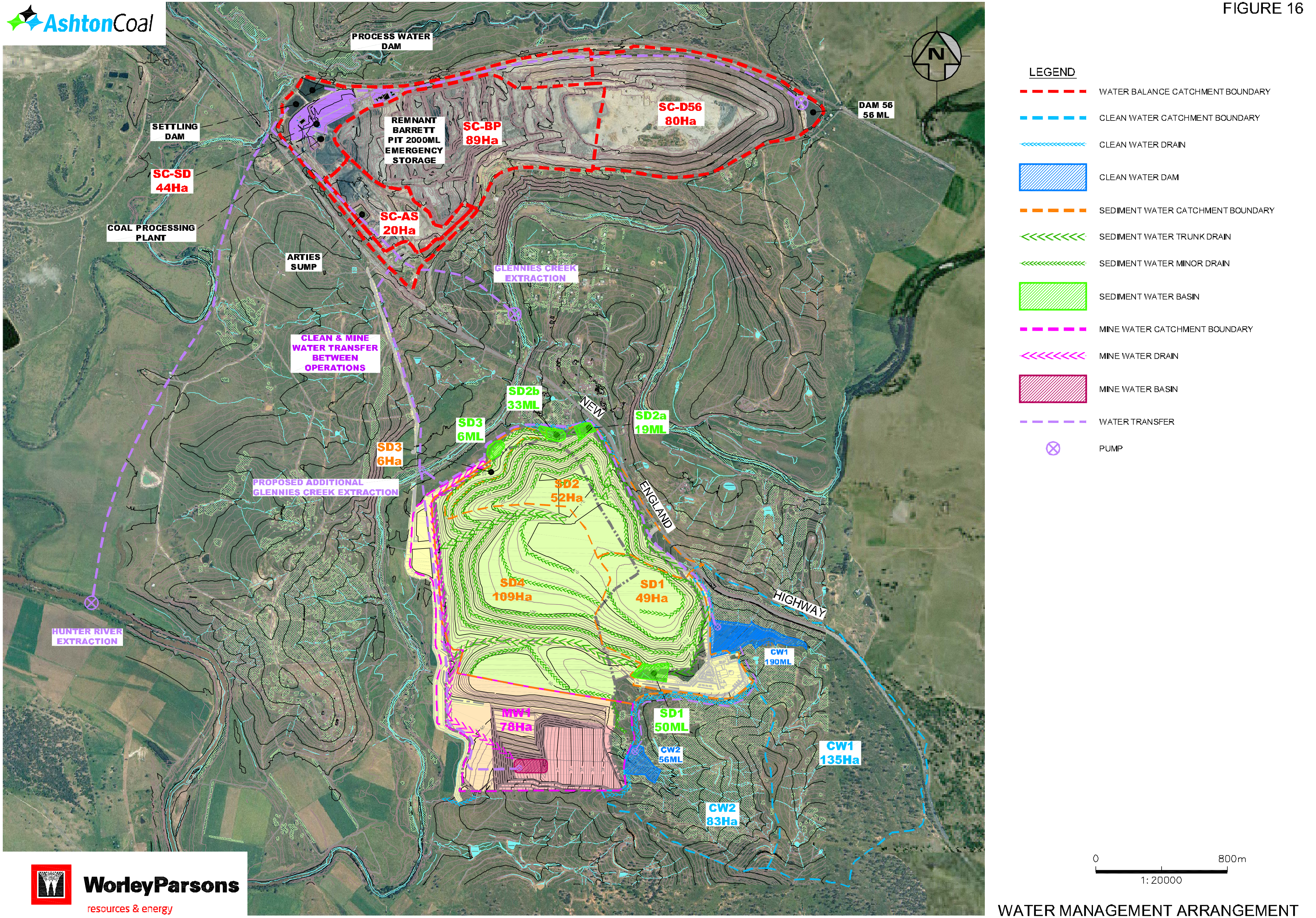
FIGURE 15



WATER BALANCE SCHEMATIC

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 15 WATER BALANCE SCHEMATIC.dwg 05/08/2009

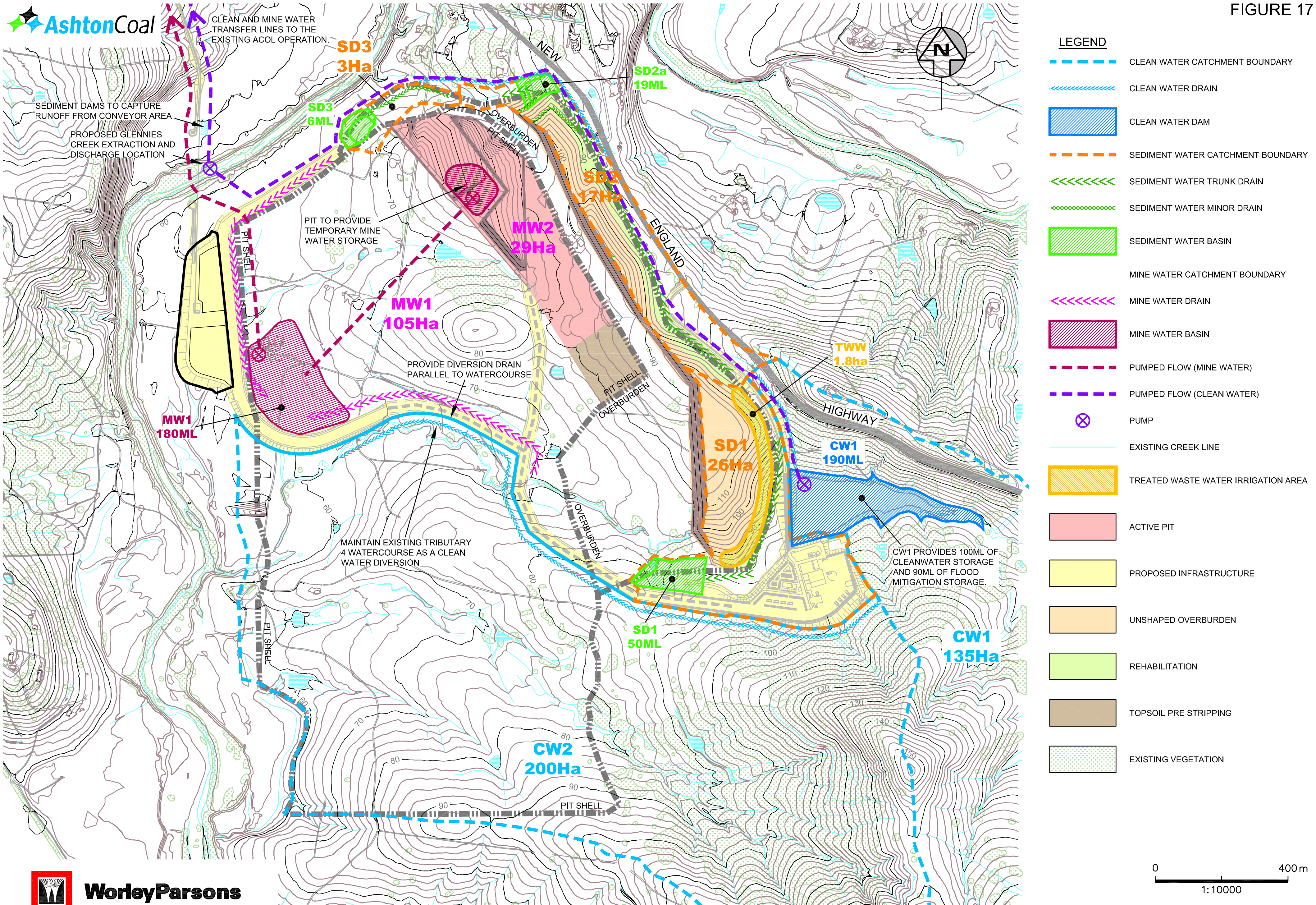
FIGURE 16



WATER MANAGEMENT ARRANGEMENT

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 16 WATER BALANCE ARRANGEMENT.dwg 22/07/2009

FIGURE 17



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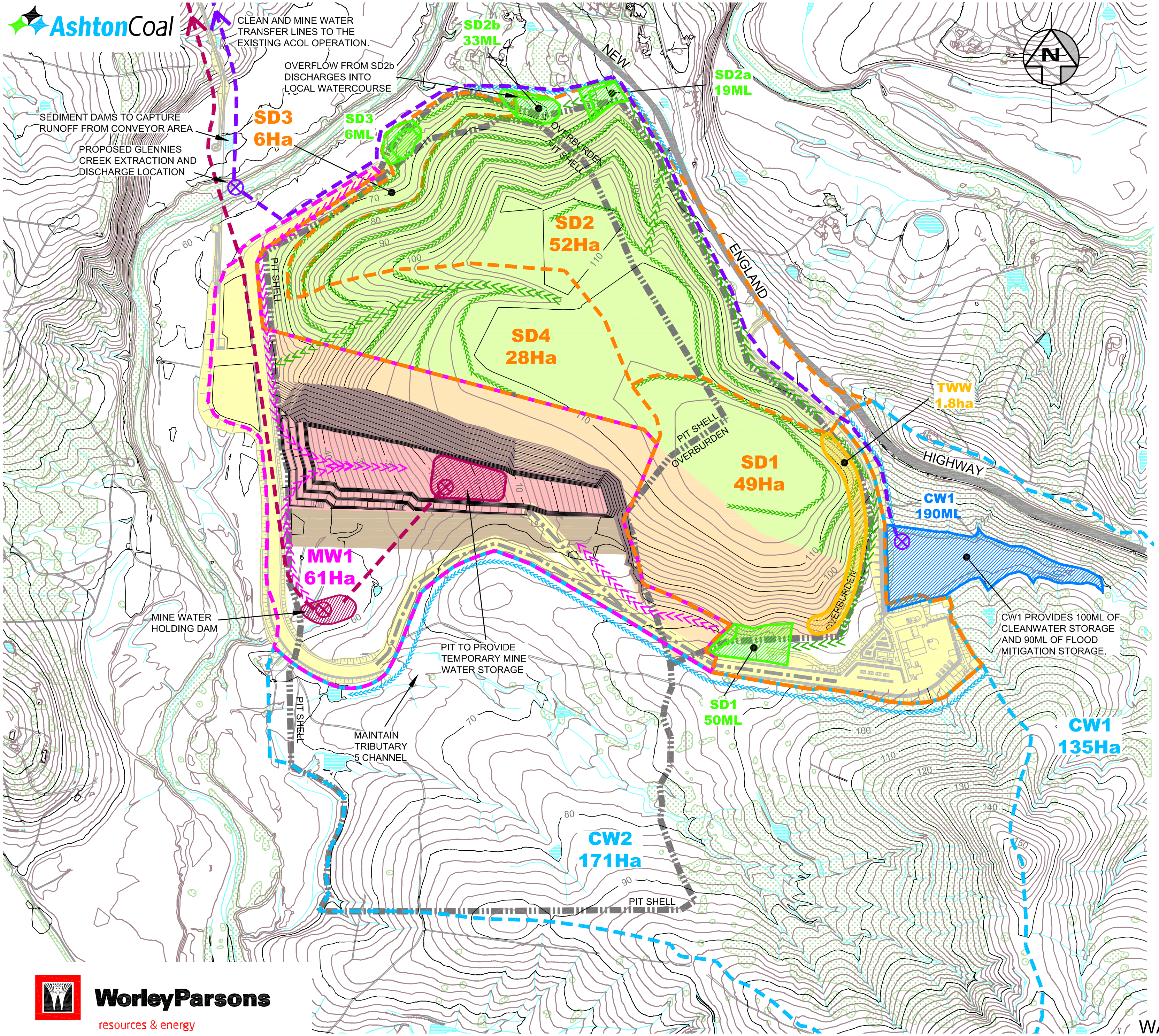
WATER MANAGEMENT PLAN - YEAR 1

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 17 WATER MANAGEMENT CONTROLS YEAR 1.dwg 22/07/2009

FIGURE 18



LEGEND

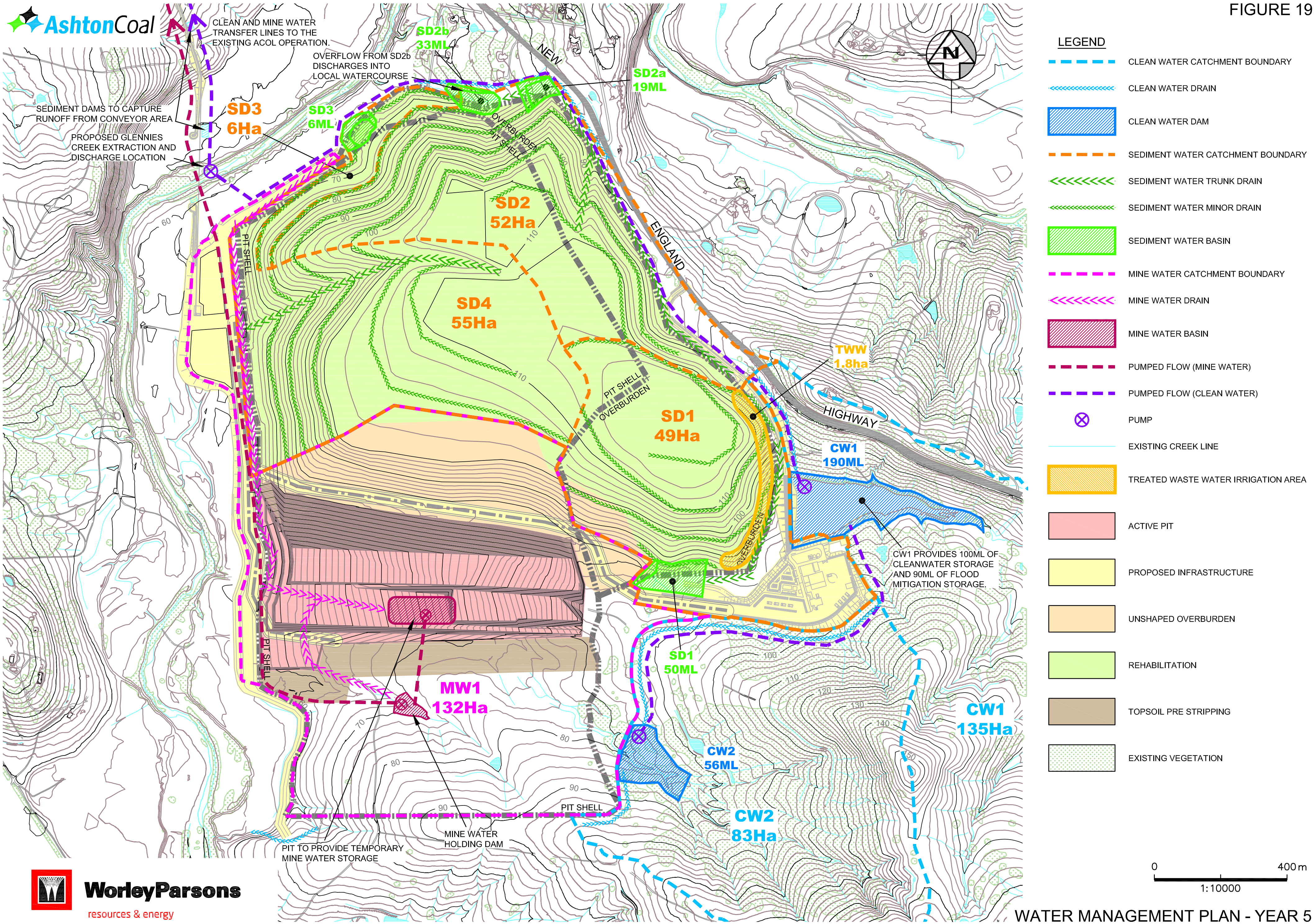
- CLEAN WATER CATCHMENT BOUNDARY
- CLEAN WATER DRAIN
- CLEAN WATER DAM
- SEDIMENT WATER CATCHMENT BOUNDARY
- SEDIMENT WATER TRUNK DRAIN
- SEDIMENT WATER MINOR DRAIN
- SEDIMENT WATER BASIN
- MINE WATER CATCHMENT BOUNDARY
- MINE WATER DRAIN
- MINE WATER BASIN
- PUMPED FLOW (MINE WATER)
- PUMPED FLOW (CLEAN WATER)
- PUMP
- EXISTING CREEK LINE
- TREATED WASTE WATER IRRIGATION AREA
- ACTIVE PIT
- PROPOSED INFRASTRUCTURE
- UNSHAPED OVERBURDEN
- REHABILITATION
- TOPSOIL PRE STRIPPING
- EXISTING VEGETATION

0 400m
1:10000

WATER MANAGEMENT PLAN - YEAR 3

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 18 WATER MANAGEMENT CONTROLS YEAR 3.dwg 22/07/2009

FIGURE 19

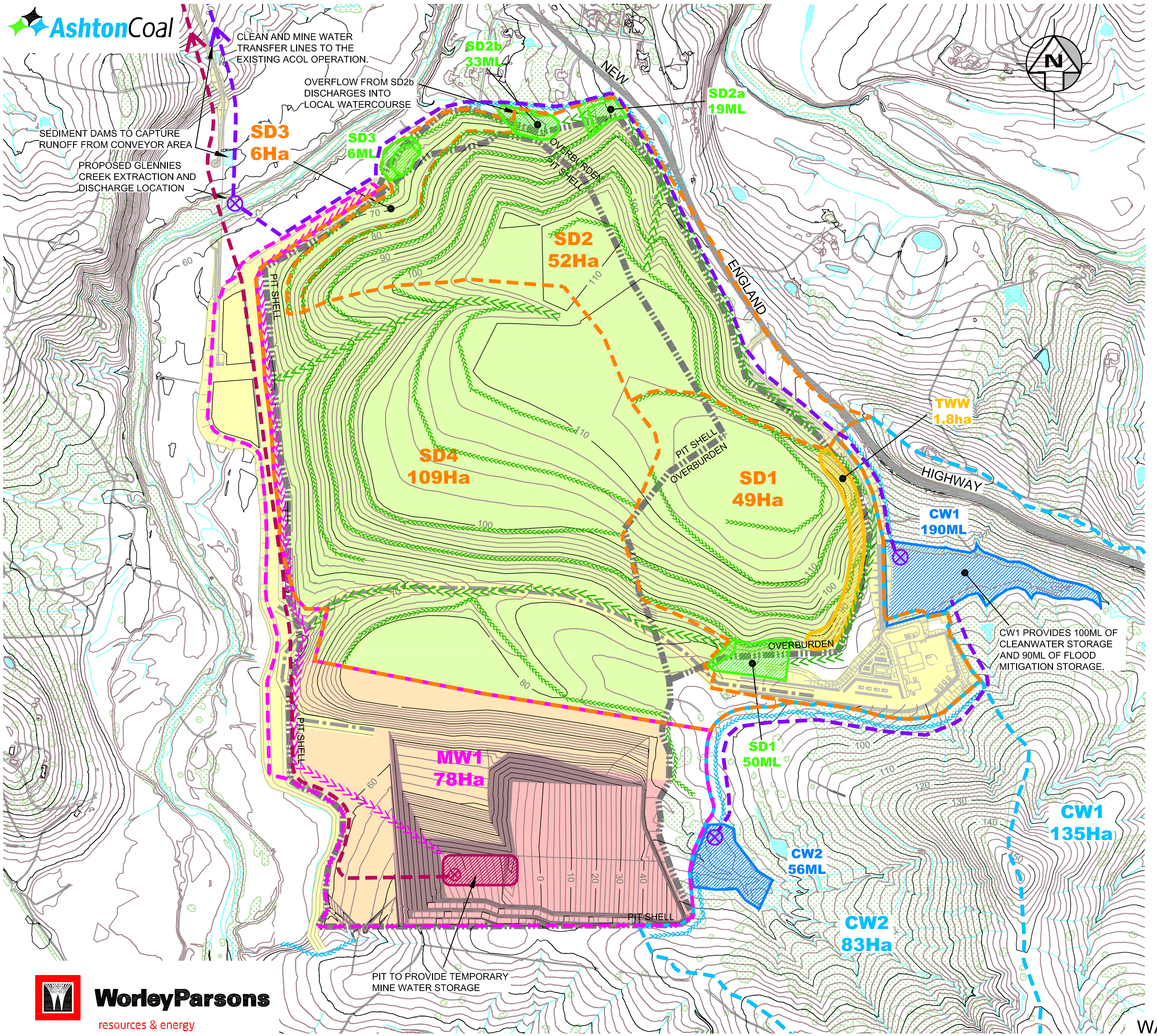


WorleyParsons
resources & energy

WATER MANAGEMENT PLAN - YEAR 5

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 19 WATER MANAGEMENT CONTROLS YEAR 5.dwg 22/07/2009

FIGURE 20



LEGEND

- CLEAN WATER CATCHMENT BOUNDARY
- CLEAN WATER DRAIN
- CLEAN WATER DAM
- SEDIMENT WATER CATCHMENT BOUNDARY
- SEDIMENT WATER TRUNK DRAIN
- SEDIMENT WATER MINOR DRAIN
- SEDIMENT WATER BASIN
- MINE WATER CATCHMENT BOUNDARY
- MINE WATER DRAIN
- MINE WATER BASIN
- PUMPED FLOW (MINE WATER)
- PUMPED FLOW (CLEAN WATER)
- PUMP
- EXISTING CREEK LINE
- TREATED WASTE WATER IRRIGATION AREA
- ACTIVE PIT
- PROPOSED INFRASTRUCTURE
- UNSHAPED OVERBURDEN
- REHABILITATION
- EXISTING VEGETATION

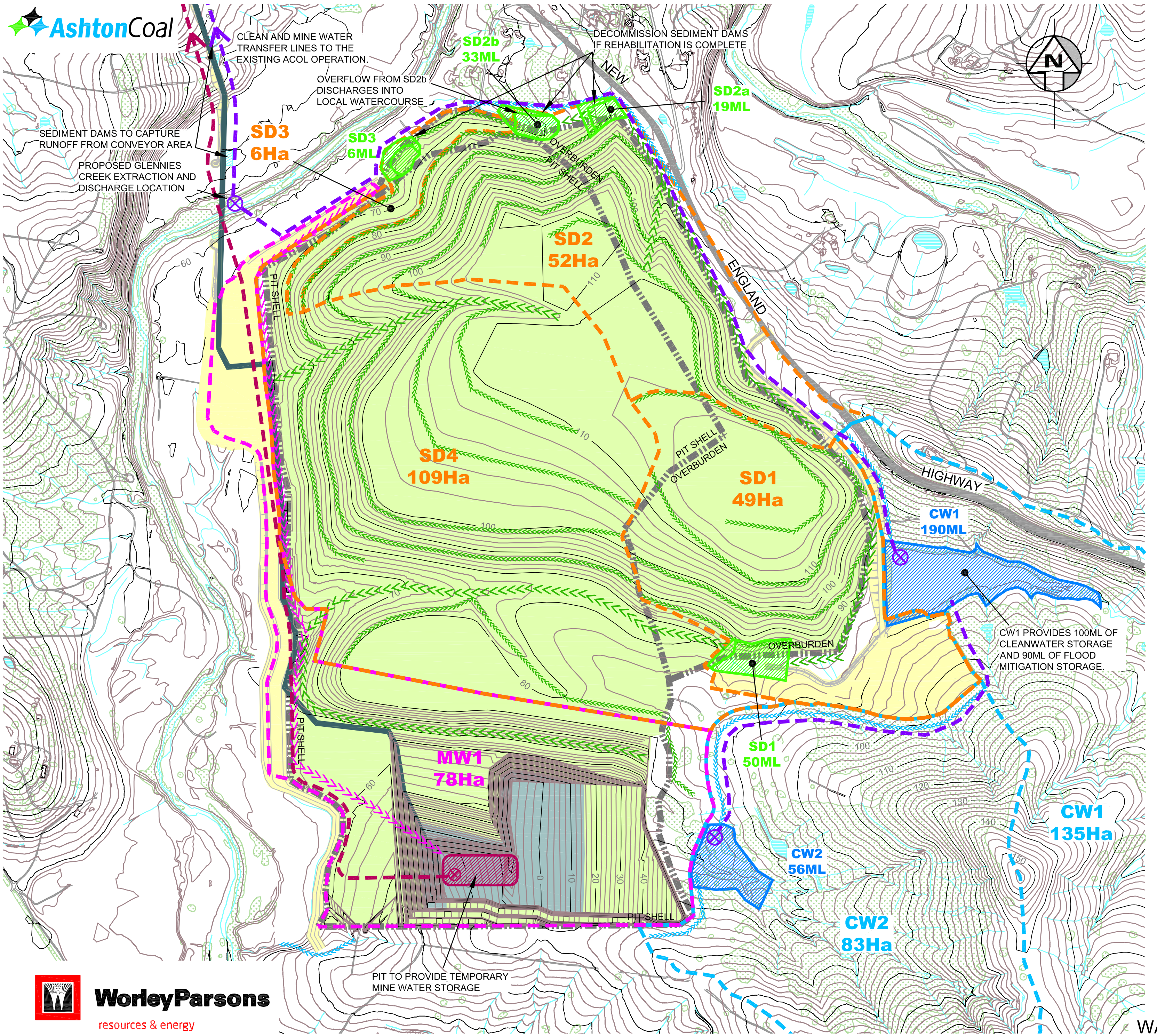
0 400m
1:10000

WorleyParsons
resources & energy

WATER MANAGEMENT PLAN - YEAR 7

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 20 WATER MANAGEMENT CONTROLS YEAR 7.dwg 22/07/2009

FIGURE 21



LEGEND

- CLEAN WATER CATCHMENT BOUNDARY
- CLEAN WATER DRAIN
- CLEAN WATER DAM
- SEDIMENT WATER CATCHMENT BOUNDARY
- SEDIMENT WATER TRUNK DRAIN
- SEDIMENT WATER MINOR DRAIN
- SEDIMENT WATER BASIN
- MINE WATER CATCHMENT BOUNDARY
- MINE WATER DRAIN
- MINE WATER BASIN
- PUMPED FLOW (MINE WATER)
- PUMPED FLOW (CLEAN WATER)
- PUMP
- EXISTING CREEK LINE
- INFRASTRUCTURE AREAS
- TAILING STORAGE AREA
- REHABILITATION
- EXISTING VEGETATION
- TAILINGS TRANSFER PIPELINE

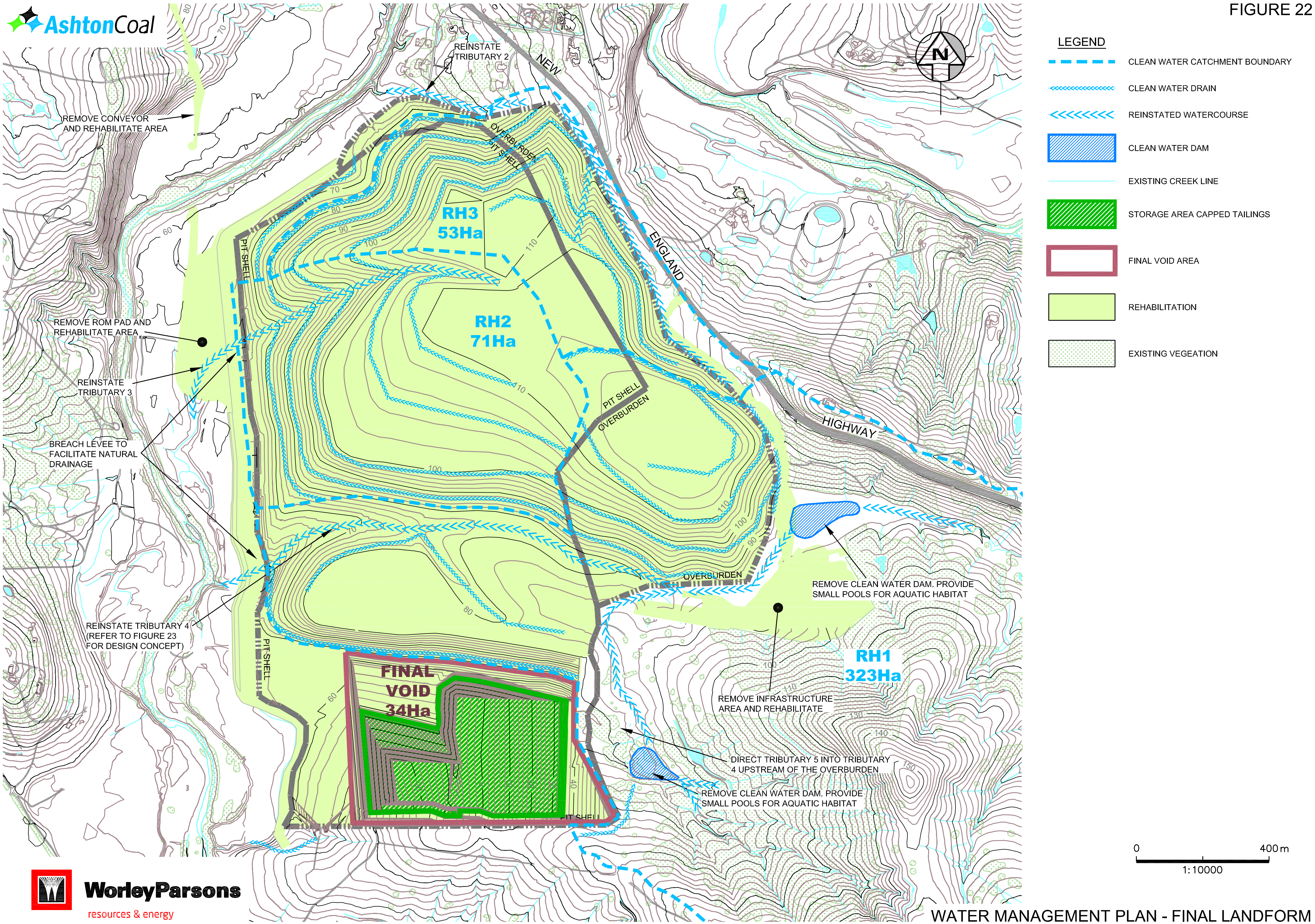
0 400m
1:10000

WorleyParsons
resources & energy

WATER MANAGEMENT PLAN - YEAR 9

N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 21 WATER MANAGEMENT CONTROLS YEAR 9.dwg 22/07/2009

FIGURE 22

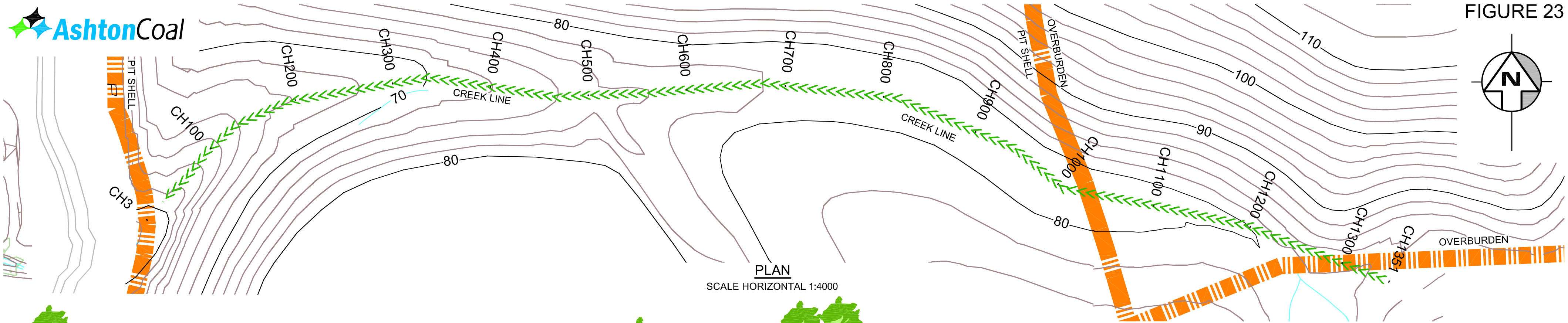


WATER MANAGEMENT PLAN - FINAL LANDFORM

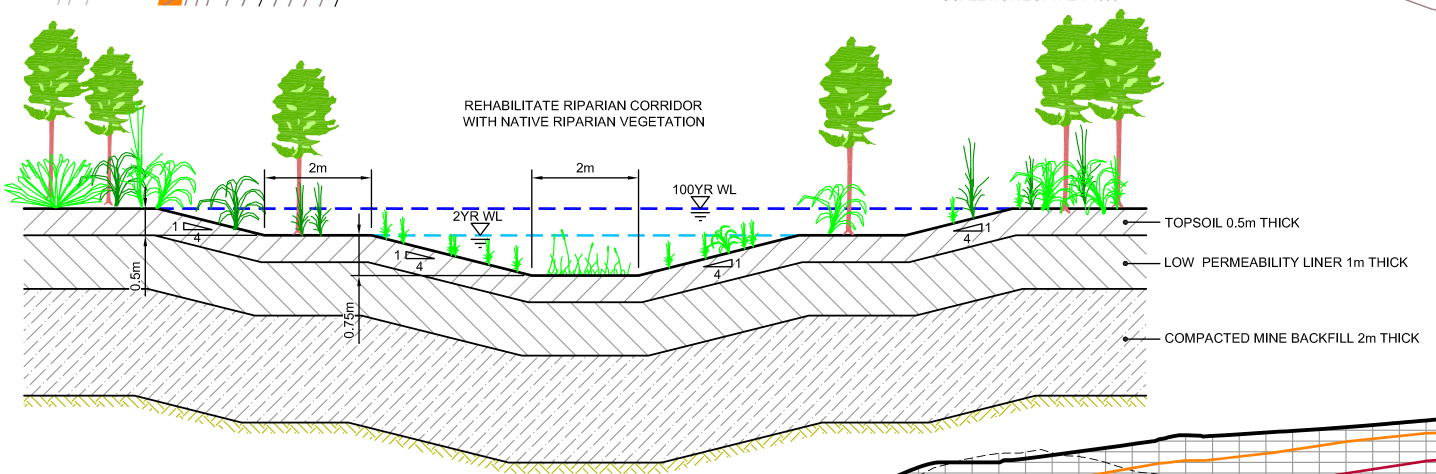
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 22 WATER MANAGEMENT CONTROLS FINAL LANDFORM.dwg 22/07/2009

AshtonCoal

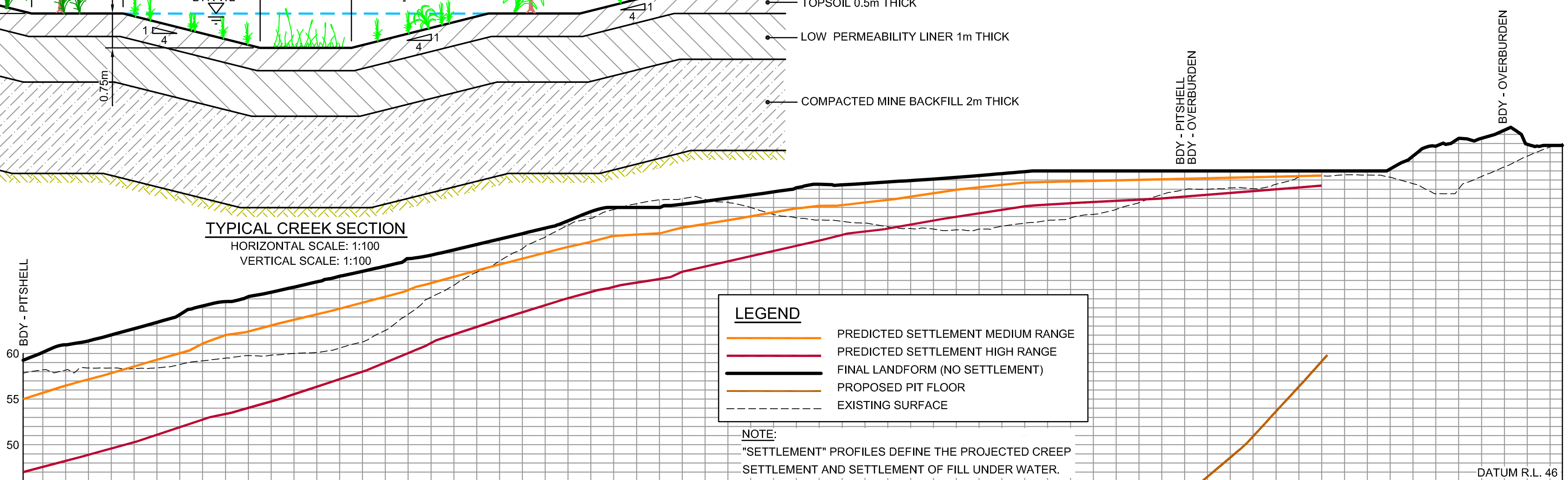
FIGURE 23



PLAN
SCALE HORIZONTAL 1:4000



TYPICAL CREEK SECTION
HORIZONTAL SCALE: 1:100
VERTICAL SCALE: 1:100



CHAINAGE	DEPTH TO PIT FLOOR	PIT FLOOR	FINAL DEVELOPED LANDFORM
2.8	114.5	-55.2	59.3
20.0	114.4	-54.3	60.1
40.0	114.1	-53.1	61.0
60.0	113.2	-51.9	61.4
80.0	112.8	-50.8	62.0
100.0	112.3	-49.6	62.7
120.0	111.7	-48.2	63.4
140.0	111.0	-46.7	64.3
160.0	110.2	-45.0	65.2
180.0	108.8	-43.1	65.7
200.0	107.4	-41.2	66.2
220.0	105.8	-39.1	66.7
240.0	104.3	-37.0	67.3
260.0	102.8	-34.9	67.8
280.0	101.4	-32.9	68.5
300.0	100.0	-31.0	69.0
320.0	98.6	-29.0	69.6
340.0	97.5	-27.2	70.4
360.0	96.3	-25.5	70.8
380.0	95.2	-23.9	71.3
400.0	94.4	-22.5	71.9
420.0	93.7	-21.2	72.5
440.0	92.9	-19.8	73.1
460.0	92.0	-18.2	73.7
480.0	91.0	-16.5	74.5
500.0	90.2	-14.7	75.5
520.0	88.3	-12.3	76.0
540.0	86.0	-10.0	76.0
560.0	84.1	-8.1	76.0
580.0	82.6	-6.3	76.4
600.0	81.0	-4.3	76.7
620.0	79.0	-2.0	77.0
640.0	77.0	0.3	77.4
660.0	74.8	2.9	77.7
680.0	72.6	5.6	78.2
700.0	70.4	8.1	78.5
720.0	67.9	10.6	78.5
740.0	65.6	13.0	78.6
760.0	63.4	15.4	78.8
780.0	61.1	17.9	79.0
800.0	58.7	20.4	79.1
820.0	56.4	22.9	79.3
840.0	54.3	25.2	79.5
860.0	52.1	27.6	79.7
880.0	49.8	30.1	79.9
900.0	47.5	32.5	80.0
920.0	45.1	34.9	80.0
940.0	42.8	37.2	80.0
960.0	41.0	39.0	80.0
980.0	39.3	40.7	80.0
1000.0	37.7	42.3	80.0
1020.0	35.7	44.3	80.0
1040.0	33.5	46.5	80.0
1060.0	31.4	48.6	80.0
1080.0	29.1	50.9	80.0
1100.0	26.4	53.6	80.0
1120.0	23.6	56.4	80.0
1140.0	20.9	59.1	80.0
1160.0			80.0
1180.0			80.0
1200.0			80.2
1220.0			81.6
1240.0			82.7
1260.0			83.5
1280.0			83.6
1300.0			84.5
1320.0			82.9
1340.0			82.8

LONGITUDINAL SECTION OF WATERCOURSE
SCALE HORIZONTAL 1:4000
SCALE VERTICAL 1:500

0 — 20 m (1:500) 0 — 160 m (1:4000)

WorleyParsons
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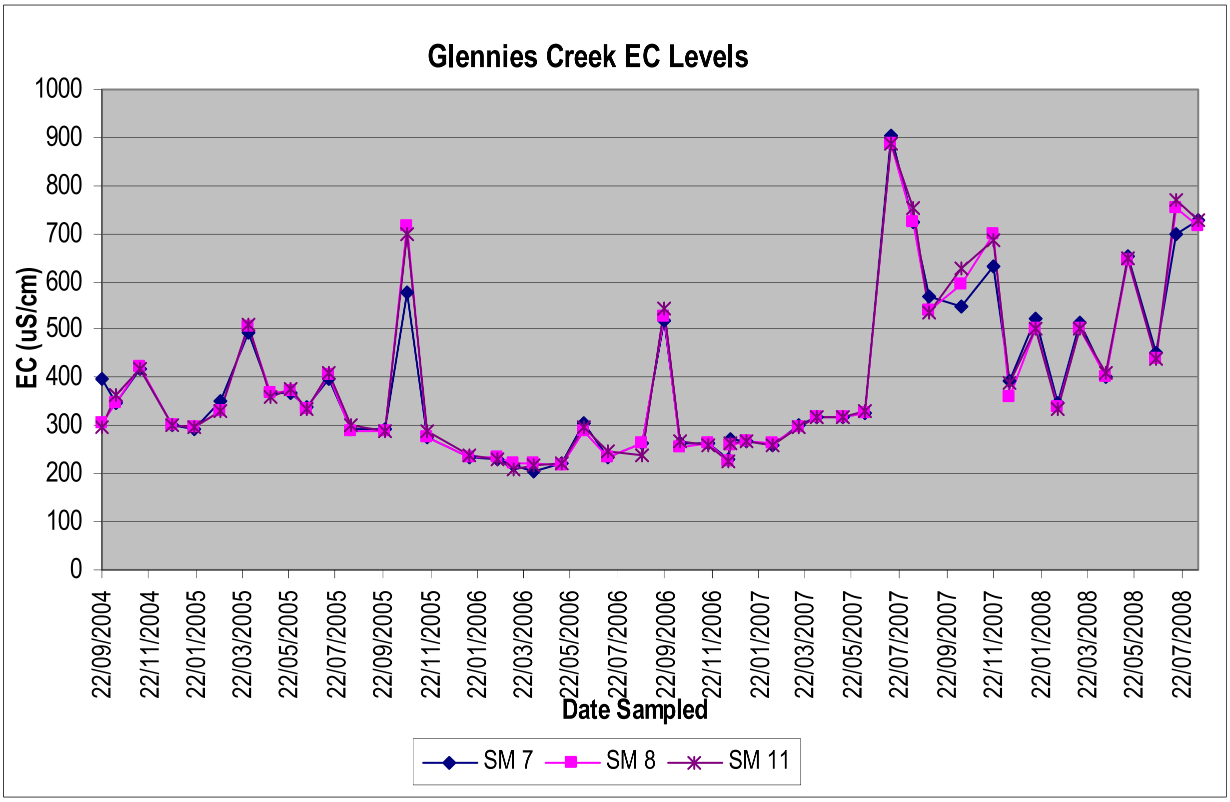
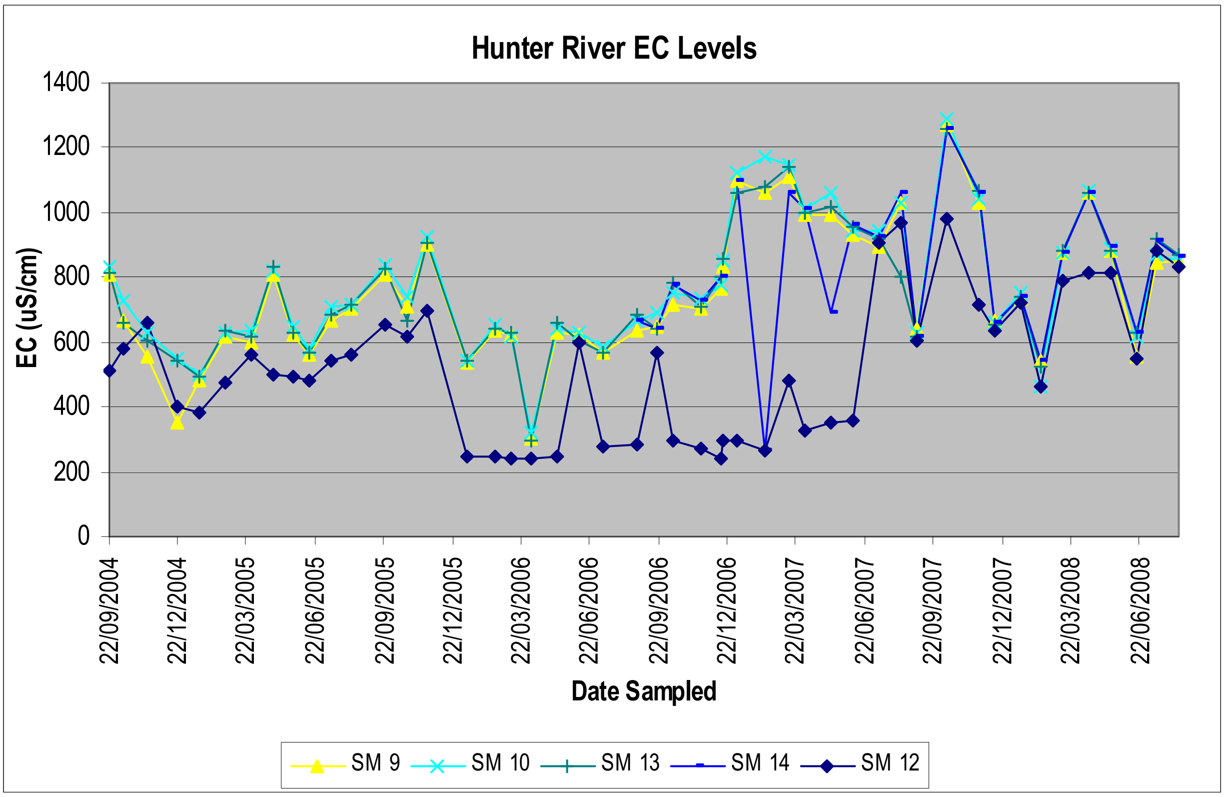
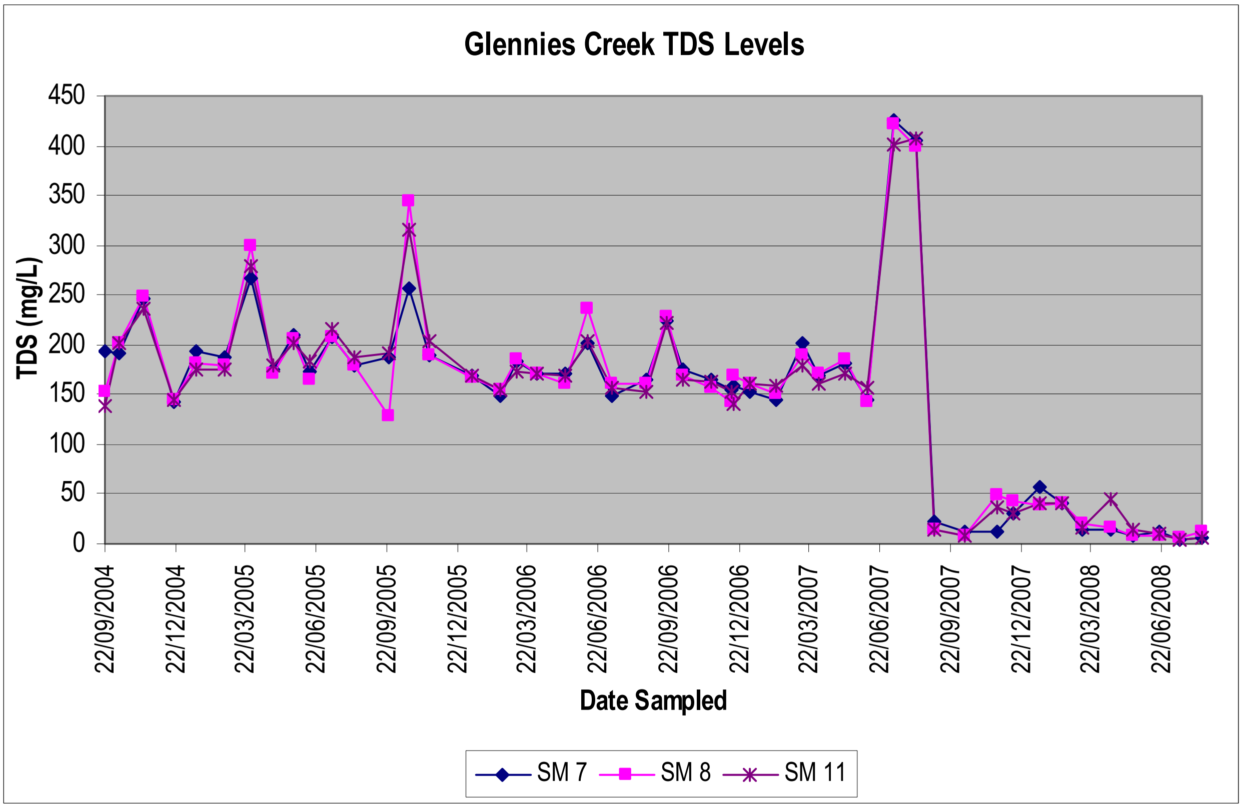
TRIBUTARY 4 RE-ESTABLISHMENT CONCEPT

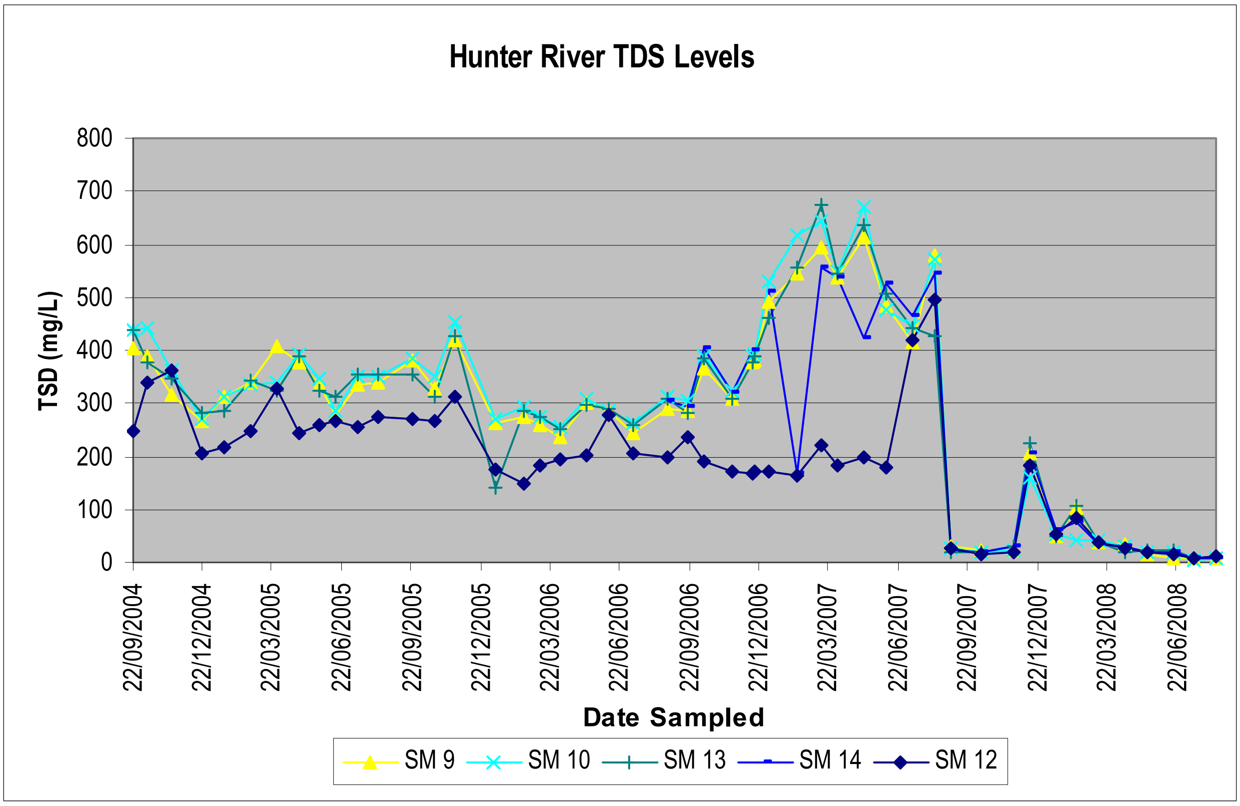
N:\Drafting Jobs\7583 Ashton Coal SEOC Environmental Assessment (MLB)\CAD\REPORT FIGURES\FIGURE 23 TRIBUTARY 4 REESTABLISHMENT CONCEPT.dwg 22/07/2009

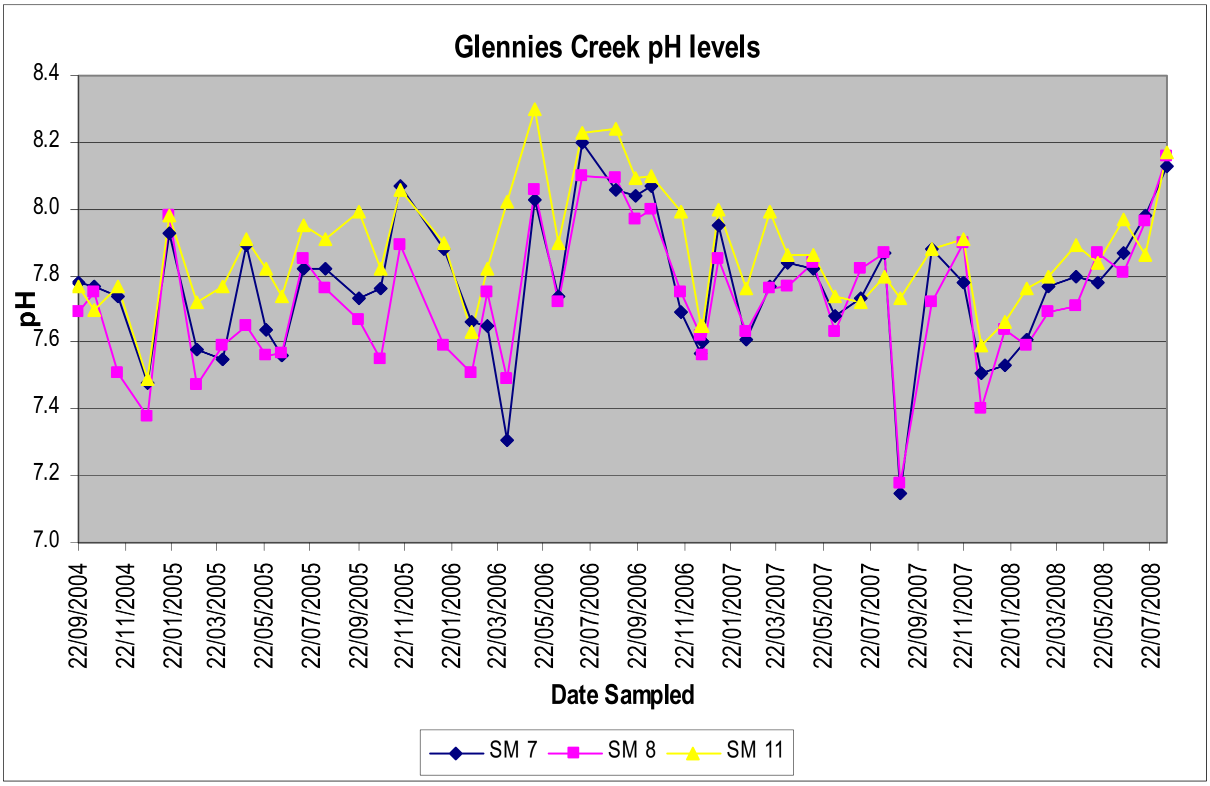
APPENDIX A – GLENNIES CREEK WATER MONITORING RESULTS

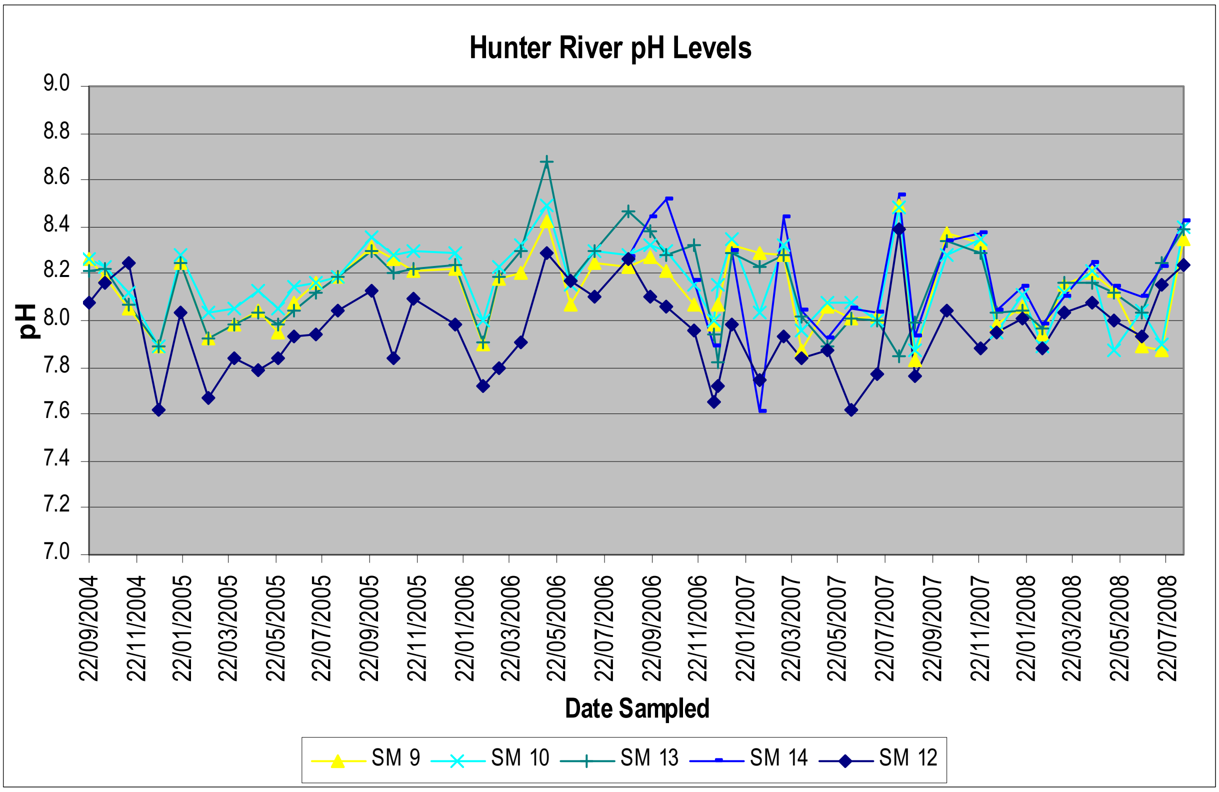

Glennies Creek EC Levels
EC (uS/cm)
1000
900
800
700
600
500
400
300
200
100
0
22/09/2004
22/11/2004
22/01/2005
22/03/2005
22/05/2005
22/07/2005
22/09/2005
22/11/2005
22/01/2006
22/03/2006
22/05/2006
22/07/2006
22/09/2006
22/11/2006
22/01/2007
22/03/2007
22/05/2007
22/07/2007
22/09/2007
22/11/2007
22/01/2008
22/03/2008
22/05/2008
22/07/2008
Date Sampled
SM 7
SM 8
SM 11

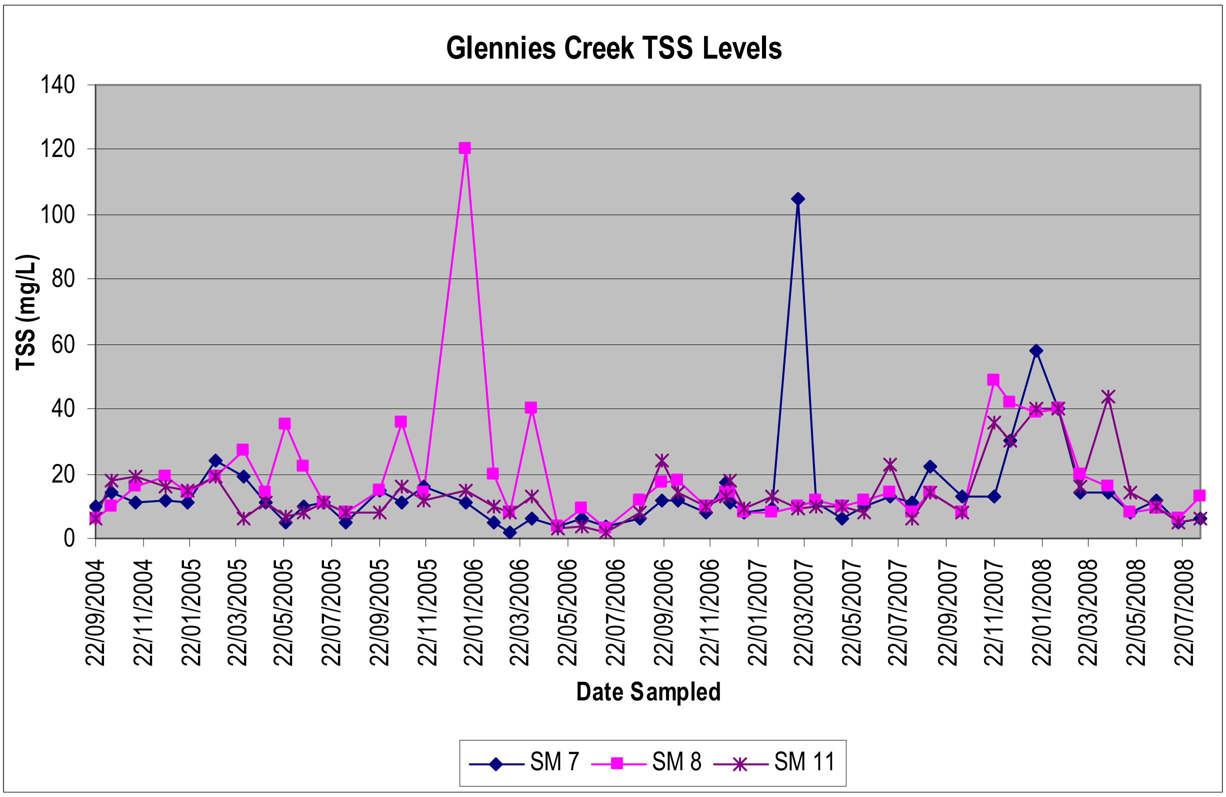

Hunter River EC Levels
EC (uS/cm)
1400
1200
1000
800
600
400
200
0
22/09/2004
22/12/2004
22/03/2005
22/06/2005
22/09/2005
22/12/2005
22/03/2006
22/06/2006
22/09/2006
22/12/2006
22/03/2007
22/06/2007
22/09/2007
22/12/2007
22/03/2008
22/06/2008
Date Sampled
SM 9
SM 10
SM 13
SM 14
SM 12

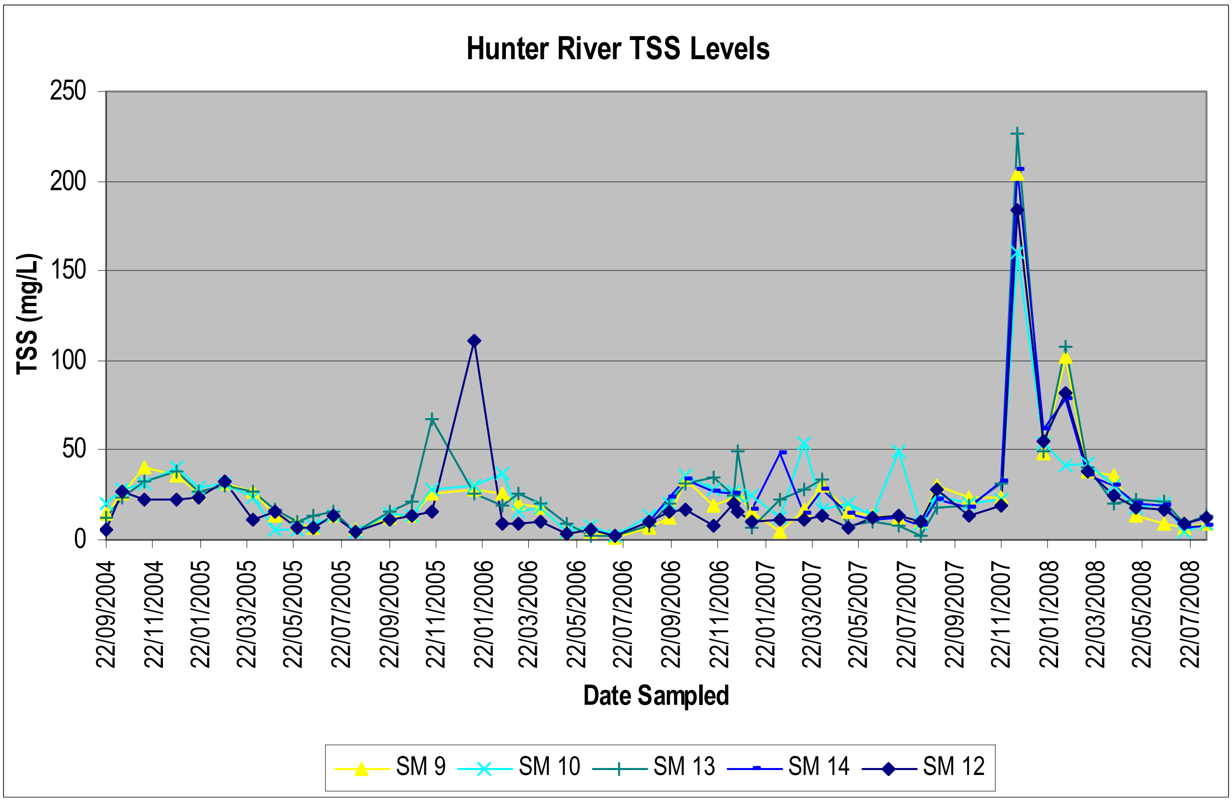

Glennies Creek TDS Levels
TDS (mg/L)
450
400
350
300
250
200
150
100
50
0
22/09/2004
22/12/2004
22/03/2005
22/06/2005
22/09/2005
22/12/2005
22/03/2006
22/06/2006
22/09/2006
22/12/2006
22/03/2007
22/06/2007
22/09/2007
22/12/2007
22/03/2008
22/06/2008
Date Sampled
SM 7
SM 8
SM 11

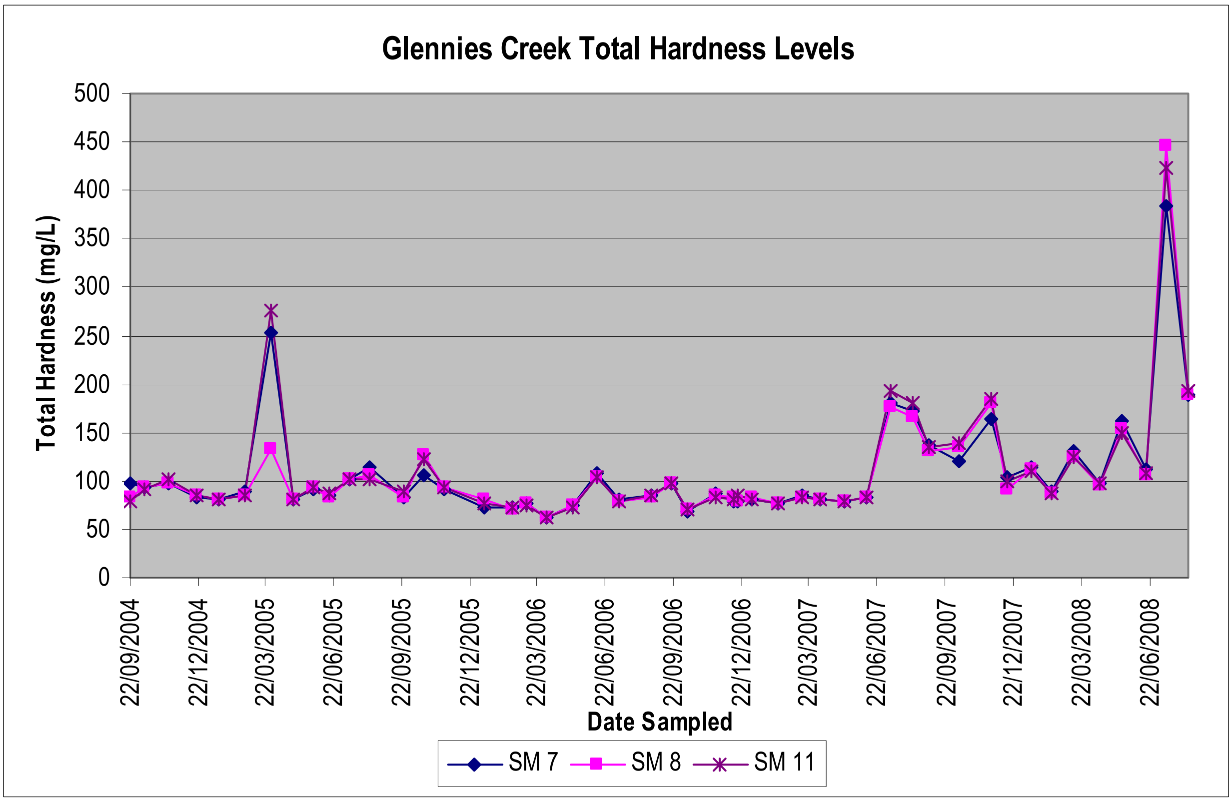

Hunter River TDS Levels
TSD (mg/L)
800
700
600
500
400
300
200
100
0
22/09/2004
22/12/2004
22/03/2005
22/06/2005
22/09/2005
22/12/2005
22/03/2006
22/06/2006
22/09/2006
22/12/2006
22/03/2007
22/06/2007
22/09/2007
22/12/2007
22/03/2008
22/06/2008
Date Sampled
SM 9
SM 10
SM 13
SM 14
SM 12

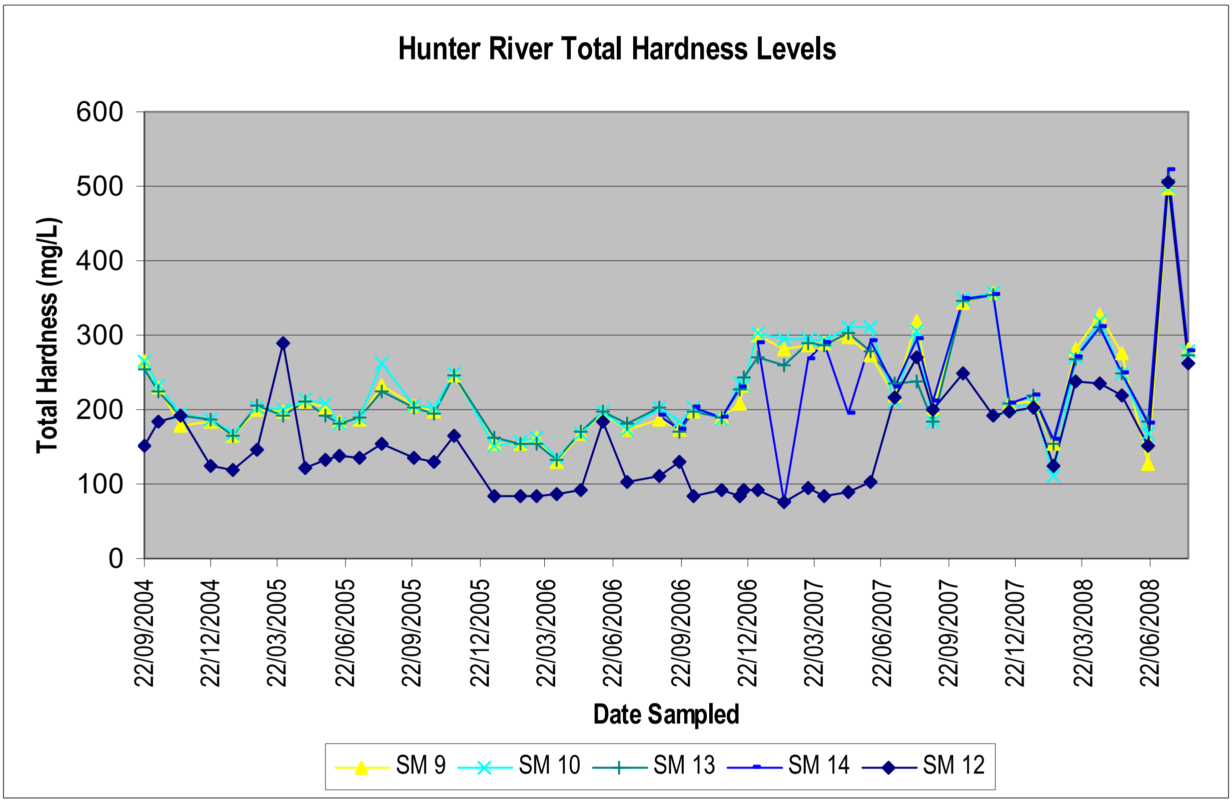

Glennies Creek pH levels
pH
Date Sampled
SM 7
SM 8
SM 11


Hunter River pH Levels
pH
Date Sampled
SM 9
SM 10
SM 13
SM 14
SM 12


Glennies Creek TSS Levels
TSS (mg/L)
140
120
100
80
60
40
20
0
22/09/2004
22/11/2004
22/01/2005
22/03/2005
22/05/2005
22/07/2005
22/09/2005
22/11/2005
22/01/2006
22/03/2006
22/05/2006
22/07/2006
22/09/2006
22/11/2006
22/01/2007
22/03/2007
22/05/2007
22/07/2007
22/09/2007
22/11/2007
22/01/2008
22/03/2008
22/05/2008
22/07/2008
Date Sampled
SM 7
SM 8
SM 11


Hunter River TSS Levels
TSS (mg/L)
250
200
150
100
50
0
22/09/2004
22/11/2004
22/01/2005
22/03/2005
22/05/2005
22/07/2005
22/09/2005
22/11/2005
22/01/2006
22/03/2006
22/05/2006
22/07/2006
22/09/2006
22/11/2006
22/01/2007
22/03/2007
22/05/2007
22/07/2007
22/09/2007
22/11/2007
22/01/2008
22/03/2008
22/05/2008
22/07/2008
Date Sampled
SM 9
SM 10
SM 13
SM 14
SM 12


Glennies Creek Total Hardness Levels
Total Hardness (mg/L)
0
50
100
150
200
250
300
350
400
450
500
22/09/2004
22/12/2004
22/03/2005
22/06/2005
22/09/2005
22/12/2005
22/03/2006
22/06/2006
22/09/2006
22/12/2006
22/03/2007
22/06/2007
22/09/2007
22/12/2007
22/03/2008
22/06/2008
Date Sampled
SM 7
SM 8
SM 11


Hunter River Total Hardness Levels
Total Hardness (mg/L)
0
100
200
300
400
500
600
22/09/2004
22/12/2004
22/03/2005
22/06/2005
22/09/2005
22/12/2005
22/03/2006
22/06/2006
22/09/2006
22/12/2006
22/03/2007
22/06/2007
22/09/2007
22/12/2007
22/03/2008
22/06/2008
Date Sampled
SM 9
SM 10
SM 13
SM 14
SM 12

APPENDIX B – HYDROLOGIC DATA & RESULTS

Appendix B – Hydrology Data and Results

Glennies Creek Dam Spillway Rating Curve

Elevation	Total Discharge (m^3/s)	Spillway Discharge (m^3/s)
186.0	0	0
186.5	0	0
187.0	23	23
187.5	61	61
188.0	107	107
188.5	160	160
189.0	219	219
189.5	282	282
190.0	351	351
190.5	423	423
191.0	498	498
191.5	578	578
192.0	660	660
192.5	746	746
192.8	800	800
193.3	1230	888
193.8	1883	981
194.3	2668	1076
194.8	3555	1174
195.3	4528	1274
195.7	5361	1356
196.3	6692	1482
198.1	11191	1876
199.7	15725	2248
200.0	16625	2320

Data provided by State Water

Glennies Creek Sub-Catchment data

Subcatchment ID	Area	Percentage Impervious	Average Slope	Roughness	Initial Loss	Continuing Loss
	ha	**%**	**%**	**n**	**mm**	**mm/hr**
SC 1	3827	0	0.7	0.08	20	3.6
SC 2	2080	0	1.6	0.08	20	3.6
SC 3	4890	0	0.7	0.08	20	3.6
SC 4	2730	0	3.6	0.08	20	3.6
SC 4a	1440	0	12.1	0.08	20	3.6
SC 5	4856	0	3.1	0.08	20	3.6
SC 6	2679	0	3.8	0.15	20	3.6
SC 7	2791	0	2.4	0.15	20	3.6
SC 7a	1185	0	6.1	0.15	20	3.6
SC 8	3907	0	3.1	0.15	20	3.6
SC 9	2470	0	4.1	0.15	20	3.6
SC 10	6969	0	4.5	0.20	20	3.6
SC 11	4336	0	2.8	0.20	20	3.6
SC 12	3827	0	7.1	0.20	20	3.6
SC 13	3430	0	5.8	0.20	20	3.6
Total	**51417**					

Lag time calculations

Lag times	Flowpath Length	Upstream Level	Downstream Level	Average Slope	Average Velocity	Lag Time
	m	mAHD	mAHD	%	ms	min
Link 13	10500	260	150	1.0	1.0	171
Link 12	10494	400	280	1.1	1.1	164
Link 11	8400	280	135	1.7	1.3	107
Link 10	3800	150	135	0.4	0.6	101
Link 9	3000	210	160	1.7	1.3	39
Link 8	10000	270	95	1.8	1.3	126
Link 7	4200	135	115	0.5	0.7	101
Link 7a	4200	135	115	0.5	0.7	101
Link 6	9500	160	95	0.7	0.8	191
Link 5	10000	95	70	0.3	0.5	333
Link 4	10000	95	70	0.3	0.5	333
Link 4a	5000	115	95	0.4	0.6	132
Link 3	8500	70	50	0.2	0.5	292
Link 2	8500	70	50	0.2	0.5	292

Glennies Creek Hydrology Results

Duration (hrs)	Peak Flow (m3/s)		
	5 Year	20 Year	100 Year
24	188	364	754
30	219	416	762
36	**237**	**457**	**834**
48	223	434	794
72	133	275	540

IFD Parameters

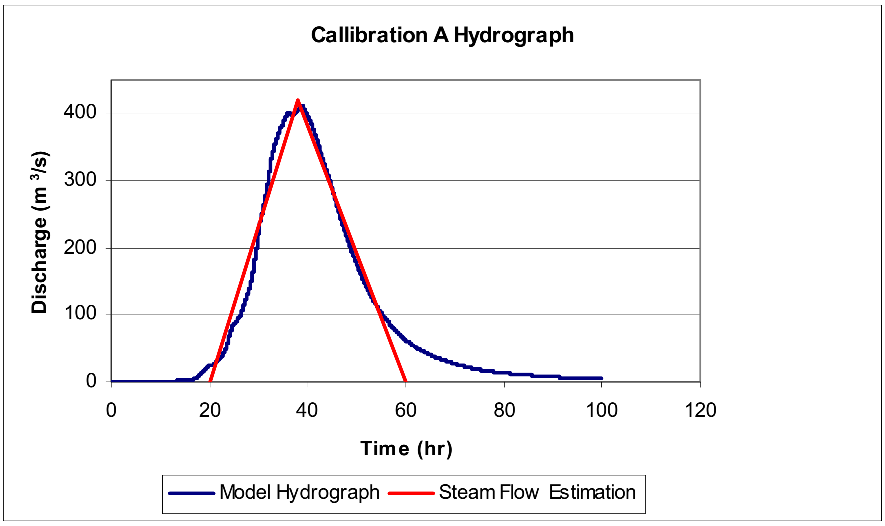
Parameter	Upper Catchment	Lower Catchment
${}^{1}I_{2}$	47	46
${}^{12}I_{2}$	11	10.1
${}^{72}I_{2}$	3.7	3.4
${}^{1}I_{50}$	26.5	25.2
${}^{12}I_{50}$	5.8	5.4
${}^{72}I_{50}$	1.8	1.7
F2	4.32	4.32
F50	15.95	15.95
G	0.75	0.75

Calibration

Storm A

	MIDDLE FALLBROOK GAUGE	61146	61176	61047
Date	Discharge (ML/d)	mm/day	mm/day	mm/day
9-May-62	65	0	0	0
10-May-62	187	53.8	58.4	30.5
11-May-62	1257	20.6	20.3	20.3
12-May-62	1752	13.5	6.9	9.4
13-May-62	5858	91.9	101.6	125
14-May-62	21589	37.3	40.6	42.7
15-May-62	5539	3	5.1	0
16-May-62	2315	0	0	0
17-May-62	1462	0	2.5	2.5

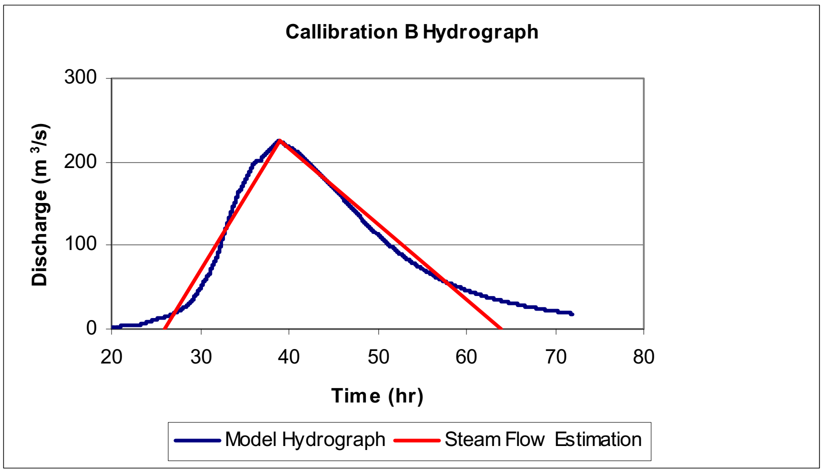
48 Hour Storm		
Gauge	**Avg Rainfall mm/hr**	
61176	2.96	
61047	3.49	
61146	2.69	
24hr Stream Flow	22,000	ML
72hr Streamflow	32,000	ML



Storm B

Date	MIDDLE FALLBROOK GAUGE Discharge (ML/d)	61272 mm/day	61146 mm/day
24-Jan-70	59	0	0
25-Jan-70	56	0	0
26-Jan-70	57	3.8	4.8
27-Jan-70	65	12.7	19.1
28-Jan-70	172	24.1	11.9
29-Jan-70	3175	24.9	97.3
30-Jan-70	14411	52.1	42.7
31-Jan-70	5667	9.4	11.9
1-Feb-70	1505	1.3	0
2-Feb-70	596	0	0.8
3-Feb-70	303	0	0

48 Hour Storm		
Gauge	**Avg Rainfall mm/hr**	
61272	1.604	
61146	2.917	
24 hr Stream Flow	14,000	ML



APPENDIX C – HEC-RAS RESULTS

WorleyParsons
resources & energy

HEC-RAS Cross-Section Data

Cross Section	ARI	Scenario	Water Surface Elevation	Maximum Channel Depth	Average Velocity	Froude Number	Energy Grade Line	Energy Grade Line Slope
			(m)	(m)	(m/s)		(m)	(m/m)
8680.61	5 yr	Proposed	62.14	3.81	1.3	0.23	62.22	0.000946
	5 yr	Existing	62.14	3.81	1.3	0.23	62.22	0.000946
	20 yr	Proposed	63.48	5.15	1.7	0.26	63.63	0.001069
	20 yr	Existing	63.48	5.15	1.7	0.26	63.63	0.001068
	100 yr	Proposed	65.04	6.71	2.04	0.29	65.27	0.001167
	100 yr	Existing	65.04	6.71	2.04	0.29	65.27	0.001168
8376.83	5 yr	Proposed	61.61	3.47	1.87	0.36	61.79	0.00225
	5 yr	Existing	61.61	3.47	1.87	0.36	61.79	0.00225
	20 yr	Proposed	62.91	4.77	2.22	0.37	63.18	0.002117
	20 yr	Existing	62.91	4.77	2.22	0.37	63.18	0.002116
	100 yr	Proposed	64.42	6.28	2.65	0.39	64.8	0.00208
	100 yr	Existing	64.42	6.28	2.65	0.39	64.8	0.002081
8123.42	5 yr	Proposed	61.42	4.64	1.16	0.2	61.49	0.000628
	5 yr	Existing	61.42	4.64	1.16	0.2	61.49	0.000627
	20 yr	Proposed	62.72	5.94	1.55	0.23	62.84	0.000755
	20 yr	Existing	62.72	5.94	1.55	0.23	62.84	0.000755
	100 yr	Proposed	64.19	7.41	2.05	0.27	64.41	0.00095
	100 yr	Existing	64.19	7.41	2.05	0.27	64.41	0.00095
7868.51	5 yr	Proposed	61.24	4.46	1.16	0.22	61.31	0.000805
	5 yr	Existing	61.24	4.46	1.16	0.22	61.31	0.000805
	20 yr	Proposed	62.52	5.74	1.46	0.23	62.64	0.00082
	20 yr	Existing	62.53	5.75	1.46	0.23	62.64	0.00082
	100 yr	Proposed	64.02	7.24	1.57	0.24	64.17	0.000822
	100 yr	Existing	64.02	7.24	1.57	0.25	64.17	0.000823
7659.81	5 yr	Proposed	61	4.22	1.44	0.25	61.11	0.001017
	5 yr	Existing	61	4.22	1.44	0.25	61.11	0.001017
	20 yr	Proposed	62.26	5.48	1.69	0.28	62.43	0.001122
	20 yr	Existing	62.26	5.48	1.69	0.28	62.43	0.001122
	100 yr	Proposed	63.78	7	1.78	0.28	63.97	0.001026
	100 yr	Existing	63.77	6.99	1.78	0.28	63.97	0.001028
7408.21	5 yr	Proposed	60.71	3.93	1.48	0.27	60.84	0.001176
	5 yr	Existing	60.71	3.93	1.48	0.27	60.84	0.001176
	20 yr	Proposed	61.99	5.21	1.61	0.27	62.15	0.001106
	20 yr	Existing	61.99	5.21	1.61	0.27	62.15	0.001106
	100 yr	Proposed	63.54	6.76	1.76	0.27	63.72	0.000949
	100 yr	Existing	63.54	6.76	1.76	0.27	63.72	0.000951
6986.49	5 yr	Proposed	60.18	3.53	1.47	0.28	60.29	0.001426
	5 yr	Existing	60.18	3.53	1.47	0.28	60.29	0.001426
	20 yr	Proposed	61.42	4.77	1.89	0.31	61.61	0.001485
	20 yr	Existing	61.42	4.77	1.89	0.31	61.61	0.001485
	100 yr	Proposed	62.89	6.24	2.4	0.34	63.2	0.001652
	100 yr	Existing	62.89	6.24	2.4	0.34	63.19	0.001655
6760.83	5 yr	Proposed	59.83	3.35	1.51	0.3	59.95	0.001545
	5 yr	Existing	59.83	3.35	1.51	0.3	59.95	0.001545

	20 yr	Proposed	61.09	4.61	1.87	0.31	61.28	0.001501
	20 yr	Existing	61.09	4.61	1.87	0.31	61.28	0.001501
	100 yr	Proposed	62.53	6.05	2.32	0.34	62.82	0.001612
	100 yr	Existing	62.53	6.05	2.32	0.34	62.82	0.001616
6452.9	5 yr	Proposed	59.63	3.81	0.79	0.18	59.66	0.000549
	5 yr	Existing	59.63	3.81	0.79	0.18	59.66	0.000549
	20 yr	Proposed	61.04	5.22	0.76	0.13	61.07	0.000256
	20 yr	Existing	61.04	5.22	0.76	0.13	61.07	0.000256
	100 yr	Proposed	62.56	6.74	0.82	0.13	62.6	0.000221
	100 yr	Existing	62.56	6.74	0.82	0.13	62.6	0.000222
6184.06	5 yr	Proposed	59.42	4.27	1.13	0.21	59.49	0.000769
	5 yr	Existing	59.42	4.27	1.13	0.21	59.49	0.000769
	20 yr	Proposed	60.85	5.7	1.43	0.22	60.95	0.000757
	20 yr	Existing	60.85	5.7	1.43	0.22	60.96	0.000757
	100 yr	Proposed	62.31	7.16	1.73	0.25	62.48	0.000878
	100 yr	Existing	62.31	7.16	1.73	0.25	62.48	0.000881
5816.38	5 yr	Proposed	58.99	4.15	1.44	0.29	59.1	0.001555
	5 yr	Existing	58.99	4.15	1.44	0.29	59.1	0.001553
	20 yr	Proposed	60.53	5.69	1.38	0.25	60.65	0.000947
	20 yr	Existing	60.53	5.69	1.38	0.25	60.65	0.000947
	100 yr	Proposed	62.06	7.22	1.49	0.23	62.18	0.00072
	100 yr	Existing	62.05	7.21	1.49	0.23	62.18	0.000723
5498.01	5 yr	Proposed	58.7	4.34	1.11	0.2	58.77	0.000691
	5 yr	Existing	58.7	4.34	1.11	0.2	58.77	0.00069
	20 yr	Proposed	60.31	5.95	1.25	0.2	60.4	0.0006
	20 yr	Existing	60.31	5.95	1.25	0.2	60.4	0.000599
	100 yr	Proposed	61.86	7.5	1.45	0.21	61.98	0.00058
	100 yr	Existing	61.85	7.49	1.45	0.21	61.97	0.000582
5216.06	5 yr	Proposed	58.42	5.12	1.42	0.25	58.52	0.001081
	5 yr	Existing	58.42	5.12	1.42	0.25	58.52	0.00108
	20 yr	Proposed	60.01	6.71	1.79	0.26	60.17	0.001066
	20 yr	Existing	60.01	6.71	1.79	0.26	60.17	0.001066
	100 yr	Proposed	61.42	8.12	2.3	0.31	61.72	0.001385
	100 yr	Existing	61.41	8.11	2.3	0.31	61.71	0.001393
5174.08	5 yr	Proposed	58.35	5.03	1.54	0.27	58.47	0.001196
	5 yr	Existing	58.35	5.03	1.54	0.27	58.47	0.001194
	20 yr	Proposed	59.94	6.62	1.87	0.28	60.13	0.001134
	20 yr	Existing	59.94	6.62	1.87	0.28	60.13	0.001133
	100 yr	Proposed	61.3	7.98	2.5	0.34	61.65	0.001599
	100 yr	Existing	61.29	7.97	2.51	0.34	61.65	0.001607
5160			Bridge					
5149.17	5 yr	Proposed	58.31	5	1.33	0.22	58.4	0.000769
	5 yr	Existing	58.31	5	1.33	0.22	58.4	0.000769
	20 yr	Proposed	59.88	6.57	1.71	0.24	60.04	0.000844
	20 yr	Existing	59.88	6.57	1.71	0.24	60.04	0.000845
	100 yr	Proposed	61.2	7.89	2.35	0.31	61.5	0.001274
	100 yr	Existing	61.19	7.88	2.36	0.31	61.49	0.001281
5021.88	5 yr	Proposed	58.18	4.99	1.43	0.25	58.29	0.001053
	5 yr	Existing	58.18	4.99	1.43	0.25	58.29	0.001052
	20 yr	Proposed	59.73	6.54	1.86	0.28	59.9	0.001292

	20 yr	Existing	59.73	6.54	1.86	0.28	59.9	0.001293
	100 yr	Proposed	60.96	7.77	2.52	0.36	61.3	0.001969
	100 yr	Existing	60.95	7.76	2.53	0.36	61.29	0.001985
4724.28	5 yr	Proposed	57.87	4.88	1.44	0.25	57.97	0.001068
	5 yr	Existing	57.87	4.87	1.44	0.25	57.97	0.001069
	20 yr	Proposed	59.38	6.39	1.49	0.27	59.53	0.001183
	20 yr	Existing	59.38	6.39	1.49	0.27	59.52	0.001184
	100 yr	Proposed	60.74	7.75	1.4	0.24	60.86	0.000897
	100 yr	Existing	60.72	7.73	1.41	0.25	60.84	0.000915
4389.29	5 yr	Proposed	57.55	4.56	1.32	0.23	57.63	0.000918
	5 yr	Existing	57.55	4.56	1.32	0.23	57.63	0.000918
	20 yr	Proposed	58.95	5.96	1.67	0.29	59.1	0.001375
	20 yr	Existing	58.95	5.96	1.67	0.29	59.1	0.001375
	100 yr	Proposed	60.32	7.33	1.59	0.3	60.48	0.001466
	100 yr	Existing	60.29	7.3	1.61	0.31	60.45	0.001519
3958.19	5 yr	Proposed	57.22	5	1.07	0.2	57.28	0.000696
	5 yr	Existing	57.22	5	1.07	0.2	57.28	0.000696
	20 yr	Proposed	58.5	6.28	1.4	0.24	58.6	0.000925
	20 yr	Existing	58.5	6.28	1.4	0.24	58.6	0.000925
	100 yr	Proposed	59.77	7.55	1.79	0.27	59.94	0.001075
	100 yr	Existing	59.72	7.5	1.78	0.27	59.9	0.001103
3584.46	5 yr	Proposed	56.99	5.13	1.09	0.18	57.06	0.000538
	5 yr	Existing	56.99	5.13	1.09	0.18	57.05	0.000538
	20 yr	Proposed	58.12	6.26	1.59	0.25	58.25	0.000958
	20 yr	Existing	58.12	6.26	1.59	0.25	58.25	0.000958
	100 yr	Proposed	59.22	7.36	2.15	0.31	59.47	0.001444
	100 yr	Existing	59.22	7.36	1.85	0.3	59.44	0.00132
3221.85	5 yr	Proposed	56.85	4.99	0.8	0.15	56.89	0.000384
	5 yr	Existing	56.85	4.99	0.8	0.15	56.88	0.000384
	20 yr	Proposed	57.93	6.08	0.99	0.17	57.99	0.000479
	20 yr	Existing	57.93	6.07	0.99	0.17	57.99	0.00048
	100 yr	Proposed	59.04	7.18	1.21	0.19	59.12	0.000535
	100 yr	Existing	59.03	7.17	1.21	0.19	59.12	0.000538
2965.25	5 yr	Proposed	56.79	5.01	0.61	0.11	56.81	0.000203
	5 yr	Existing	56.79	5.01	0.61	0.11	56.81	0.000203
	20 yr	Proposed	57.86	6.08	0.83	0.13	57.89	0.000272
	20 yr	Existing	57.85	6.07	0.83	0.13	57.89	0.000272
	100 yr	Proposed	58.94	7.16	1.03	0.16	59	0.000368
	100 yr	Existing	58.94	7.16	0.99	0.16	59	0.000362
2780.57	5 yr	Proposed	56.78	5.59	0.38	0.07	56.79	0.000085
	5 yr	Existing	56.78	5.59	0.38	0.07	56.79	0.000085
	20 yr	Proposed	57.85	6.66	0.5	0.08	57.86	0.000093
	20 yr	Existing	57.85	6.66	0.5	0.08	57.86	0.000093
	100 yr	Proposed	58.94	7.75	0.68	0.09	58.96	0.000123
	100 yr	Existing	58.93	7.74	0.69	0.09	58.95	0.000124
2651.49	5 yr	Proposed	56.77	5.82	0.29	0.05	56.78	0.000039
	5 yr	Existing	56.77	5.82	0.29	0.05	56.78	0.000039
	20 yr	Proposed	57.85	6.9	0.37	0.06	57.85	0.000048
	20 yr	Existing	57.84	6.89	0.37	0.06	57.85	0.000048
	100 yr	Proposed	58.93	7.98	0.47	0.07	58.95	0.000067

	100 yr	Existing	58.93	7.98	0.46	0.07	58.94	0.000067
2371.08	5 yr	Proposed	56.75	6.26	0.5	0.09	56.76	0.000115
	5 yr	Existing	56.75	6.26	0.5	0.09	56.76	0.000115
	20 yr	Proposed	57.8	7.31	0.7	0.11	57.83	0.000166
	20 yr	Existing	57.8	7.31	0.68	0.11	57.83	0.000165
	100 yr	Proposed	58.87	8.38	0.89	0.13	58.91	0.000238
	100 yr	Existing	58.87	8.38	0.8	0.13	58.91	0.000218
2106.89	5 yr	Proposed	56.74	6.34	0.26	0.04	56.74	0.000029
	5 yr	Existing	56.74	6.34	0.26	0.04	56.74	0.000028
	20 yr	Proposed	57.8	7.4	0.34	0.05	57.8	0.00004
	20 yr	Existing	57.8	7.4	0.33	0.05	57.8	0.000038
	100 yr	Proposed	58.87	8.47	0.43	0.06	58.88	0.000053
	100 yr	Existing	58.87	8.47	0.41	0.06	58.88	0.000049
1838.11	5 yr	Proposed	56.73	6.73	0.24	0.04	56.74	0.000021
	5 yr	Existing	56.73	6.73	0.23	0.04	56.74	0.000021
	20 yr	Proposed	57.79	7.79	0.31	0.05	57.79	0.000032
	20 yr	Existing	57.79	7.79	0.3	0.05	57.79	0.000032
	100 yr	Proposed	58.85	8.85	0.39	0.06	58.86	0.000044
	100 yr	Existing	58.85	8.85	0.38	0.06	58.86	0.000042
1785.06	5 yr	Proposed	56.73	7.07	0.25	0.04	56.74	0.000019
	5 yr	Existing	56.73	7.07	0.25	0.04	56.74	0.000019
	20 yr	Proposed	57.78	8.12	0.37	0.05	57.79	0.000035
	20 yr	Existing	57.78	8.12	0.37	0.05	57.79	0.000035
	100 yr	Proposed	58.84	9.18	0.52	0.07	58.86	0.000061
	100 yr	Existing	58.84	9.18	0.52	0.07	58.86	0.000061
1481	5 yr	Proposed	56.71	8.39	0.41	0.07	56.72	0.000072
	5 yr	Existing	56.71	8.39	0.41	0.07	56.72	0.000072
	20 yr	Proposed	57.76	9.44	0.47	0.08	57.77	0.000089
	20 yr	Existing	57.76	9.44	0.47	0.08	57.77	0.000089
	100 yr	Proposed	58.81	10.49	0.59	0.09	58.83	0.000105
	100 yr	Existing	58.81	10.49	0.59	0.09	58.84	0.000105
689.06	5 yr	Proposed	56.66	8.34	0.42	0.07	56.67	0.000072
	5 yr	Existing	56.66	8.34	0.42	0.07	56.67	0.000072
	20 yr	Proposed	57.69	9.37	0.47	0.08	57.71	0.000092
	20 yr	Existing	57.69	9.37	0.47	0.08	57.71	0.000092
	100 yr	Proposed	58.74	10.42	0.52	0.09	58.76	0.000099
	100 yr	Existing	58.74	10.42	0.52	0.09	58.76	0.000099
438.49	5 yr	Proposed	56.63	8.21	0.58	0.08	56.65	0.000098
	5 yr	Existing	56.63	8.21	0.58	0.08	56.65	0.000098
	20 yr	Proposed	57.63	9.21	0.84	0.12	57.67	0.000185
	20 yr	Existing	57.63	9.21	0.84	0.12	57.67	0.000185
	100 yr	Proposed	58.63	10.21	1.15	0.16	58.71	0.000338
	100 yr	Existing	58.63	10.21	1.15	0.16	58.71	0.000338
347.02	5 yr	Proposed	56.62	8.12	0.54	0.09	56.64	0.000111
	5 yr	Existing	56.62	8.12	0.54	0.09	56.64	0.000111
	20 yr	Proposed	57.62	9.12	0.64	0.11	57.65	0.000156
	20 yr	Existing	57.62	9.12	0.64	0.11	57.65	0.000156
	100 yr	Proposed	58.63	10.13	0.72	0.13	58.67	0.000208
	100 yr	Existing	58.63	10.13	0.72	0.13	58.67	0.000208
0	5 yr	Proposed	56.6	8.13	0.37	0.06	56.61	0.000053

	5 yr	Existing	56.6	8.13	0.37	0.06	56.61	0.000053
	20 yr	Proposed	57.6	9.13	0.45	0.07	57.61	0.000072
	20 yr	Existing	57.6	9.13	0.45	0.07	57.61	0.000072
	100 yr	Proposed	58.6	10.13	0.57	0.09	58.62	0.000097
	100 yr	Existing	58.6	10.13	0.57	0.09	58.62	0.000097

HEC-RAS Cross-Section Data - PMF

Cross Section	Scenario	Water Surface Elevation	Maximum Channel Depth	Average Velocity	Froude Number	Energy Grade Line	Energy Grade Line Slope
		(m)	(m)	(m/s)		(m)	(m/m)
8680.61	Dam Break	94.24	35.91	4.37	0.24	95.22	0.000442
	PMP	68.74	10.41	1.86	0.26	68.98	0.000798
8376.83	Dam Break	93.25	35.11	5.74	0.32	94.98	0.000793
	PMP	67.31	9.17	3.78	0.57	68.43	0.003949
8123.42	Dam Break	93.5	36.72	4.75	0.26	94.65	0.000518
	PMP	67.1	10.32	2.75	0.37	67.65	0.001664
7868.51	Dam Break	93.75	36.97	3.59	0.19	94.41	0.000276
	PMP	67.13	10.35	1.57	0.23	67.29	0.000634
7659.81	Dam Break	93.61	36.83	3.8	0.2	94.34	0.000306
	PMP	66.96	10.18	1.69	0.25	67.14	0.000729
7408.21	Dam Break	93.34	36.56	4.19	0.22	94.24	0.000371
	PMP	66.77	9.99	1.68	0.26	66.96	0.000772
6986.49	Dam Break	92.57	35.92	5.26	0.29	94	0.000628
	PMP	65.97	9.32	2.58	0.38	66.46	0.001768
6760.83	Dam Break	92.56	36.08	4.94	0.27	93.82	0.000539
	PMP	65.73	9.25	2.25	0.33	66.07	0.001353
6452.9	Dam Break	92.95	37.13	3.28	0.17	93.51	0.000209
	PMP	65.8	9.98	1.03	0.13	65.85	0.000204
6184.06	Dam Break	92.88	37.73	3.32	0.17	93.45	0.000223
	PMP	65.63	10.48	1.43	0.21	65.77	0.000531
5816.38	Dam Break	92.42	37.58	4.19	0.22	93.32	0.00038
	PMP	65.37	10.53	1.78	0.24	65.55	0.000684
5498.01	Dam Break	91.93	37.57	4.88	0.27	93.15	0.00053
	PMP	65.13	10.77	1.89	0.24	65.34	0.000651
5216.06	Dam Break	90.59	37.29	6.61	0.37	92.85	0.001072
	PMP	64.49	11.19	2.83	0.38	65.03	0.001776
5174.08	Dam Break	88.32	35	9.1	0.55	92.59	0.002394
	PMP	63.88	10.56	4.25	0.5	64.88	0.003098
5160		Bridge					
5149.17	Dam Break	76.46	23.15	16.71	1.33	91.26	0.016059
	PMP	63.19	9.88	4.59	0.54	64.36	0.003653
5021.88	Dam Break	69.05	15.86	18.01	2.05	87.66	0.046676
	PMP	62.9	9.71	3.61	0.54	63.79	0.00397
4724.28	Dam Break	75.19	22.2	6.7	0.51	77.54	0.002486
	PMP	62.81	9.82	1.85	0.29	63.02	0.001135
4389.29	Dam Break	74.83	21.84	5.84	0.46	76.62	0.002015

	PMP	62.46	9.47	1.77	0.28	62.64	0.001119
3958.19	Dam Break	74.2	21.98	5.75	0.47	75.9	0.002064
	PMP	61.64	9.42	2.43	0.37	62.03	0.001842
3584.46	Dam Break	73.32	21.47	6.01	0.49	75.18	0.002266
	PMP	61.02	9.16	2.16	0.37	61.36	0.001803
3221.85	Dam Break	73.47	21.61	4.22	0.34	74.38	0.00106
	PMP	60.35	8.49	2.19	0.39	60.69	0.001999
2965.25	Dam Break	73.21	21.43	4.22	0.32	74.12	0.000969
	PMP	60.13	8.35	1.57	0.26	60.31	0.000914
2780.57	Dam Break	72.34	21.15	5.43	0.41	73.87	0.001614
	PMP	60.08	8.89	1.44	0.18	60.19	0.000441
2651.49	Dam Break	72.63	21.68	4.22	0.3	73.55	0.000834
	PMP	60.1	9.15	0.88	0.12	60.14	0.000194
2371.08	Dam Break	70.02	19.53	7.58	0.62	72.97	0.003704
	PMP	59.89	9.4	1.53	0.24	60.04	0.00075
2106.89	Dam Break	70.7	20.3	5.08	0.38	72.02	0.00136
	PMP	59.88	9.48	0.85	0.13	59.92	0.000201
1838.11	Dam Break	70.53	20.53	4.55	0.35	71.59	0.001152
	PMP	59.83	9.83	0.79	0.11	59.87	0.000161
1785.06	Dam Break	70.47	20.81	4.41	0.37	71.5	0.001263
	PMP	59.77	10.11	1.11	0.15	59.85	0.000285
1481	Dam Break	70.17	21.85	4.27	0.34	71.11	0.001098
	PMP	59.65	11.33	1.23	0.18	59.75	0.000414
689.06	Dam Break	69.5	21.18	3.99	0.34	70.32	0.001135
	PMP	59.35	11.03	1.13	0.18	59.44	0.000428
438.49	Dam Break	68.18	19.76	5.65	0.52	69.86	0.002719
	PMP	58.43	10.01	3.43	0.47	59.16	0.002958
347.02	Dam Break	68.14	19.64	5.2	0.45	69.52	0.002046
	PMP	58.45	9.95	2.25	0.38	58.83	0.001973
0	Dam Break	64.57	16.1	8.11	0.84	68.1	0.007635
	PMP	58	9.53	1.96	0.31	58.25	0.001282

APPENDIX D – DAM SIZE CALCULATIONS

WorleyParsons

Project Number: **301017-00136**

Appendix D - Dam Calculations

	Assumptions	
Soil Type	DISPERSIVE	Type D' soil
Average Rainfall	20yr, 12hr storm	7.93mm/hr
Intensity	100yr, 72hr storm	3.32mm/hr
Runoff Coefficient	0.7	

SEDIMENT DAM SIZING CALCULATIONS

Basin Catchment Area (ha)

Sediment Basin	Year 1	Year 3	Year 5	Year 7
SD 1	26	49	49	49
SD 2 (a & b)	17	52	52	52
SD 3	6	6	6	6

Required Retention Volume (ML) - 20yr ARI Storm Event

Sediment Basin	Year 1	Year 3	Year 5	Year 7
SD 1	17	33	33	33
SD 2 (a & b)	11	35	35	35
SD 3	4	4	4	4

Required Sediment Storage Volume (ML) - 20yr ARI Storm Event

Sediment Basin	Year 1	Year 3	Year 5	Year 7
SD 1	9	16	16	16
SD 2 (a & b)	6	17	17	17
SD 3	2	2	2	2

Minimum Required Sediment Basin Volume (ML) - 20yr ARI Storm Event

Sediment Basin	Year 1	Year 3	Year 5	Year 7
SD 1	26	49	49	49
SD 2 (a & b)	17	52	52	52
SD 3	6	6	6	6

MINE WATER DAM SIZING CALCULATIONS

Catchment Area (Ha)

Mine Water Dam	1 year	3 year	5 year	7 year	
MW1	105	In Pit Storage	In Pit Storage	In Pit Storage	
					75

Storage Volume (ML) - 100yr ARI Storm Event

Mine Water Dam Name	1 year	3 year	5 year	7 year
MW1	176	In Pit Storage	In Pit Storage	In Pit Storage

*NOTE: Mine water storage to be provided in pit after Year 2

CLEAN WATER DAM SIZING CALCULATIONS

Catchment Area (Ha)

Basin Name	1 year	3 year	5 year	7 year
CW1	135	135	135	135
CW2	N/A	N/A	83	83
				218

Flood Storage Volume (ML) - 20yr ARI Storm Event

Basin Name	1 year	3 year	5 year	7 year
CW1	90	90	90	90
CW2	N/A	N/A	55	55

APPENDIX E – WASTEWATER TREATMENT

ASHTON COAL WASTEWATER TREATMENT

Ashton Coal On-site Water Demands/Flow

New on-site wastewater facilities are to be provided to service new facilities for 160 staff.

Ashton Coal Operations Limited currently operates three existing on-site sewerage management systems as follows:

- Underground mine bath-house and administration buildings. The sewage treatment system is a two-stage Biolytix type with tertiary bromide dosing. Treated effluent is disposed of by spray irrigation,
- CHPP facilities and open cut bath-house combine, which treats waste from 25 showers, 11 WC's, 8 hand basins and one sink. The sewage treatment system is currently an Envirocycle type with disposal of by spray irrigation
- Open cut mine workshop which treats 4 showers, 4 WC's, 3 hand basins and a sink. The sewage treatment system is an Envirocycle type with disposal of the treated effluent by spray irrigation

New facilities are proposed at the Open Cut Mine Workshop, which include approximately:

- 29 Showers
- 15 WC's
- 13 Basins/Sinks
- Possible Kitchen Facilities

Peak and average wastewater loads have been estimated using a selection of methods as listed below. The results were then compared to give an approximate average flow and demands. Methods used include:

1. Hunter Water's water demand estimating criteria assuming that water use will be equivalent to wastewater load.
2. Water use estimated from assumptions based on the probable usage patterns of the number of staff on each shift and the water demands of individual water using appliances:
3. Other Guidelines (e.g. Victorian Onsite guidelines etc).

Each of these methods is discussed below:

Hunter Waters water demand estimating criteria.

Hunter Water's water demand estimating criteria was applied to the proposed new facilities assuming that water use will be equivalent to wastewater loads. The above facilities have been quantified in terms of the Equivalent Tenements (ET's) using Hunter Water's Development Customer Classification Tables, as detailed in **Table 1** below.

Table 1 ET Classification

ET Classification	Based on HW Classification	Unit	ET/unit	Total ET
Shower	Fitness Centre's Gym	29	0.42	12.18
WC	Office	15	0.4	6
Basin	Half ET of a Shower	13	0.21	2.73
			Total	**20.91**

The Fitness Centre classification for showers and the office classification for WC's were chosen as good representation of water usage at the Open Cut Coal wash shed facilities. A conservative approach was taken for the proposed washing basins – each basin was assumed to be half the ET of a shower. The Open cut mine workshop represents 21 ET's.

Assuming a total ET of 21 and using the HWC Water and Sewer Design Manual, the average daily flow was calculated as follows:

Table 2 ET's converted into Average and Peak Flows via HWC Water and Sewer Design Manual

ET's	Design	Average Day	
	Average Consumption (kL/year)	(kL/day)	(ML/day)
21	285.0	**16.3**	0.016

As seen above in **Table 2,** the average daily flow based on Hunter Water estimating Guidelines is 16.3kL/day.

Water use estimated from assumptions based on the probable usage patterns of the number of staff on each shift and the water demands of individual water using appliances

Water demands based on the 1996 NSW Planning Draft Water Use Guidelines were applied based on 160 people at the Coal facility. This method calculates flow in L/person/day for a variety if different water using appliances. The guidelines recommend values of:

- 10L/person/day for a sink
- 7.0L/person/day for a basin
- 112L/person/day for a 7 minute shower (without any water saving devices)
- 18.2L/person/day for a WC (using a dual flush system)

Assuming that each person at Ashton Coal uses the facilities at least once on a day the average site water use is 23.6kL/day or 147.2L/person/day. Assuming that every shower is being used at the change of shift, this produces a peak flow of 7.7L/s.

Other Methods of Wastewater Load Estimation

The Australian and New Zealand Standard 1547:2000 for On-site domestic wastewater management recommend a typical domestic wastewater flow design allowance between 140 – 180 L/person/day for a motel/hotel room. Likewise, the Victorian Codes of Practice for small wastewater treatment plants suggests a daily flow of 100-180L/person/day to be used for hotels and motels. Using a design allowance of 160 and 140 respectively results in L/person/day results in a design average load of 25.6 and 22.4 kL/day

While the Ashton Coal facility is not a hotel, it displays similar flow patterns, as each guest in a hotel will use each facility during their stay. This is similar to the shift worker's patterns at Ashton Coal Facility, where the workers will use the facilities about the same amount as a hotel guest would, producing a peak flow when the facilities are in high demand.

Recommended Design Wastewater Load

Determining the average daily flow and the peak flow demand required investigation of the recommended guidelines for domestic and commercial on-site wastewater design flows.

It is recommended that the loads determined using the 1996 NSW Planning Draft Water Use Guidelines be adopted for a new treatment system for the Open Cut Mine Workshop. These loads compare favourably to loads calculated using Hunter Water Demand Estimates the , Victorian Codes of practice and the AS/NZ 1547:2000 Standards as demonstrated in Table 3 below.

Table 3 Comparison of Methods

Methods	Hunter Water Demand Estimates	Water Demands (1996 NSW Planning Draft Water Use Guidelines) (Appliance Use)	Victorian Codes of Practice (Hotel)	AS/NZ 1547:2000 Standards (Hotel)	Recommended Design flows
Average Day (kL/day)	16.3	**23.6**	22.4	25.6	**24**
Peak Flow Demand (L/s)	-	**7.7**	-	-	**7.7**

Detailed calculation can be seen in **Appendix A**

Balancing Storage

It is suggested that a balancing storage may be required should all 160 workers be coming of shift and showing within a short period of time, say 30 minutes. The balance tank would need to hold approximately 14m^3 to capture the peak flow demand. A suitable above ground sized balance GRP tank of 20KL is recommended so the amenities flow into it.

Irrigation Methods

Disposal Area Calculations

Estimated land areas required for both irrigation (spray, trickle or subsurface) and evapotranspiration absorption (ETA) systems are presented below and are based on effluent quality and loading rates supplied. Minimum disposal areas have been calculated by taking account of both the hydraulic capability of the land to accept effluent as well as the ability of the land to accept nutrients. The main parameters used in these calculations are outline below in **Table 4**

Table 4 Design Parameters

Parameter	Values Used
Nitrogen Loading ($mg/m^2/day$)	25
Phosphorus loading ($mg/m^2/day$)	3
BOD Loading ($mg/L)^2$	20
Rainfall Data	Jerry's Plain Post Office
Evapotranspiration Data	Jerry's Plain Post Office
Estimated Annual flow rate (L/day)*	10,560
DIR (mm/week)	15
Design Period	50
Phosphorus Sorption Capacity**	892.5

Notes to **Table 4:**

DIR – Design Irrigation Rate in accordance with AS 1547-2000

*Calculated from 160 persons using 66L per day per person

**Based on Average Soil Profiles

During periods of rainfall, the nutrient levels in the effluent would be diluted, increasing the importance of the hydraulic capability of the soil. Wet weather storage should be provided for prolonged heavy rainfall events.

Existing Site Conditions

The minimum plan areas for effluent disposal are listed in **Table 5** below and are based on the following assumptions:

- The current soil profile is retained and unchanged;
- On-site disposal of 100% of generated wastewater;
- Sufficient land area is available for the purpose

Table 5 Minimum Plan Area Required for Effluent Disposal

Daily Effluent Load (L/day)	Nitrogen Balance Area (m^2)	Phosphorus Balance Area (m^2)	Hydraulic Loading
			Recommended Wet Weather Storage (m3)
10,560	6336	18246	621

Based on the above calculations, a land area of between 6336m^2 and 18246m^2 would be required to dispose of all wastewater generated by the Open Cut Mine Workshop. Since phosphorus is the limiting nutrient, it is recommended that for irrigation purposes, a land area of **18,246m^2** or 1.8ha is made available to dispose of wastewater generated by the coal handling facilities (for details on irrigation calculations, see **Appendix A**).

Envirocycle

Description of Treatment System

WorleyParsons contacted Envirocycle who indicated that Envirocycle Model 110NR with ultra-violet treatment would adequately treat 24,000 litres per day. The approximate cost of the Envirocycle 110 Commercial Wastewater Treatment System including 5 × 22,500L concrete tanks (storage) UV disinfection, water pumps, aerators, alarm panel and installation and 12 months maintenance is $108,000. Excavation, plumbing, electrical installation and irrigation are not included in this price. Two pumps would be installed, one acting as an emergency backup with separate alarms. The disinfected water will be pumped through an underground main irrigation line to an irrigation network.

Other proprietary treatment systems that are suitable for treating wastewater from the proposed facility are also available from other manufactures, and some cost savings may be realised by letting a performance based tender.

APPENDIX A

Phosphorus Sorptions Rates

Psorption Average
151 mg/Kg
312 mg/Kg
139 mg/Kg
248 mg/Kg
212.5 mg/Kg 212.5 × 10^6 KgP

1 ha × 0.3m = 3000m^3 × 1.4(m^3/t) × 1000Kg

= **4.2×10^6 Kg soil/ha**
P sorption Capacity
= **892.5 Kg.P/ha**

Lab No	Method	P7B/1 Particle Size Analysis (%)					P8A/2	P9B/2	C1A/4	C2A/3	C8B/1	
	Sample Id	clay	silt	f sand	c sand	gravel	D%	EAT	EC (dS/m)	pH	P sorp (mg/kg)	P sorp index
1	TP74/1 0-0.12 m	20	25	39	15	1	40	8/3(1)	0.03	5.7	151	1.5
2	TP74/2 0.12-0.40 m	55	20	20	5	<1	39	3(3)	0.12	5.6	312	2.5
3	TP79/1 0-0.07 m	12	15	34	29	10	21	8/3(1)	0.04	5.6	nt	nt
4	TP79/3 0.14-0.83 m	39	13	18	24	6	83	2(2)	0.45	8.4	nt	nt
5	TP80/1 0-0.08 m	15	14	31	18	22	19	8/3(1)	0.04	6.0	nt	nt
6	TP80/3 0.16-0.60 m	55	15	18	10	2	62	2(1)	0.35	7.6	nt	nt
7	TP80/4 0.60-1.20 m	53	16	24	7	0	84	2(3)	0.64	5.6	nt	nt
8	TP81/1 0-0.20 m	14	12	62	12	0	11	3(1)	0.02	6.3	nt	nt
9	TP81/2 0.20-1.20 m	15	12	49	24	0	48	3(2)	0.05	7.3	nt	nt
10	TP81/3 1.20-2.20 m	10	3	31	56	<1	45	3(2)	0.10	7.0	nt	nt
11	TP88/1 0-0.24 m	14	14	28	43	1	15	3(1)	<0.01	5.9	139	1.4
12	TP88/3 0.38-0.65 m	35	12	16	37	<1	55	3(2)	0.03	6.8	248	2.0
13	TP89/1 0-0.45 m	17	27	53	3	0	31	3(1)	0.04	6.9	nt	nt
14	TP89/2 0.45-0.90 m	41	14	40	5	0	52	2(1)	0.10	7.6	nt	nt
15	TP89/5 1.50-2.50 m	26	20	49	5	0	71	2(2)	0.19	7.2	nt	nt
16	TP90/1 0-0.15 m	20	14	49	10	7	18	8/3(1)	0.02	6.3	nt	nt
17	TP90/3 0.30-0.60 m	56	9	26	8	1	25	2(1)	0.19	8.6	nt	nt

nt = not tested

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CALCULATING IRRIGATION AREA AND WET WEATHER STORAGE

$$A = \frac{C \times Q}{L_x}$$

A = Land Area (m^2)
C = Concentration of Nutrient (mg/L)
10,560 **Q** = treated wastewater flow rate (L/d)
L_x = critical loading rate of nutrient ($mg/m^2/d$)
Q calculated from 160 persons using 66L per day per person

Open Cut Mine		CHPP Facilities		Actual Use (L/persons/day)		
4	*Showers*	25	*Showers*	112.0	*Shower*	3248
4	*WC's*	11	*WC's*	55.0	*Toliet*	825
3	*Hand Basins*	8	*Hand Basins*	7.0	*Basin*	77
1	*Sink*	1	*Sink*	10.0	*Sink*	20
						4170

Model Parameters (Data sourced from Douglas Partners Report Nov, 2005)

	Parameter	L_x ($mg/m^2/day$)
Nitrogen Loading (mg/L)	15	25
Phosphorus Loading (mg/L)	8	3
BOD Loading (mg/L)	20	
Rainfall Data	Singleton	
Evaporation Data	Cessnock	
Estimated Annual Flow Rate (ML/yr)	10	
DIR (mm/week)	15	
DLR (mm/day)	5	
Design Period (yrs)	10	
Phosphorus Sorption Capacity (kg P/ha)**	892.5	

Crop Factor

0.5	Shrubs
0.6	Lawn
0.7	Lawn
0.8	Turf
1	Forest

Jerry's Plain Post Office Data

	Mean Rainfall (mm)	Decile 5 monthly Rainfall (mm)
Jan	77.4	65.1
Feb	71.8	46
Mar	58	45.7
Apr	43.9	32.3
May	40.4	28.7
Jun	47.5	29.6
Jul	43.6	35.4
Aug	36.5	30.6
Sep	41.6	34
Oct	52	48
Nov	59.8	49.6
Dec	67.5	55
Mean Rainfall	638	

Nitrogen Loading
Irrigation Area Required
A= 6336 m^2

Phosphorus Loading

$P_{absorbed}$ = 297.5 kg/ha
0.02975 kg/m^2
$P_{uptake**}$ = 54750 mg/m^2
0.05475 kg/m^2

*** Amount of Vegetation uptake over 20 years*

$P_{generated}$ = TP * Vol of Wastewater produced in 50 years
1.54E+09 mg
1541.76 kg

Irrigation Area Required
A= 18246 m^2

Month	Average Monthly Evaporation^ *(mm/month)*	Areal Potential Evapotranspiration *(mm/month)*
January	180	180
February	175	140
March	125	130
April	100	90
May	90	65
June	80	60
July	75	50
August	90	70
September	120	90
October	140	120
November	180	150
December	200	165
		109.1667

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MONTHLY WATER BALANCE USED TO DETERMINE WET WEATHER STORAGE

Design Wastewater Flow	Q	L/day	10,560
Design Percolation Rate	R	mm/wk	5
Land Area	L	m^2	18246

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	-	days	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipation	P	-	mm/month	77.4	71.8	58	43.9	40.4	47.5	43.6	36.5	41.6	52	59.8	67.5	640
Evaporation	E	-	mm/month	180	140	130	90	65	60	50	70	90	120	150	165	1310
Crop Factor	C	-	-	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	-

Inputs

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation	P	-	mm/month	77.4	71.8	58	43.9	40.4	47.5	43.6	36.5	41.6	52	59.8	67.5	640
Effluent Irrigation	W	(Q × D)/L	mm/month	17.94	16.21	17.94	17.36	17.94	17.36	17.94	17.94	17.36	17.94	17.36	17.94	211.25
Inputs		(P + W)	mm/month	95.34	88.01	75.94	61.26	58.34	64.86	61.54	54.44	58.96	69.94	77.16	85.44	851.25

Outputs

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Evapotranspiration	ET	E × C	mm/month	144	112	104	72	52	48	40	56	72	96	120	132	1048
Percolation	B	(R/7) × D	mm/month	22.14	20.00	22.14	21.43	22.14	21.43	22.14	22.14	21.43	22.14	21.43	22.14	260.71
Outputs		(ET + B)		166.14	132.00	126.14	93.43	74.14	69.43	62.14	78.14	93.43	118.14	141.43	154.14	1308.71

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Storage	S	(P + W) - (ET +B)	mm/month	-48.66	-23.99	-28.06	-10.74	6.34	16.86	**21.54**	-1.56	-13.04	-26.06	-42.84	-46.56	-
Cummulative Storage	M	-	mm	0.00	0.00	0.00	-10.74	-4.40	12.47	**34.01**	32.45	19.41	-6.64	-49.48	-96.04	-

Storage	V	Largest M Value	mm	34.01	
		(V × L)/ 1000	m^3	620.53	*Tank Size*

Job Name:	**ASHTON COAL ON-SITE TREATMENT**	**Job No:**	**7583**
Prepared by:		**Date:**	**16/06/2009**
System element:	**Wastewater Demands**		

Hunter Water Water Demand Estimates (Assuming Water in = Water Out)

Development Customer Classification & ET Methodolgy/Charges

Total ET

ET Classification	Based on HW Classification	Unit	ET/unit	Total ET
Shower	Fitness Centre's Gym	29	0.42	12.18
WC	Office	15	0.4	6
Basin	Half ET of a Shower	13	0.21	2.73
			Total	**20.91**

Diversity Factor		Diurnal Factor	
		(< 80 ET)	
ET	Factor	ET	Factor
21	1.9180303	20.91	1.8401977

Assumptions

Showers that were used to classifiy Industrial showers were Fitness centre Gym
WC that were used were that of offices
Basins and Sinks were combined - A basin was assummed to be half a shower (that of a Fitness centre gym shower)

	Connections	Design	Average Day		Peak Day Demand				Peak Hour Demand		
		Average Consumption (kL/year)	(kL/day)	(ML/day)	Peak Day Factor	Diversity Factor	Diurnal Factor	Total Demand (ML/day)	Peak Hour Factor	Total Demand (ML/day)	Total Demand (L/s)
ET (all other development)	21	285.0	16.3	0.01633	2.25	1.9180303	1	0.070	2.020	0.142	1.65
Unaccounted for Water			2.4	0.00001	1	1	1	0.000	1.000	0.000	0.00
Total			**19**	**0.00**				**0.070**		**0.142**	**1.65**

Hunter Water Wastewater Water Load Estimates

HWC Water and Sewer Design Manual

ADWF	ADWF=	0.23001	L/sec	19.87286	kL/day
Ratio of peak to Average Flow:	r=	4	L/sec	345.6	kL/day
Peak Dry Weather Flow	PDWF=	0.92004	L/sec	79.49146	kL/day

Assumming ET of 21
ADWF = ET × 0.011L/sec for each tenement
When ET is less than 30, use r=4.0
PDWF is = r × ADWF

Water Demands (Based on 1996 NSW Planning Draft Water Use Guidelines)

Number of Staff finishing each shift 160

Classification	Usage (L/person/day)	Average Day (kL/day)
Kitchen Sink	10.0	
Bathroom Basin	7.0	
Shower	112.0	
Toilet	18.2	
Total	**147.2**	**23.6**

Facilities

29 *Showers*
15 *WC's*
11 *Hand Basins*
2 *Sink*

Assumptions

Classification	Usage (L/person/day)	Peak Flow Demand (L/min)	Peak Flow demand (L/s)
Average Shower	112.0	464.0	7.7

This is the closest value from the guidelines that mimic the coal site (i.e. everyone on site will use each facility at least once)

Victorian Codes of Practice

Using Guide to design rates for WWTW - Motel/Hotel Category	100-180	L/person/day*
	22.4	kL/day/160 persons*
Comparison with NSW Planning Water Use Guidelines	147.2	L/person/day
	23.6	kL/day/160 persons

** Average taken to achieve L/person/day*

AS/NZS 1547:2000 Standards

Using Typical Domestic WW flow design allowances - Motel/Hotel	140 - 180	L/day/person*
	25.6	kL/day/160 persons*
Comparison with NSW Planning Water Use Guidelines	147.2	L/person/day
	23.6	kL/day/160 persons

Job Name: ASHTON COAL ON-SITE TREATMENT **Job No:** 7583

Prepared by: **Date:** 16/06/2009

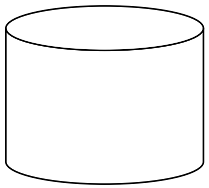
WorleyParsons
resources & energy

System element: Balance Tank

Peak Site Water Use (L/s)	7.73
(L/min)	464

Assuming Peak site water use is on shift change when all showers are in use and the average shower is 7 mins

Balance Tank



13.92 m^3 *Based on a 30 minute peak flow loading*

Tanks come in standard sizes - we could use a 20KL above ground GRP tank here, ideally located so the amenities flow into it.

APPENDIX F – SETTLEMENT CALCULATIONS

WorleyParsons
resources & energy

Calculation Sheet

Customer	Ashton Coal	**Proj No**	301017-00136
Project Title	Ashton South East Open Cut - Settlement under river	**Calc No**	1
Calculation Title	Calculation using Building on fill:geotechnical aspects	**Phase/CTR**	3
Elec File Location	K:\FRASER\GEOTECHNICAL\PROJECTS\301017-00136 Ashton South East Open Cut Hunter Valley\[Settlement calculation based on Building on Fill Geotechnical Aspects.xls]Calculation Cover Sheet		
Project File Location		**Page** 2	**of** 2

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
1	28.05.09	LBI	JH								

CALCULATION TO ESTIMATE SETTLEMENT OF MINE BACKFILL DUE TO WATER LOADING

Input: Creek expect to contain 'a few' metres of water

Consider 3m of water = 30kPa uniform load applied to fill (conservative to assume no load spread)

One dimensional compression for granular fill

$\sigma_v = a\,\varepsilon_v^{2}$ (1) (page 26 Reference 1)

where σ_v is applied vertical stress

ε_v is induced vertical strain

and

$D_{sec} = \frac{\sigma_v}{\varepsilon_v} = a^{0.5} \times \sigma_v^{0.5}$ (2) (page 26 Reference 1)

and

$D_{sec} = D_{secn} \times \left(\frac{\sigma_v}{\sigma_{vn}}\right)^{0.5}$ (3) (page 26 Refernce 1)

Assume σ_v =50kPa (5m of water)

Dsecn=3MPa (for uncompactd colliery spoil under 100kPa) (case study results page 28 Reference 1)

$\therefore$ $D_{sec} = 3\left(\frac{30}{100}\right)^{0.5} = 1.64$ Mpa

Rearranging (2)

$\therefore$ $\varepsilon_v = \frac{\sigma_v}{D_{sec}} = \frac{30}{1.64}$ /1000 (converting 50kPa to Mpa) 0.018 = 1.8%

$\therefore$ 1.8% x depth of fill (115m) = **2.05 m** **max settlement due to water loading**

Mitigation measures:

- compacted fill (would make less than half based on published information)
- preload area with at least soil half depth of maximum expected water depth as settlement expect on first loading due to granular fill
- allow water to flow prior to finalising ground surface works (preloading with water rather than soil)

Calculation Sheet

WorleyParsons resources & energy

Customer	Ashton Coal	**Proj No**	301017-00136
Project Title	Ashton South East Open Cut - Settlement under river	**Calc No**	1
Calculation Title	Calculation using Building on fill:geotechnical aspects	**Phase/CTR**	3
Elec File Location	K:\FRASER\GEOTECHNICAL\PROJECTS\301017-00136 Ashton South East Open Cut Hunter Valley\[Settlement calculation based on Building on Fill Geotechnical Aspects.xls]Calculation Cover Sheet		
Project File Location		**Page** 1	**of** 2

Rev	Date	By	Checked	Rev	Date	By	Checked	Rev	Date	By	Checked
1	28.05.09	LBI	JH								

CALCULATION TO ESTIMATE CREEP SETTLEMENT OF MINE BACKFILL UNDER SELF WEIGHT

Creep settlement

$\Delta s = \alpha H \log(t2/t1)$ (1) (page 29 refence 1)

where Δs is settlement of fill height H between time t2 and t1 since construction

where case studies α =0.2% to 1% for rockfill dams (page 37 Reference 1)

Note: settlement did not appear related to rock type or dam type but significantly due to method of placement with upper end of these values for least compaction

α =0.74% and 1% for opencast mine backfill (page 37 reference 1)

α =0.5% to 1% for backfilled coal areas up to 100m deep (page 37 reference 1)

α =0.9% to 1.5% for sandstone and mudstone backfill with no systematic compaction (page 38 reference 1)

α =0.3% for oedometer tests on colliery spoil (page 42, reference 1)

α found to be proportional to σv in well compacted, no poorly compacted (page 42, reference 1)

∴ consider α =0.2% to 1.0% as range with 0.3% adopted as most likely as colliery spoil most similar

∴ consider t1 = 0.1 days and t1=2920 days (8 years)

$\Delta s = \alpha H \log(t2/t1)$

where H = 115m

t (days)		Δ s (m) t1 0.1 days α = 0.2	**α = 0.3**	**α = 1**	t1 2920 days α = 0.2	α = 0.3	α = 1
	1	0.23	0.35	1.15	N/A	N/A	N/A
	30	0.57	0.85	2.85	N/A	N/A	N/A
	90	0.68	1.02	3.40	N/A	N/A	N/A
(1yr)	365	0.82	1.23	4.10	N/A	N/A	N/A
(3yr)	1095	0.93	1.39	4.65	N/A	N/A	N/A
(5yr)	1825	0.98	1.47	4.90	N/A	N/A	N/A
(8yr)	2920	1.03	1.54	5.14	N/A	N/A	N/A
(10yr)	3650	1.05	1.57	5.25	0.02	0.03	0.11
100yr	36500	1.28	**1.92**	**6.40**	0.25	0.38	1.26
274yr	99999	1.38	**2.07**	**6.90**	0.35	0.53	1.76

Mitigation measures

-if fill can stand for 8 years then 80% of creep settlement would be expected to have taken place

Reference 1 J A Charles and K S Watts, Building on fill: geotechnical aspects, BRE Centre of Ground Engineering

APPENDIX G – CHANNEL WATERCOURSE REINSTATEMENT CALCULATIONS

Appendix G – Channel Watercourse Reinstatement Calculations

Rational Method

Ref: AR&R (87) Book IV pg 6, Book VIII pg 18-19

Name : SEOC

Area (ha)	306
C_{10} *	0.26

* Read from AR&R Map 5.5

C_{10}	0.4	Adjusted for Area
tc (min)	69.7	Calculated using Probabilistic Rational Method

Duration (Y)	1	2	5	10	20	50	100
$^{Y}I_{tc}$ (mm/hr)	19.54	24.77	31.54	35.6	41.07	48.39	54.08
C_Y	0.34	0.36	0.38	0.40	0.42	0.46	0.52
Peak Flow (m^3/s)	**5.7**	**7.6**	**10.2**	**12.1**	**14.7**	**18.9**	**23.9**

HEC-RAS Output