Mannering Colliery

Environmental Assessment

Appendix I
GROUNDWATER IMPACT ASSESSMENT

Australasian
Groundwater & Environmental
Consultants Pty Ltd

REPORT on

MANNERING COLLIERY CONTINUATION OF MINING

ENVIRONMENTAL ASSESSMENT GROUNDWATER

prepared for
HANSEN BAILEY PTY LTD

Project Number G1373
December 2006

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REPORT ON

MANNERING COLLIERY CONTINUATION OF MINING

ENVIRONMENTAL ASSESSMENT – GROUNDWATER

1.0 INTRODUCTION

Centennial Coal Company Ltd (Centennial) operates the Mannering Colliery (Mannering), which is located in the Lake Macquarie area of the Central Newcastle Coalfields of New South Wales. Due to amendments to the Environmental Planning and Assessment Act 1979 (EP&A Act) Mannering is required to submit an application for Project Approval under Part 3A of the EP&A Act for continuation of mining.

In order to provide Project Approval, the Department of Planning (DoP) require an Environmental Assessment (EA) to accompany the application.

This report has been prepared for inclusion in the EA and addresses the potential impact of the application on the groundwater resources and features related to the groundwater regime.

The report describes the hydrogeological regime of the area and provides an assessment of potential subsidence impacts on the groundwater regime. The report relies heavily on past detailed studies that have been undertaken on the impact of subsidence on the hydrogeological regime of the area and the fact that extensive mining has been undertaken at the Mannering Colliery and in surrounding collieries. Where appropriate, management and mitigation measures to minimise impacts are also described.

The report has been prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of Hansen Bailey Pty Ltd (HB) on behalf of their client, Centennial.

2.0 METHODOLOGY

The study was undertaken essentially as a “desk-top” study but included a site familiarisation visit during which discussions and briefings were held with:

Mr. Malcolm Ives	- Geologist
Mr. Paul Williams	- Environmental Co-ordinator
Mr. Geoff Nowland	- Mine Surveyor
Mr. Roger Davis	- Technical Services Manager

The scope of work undertaken for this study was to:

- review various, geotechnical and environmental reports to develop an appreciation of the hydrogeological setting and groundwater issues encountered to date at Mannering and by other adjacent mines;
- analyse all data and conceptualise the groundwater regime of the Project Area and surrounds;
- describe the baseline data (water levels and water quality), of the aquifers against which the impact of mining will be assessed;
- assess the character and extent of the alluvial aquifers (if any) and the potential for connectivity between them and Permian coal seam aquifers;
- predict project specific groundwater impacts of the proposed continuation of mining;
- identify other groundwater users in the area, both human and groundwater dependent ecosystems and the potential impact of mining on these groundwater users; and
- if necessary, develop mitigation or remedial measures and a program to monitor their effectiveness.

3.0 LEGISLATION/POLICY

The following section outlines New South Wales State Government statutory requirements relating to groundwater that apply to the Project Area and proposed mining operation.

3.1 Water Management Act 2000

The object of the Water Management Act 2000 is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The Act provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for four types of approval:

- water use approvals – authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- water management work approval;
- controlled activity approval; and
- aquifer interference activity approval – authorise the holder to conduct activities that affect the aquifer. This approval is for activities that intersect groundwater, other than water supply bores and may be issued for up to ten years.

For controlled activities and aquifer interference activities, the Act requires that the activities avoid or minimise their impact on the water resource and land degradation, and where possible the land must be rehabilitated.

3.2 State Groundwater Policy

The NSW State Groundwater Policy (Framework Document) was adopted in 1997 and aims to manage the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three components:

- the NSW Groundwater Quality Protection Policy, adopted in December 1998;
- the NSW State Groundwater Dependent Ecosystems Policy;
- the NSW Groundwater Quantity Management Policy.

3.2.1 Groundwater Quality Protection

The NSW Groundwater Quality Protection Policy (1998), states that the objectives of the policy will be achieved by applying the management principles listed below.

1. *All groundwater systems should be managed such that their most sensitive identified beneficial use (or environmental value) is maintained.*
2. *Town water supplies should be afforded special protection against contamination.*
3. *Groundwater pollution should be prevented so that future remediation is not required.*
4. *For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the groundwater resource.*
5. *A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation and receiving waters.*
6. *Groundwater dependent ecosystems will be afforded protection.*
7. *Groundwater quality protection should be integrated with the management of groundwater quality.*
8. *The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource.*
9. *Where possible and practical, environmentally degraded areas should be rehabilitated and their ecosystem support functions restored.*

3.2.2 Groundwater Dependent Ecosystems

The NSW Groundwater Dependent Ecosystems Policy is specifically designed to protect valuable ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations. The policy defines Groundwater Dependent Ecosystems (GDE), as *"communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater".*

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes in dependent ecosystems are maintained or restored. A summary of the principles follows:

- GDE can have important values. Threats should be identified and action taken to protect them;
- Groundwater extractions should be managed within the sustainable yield of aquifers;
- Priority should be given to ensure that sufficient groundwater is available at all time to identified GDEs;
- Where scientific knowledge is lacking, the precautionary principle should be applied to protect GDE; and
- Planning, approval and management of developments should aim to minimise adverse affects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater systems.

3.2.3 Groundwater Quantity Protection

The objectives of managing groundwater quantity in New South Wales are:

- To achieve the efficient, equitable and sustainable use of the State's groundwater;
- To prevent, halt and reverse degradation of the State's groundwater and their dependent ecosystems;
- To provide opportunities for development which generate the most cultural, social and economic benefits to the community, region, state and nation, within the context of environmental sustainability; and
- To involve the community in the management of groundwater resources.

3.2.4 Aquifer Risk

The aquifers in the Project Area have not been given a risk classification by DLWC (1998)[1] presumably because they are minor aquifers without regional significance.

4.0 PHYSICAL SETTING

4.1 Location

The Mannering Continuation of Mining Project (the Project) is located about 40km south of Newcastle New South Wales, on the shores of Lake Macquarie. Mannering is located within the West Lake Macquarie and Swansea – North Entrance Mine Subsidence Districts and is within both the Lake Macquarie and Wyong Local Government Areas.

The Project Area (shown on Drawing Nos. 1 and 2 in Appendix A), that is, the area within the Environmental Assessment (EA) boundary is approximately 1,360 Ha in size. The mine plan is predominantly positioned beneath Lake Macquarie to the east and residential and forest areas to the west. The residential areas include parts of Mannering Park and Wyee Point. The Vales Point Power Station and Mannering Ash Dam are located to the immediate south of the Project Area.

[1] NSW Department of Land and Water Conservation, (April 1998), *"Aquifer Risk Assessment Report",* HO/16/98.

4.2 Topography and Drainage

The topography of the Project Area is undulating around the foreshores of Lake Macquarie with higher topographic areas forming points extending out into the lake and areas of lower topography forming the bays. In general the topography undulates between sea level and RL25m Australian Height Datum (AHD).

Drainage is to the east towards Lake Macquarie with main creeks in the Project Area being Wyee Creek to the south, Cobra Creek, and Pourmalong Creek in the north. There are also gullies with small catchment areas that drain into Lake Macquarie or into the three main creeks. The creeks are tidal within the Project Area.

Within the Project Area the terrain varies from wooded scrubland and wetlands to small acreages and residential allotments.

4.3 Climate

Mean annual and monthly rainfall for the period 1899 to the present was obtained from the Wyee Post Office weather monitoring station (BoM Station 61082), which is approximately six km to the west of the Project Area. Evaporation data was obtained from the Australian Bureau of Meteorology (BOM) station at Maryville (Stn 061322) about 25km to the north. A summary of the rainfall and evaporation data is shown in Table 1.

Table 1: CLIMATE DATA

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall (mm)	111.0	130.6	133.8	123.9	113.2	106.7	78.6	69.6	68.4	76.0	79.9	97.8	1187.8
Mean Pan Evaporation (mm)	186	154	143	105	74	60	71	90	120	149	165	195	1512
Open Water Body Evaporation (mm)	140	115	107	79	56	45	53	67	90	112	124	146	1134

Note: (i) Pan evaporation correction factor of 0.75 applied to obtain open water body evaporation rate.

Table 1 indicates that the annual average rainfall is about 1,188mm and that the majority of rainfall occurs between January and June. The annual average pan evaporation of 1,512mm exceeds rainfall by about 27%. Mean annual evaporation from an open water body such as Lake Macquarie is about 54mm less than the mean annual rainfall. It was estimated by applying a correction factor of 0.75 to the pan evaporation data.

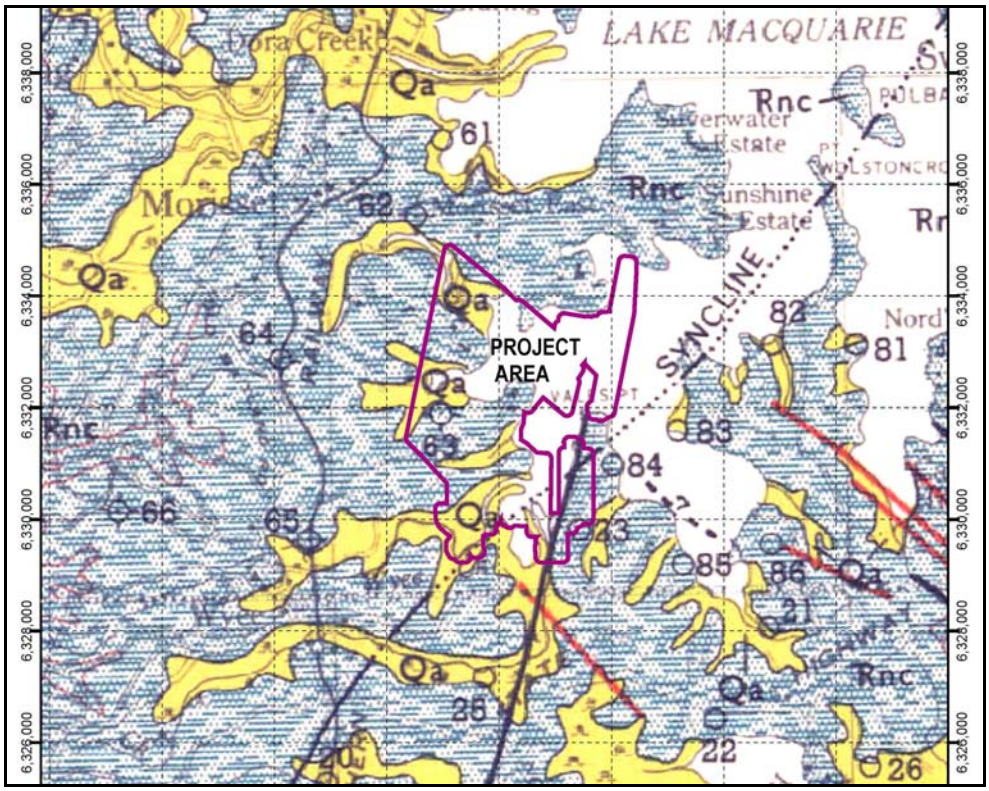
5.0 GEOLOGICAL SETTING

The geological setting of the area is shown on the Sydney 1:250,000 series geological map, Sheet SI 56-5, third ed.,1966. The map indicates that the Narrabeen Group which consists of sandstone, conglomerate and shale overlies the whole of the Project Area and surrounds, with the exception

of localised deposits of Quaternary alluvial sediments. The alluvial sediments are associated with the valleys of the major creeks and consist of clay, silt, sand and gravel. They are irregular and lensoid in nature and have been deposited unconformably on the eroded surface of the older basement rocks.

The axis of the Macquarie Syncline crosses the south-east corner of the Project Area and plunges to the south-west at 3-5 degrees.

The geology of the area is shown on Figure 1.



LEGEND

Qa = Quaternary alluvium
Gravel, sand, silt and clay

Rnc = Narrabeen Group
Sandstone, conglomerate and shale.

Geology after SYDNEY 1:250,000 series geological map – third ed. 1966

Figure 1: Geology of the Project Area and Surrounds

The stratigraphic sequence beneath the Project Area is summarised in Table 2 below. It comprises three distinct units, viz:

- upper Permian Newcastle Coal Measures, a sandstone/coal sequence with lesser siltstone;
- the overlying Clifton Sub-group which is the basal unit of the Triassic Narrabeen Group; and
- Quaternary to Recent alluvial sediments.

The coal deposits are contained within the Late Permian age Newcastle Coal Measures, which together with the overlying Clifton Sub-group, form a regular layered sedimentary sequence dipping regionally at about one or two degrees to the south-west. Locally however, dips are strongly influenced by structural and depositional features (M. Ives pers com). Superimposed on the regional dip is the effect of the broad Macquarie Syncline which trends at about 030 degrees and passes through the Myuna and Mannering Colliery holdings.

The coal seams which are of significance in the Project Area and surrounds are the Wallarah, Great Northern and Fassifern which are located near the top of the Newcastle Coal Measures.

The Vales Point and Wallarah Seams are relatively thin as shown on Table 2 and generally do not present a significant economic resource. The Wallarah Seam however is being, or has been mined in the area in surrounding leases. The Great Northern Seam is the most continuous seam with a seam thickness ranging from 2-3m and as shown on Drawing No. 3 (see Appendix A) workings in this seam are quite extensive.

The Fassifern Seam attains a maximum thickness in excess of 6m and has been amenable to longwall mining at Mannering in the past.

Table 2: SUMMARY OF STRATIGRAPHIC SEQUENCE – MANNERING MINE

Age	Group	Sub-Group	Unit/Formation	Thickness (m)
Quaternary	-	-	Alluvium	0 – 5
Triassic	Narrabeen	Clifton	Munmorah Conglomerate	103 - 120
			Dooralong Shale	13 – 19
Permian	Newcastle Coal Measures	Moon Island Beach	**Vales Point Seam**	0.5 - 0.7
			Karignan Conglomerate	17 – 25
			Wallarah Coal Seam	0.7 - 2.0
			Mannering Park Tuff	1.1 - 1.9
			Teralba Conglomerate	39
			Great Northern Seam	2-3
			Awaba Tuff	~20
			Fassifern Seam	6-6.5

The Newcastle Coal Measures are overlain by the basal unit of the Clifton Sub-group which consists of the Munmorah Conglomerate and the Dooralong Shale. The Munmorah Conglomerate which occurs from surface to a depth of between 103-120m, comprises mostly quartz-lithic sandstone interbedded with pebble conglomerate, while the Dooralong Shale is up to 20m thick and is composed of cross bedded sandstone intercalated with siltstone and claystone, (Forster and Enever 1992)[2].

The total thickness of the Clifton Sub-group within the lease area comprises the majority of the overburden.

The Quaternary to Recent alluvial sediments consist of sand, gravel, clay and silt of varying content that have been unconformably deposited in an eroded, valley-fill environment associated with the creeks in the area.

[2] Forster I., and Enever J., (1992), *"Hydrogeological Response of Overburden Strata to Underground Mining – Central Coast, New South Wales",* Office of Energy.

6.0 EXISTING MINES AND OPERATIONS

6.1 Mannering Colliery

Mannering commenced operations in 1960 as the Wyee State Mine, in conjunction with the construction of the Vales Point Power Station. Extensive mining, both first workings and secondary extraction, has taken place in both the Great Northern and Fassifern Seams. Mining was undertaken in the Great Northern Seam until the mid 1980's followed by expansion of operations into the Fassifern Seam as a longwall mine. Mining of the Fassifern Seam continued for over 20 years until mid 2002, with coal being extracted from beneath land and the foreshores and waters of Lake Macquarie. Longwall mining ceased in 2002 due to uneconomic operations and the mine was put on care and maintenance until late 2004 when Centennial undertook a feasibility study and reopened the mine.

Since December 2004, mining has progressed in the Fassifern Seam to gain access to more than 5 million tonnes of recoverable reserves beneath Lake Macquarie and its foreshores. The predominant mining method implemented since 2004 is a form of bord and pillar mining using three continuous miners. For more detail on this method of mining please refer to the main volume of the EA.

The existing workings in the Great Northern and Fassifern Seams are shown on Drawing Nos. 3 and 4 in Appendix A.

6.2 Other Mines

As discussed above, Mannering was formerly known as the Wyee State Coal Mine, the name change occurring in 2004. The Wyee Colliery holdings included the Newvale Colliery holdings and the mine workings of the Newvale Colliery. Newvale ceased production in 1992 and is now sealed.

Mannering is surrounded by the Munmorah, Chain Valley, Wallarah, Moonee, Myuna, Cooranbong and Mandalong Collieries. The colliery holding boundaries of these various mines are shown on Drawing Nos. 3 and 4 (in Appendix A) which show that Mannering's Colliery holdings and hence the Project Area are essentially completely surrounded by these other collieries, the exception being an area in the south-west quadrant. Some of these surrounding collieries are currently operating whereas others are closed, as discussed further below.

The Munmorah Colliery holding is located to the immediate south of Mannering. It includes the mine workings of the Endeavour Colliery as well as that of the Munmorah Colliery. It should be noted that Endeavour Colliery was also previously named Newvale No. 2 Colliery.

The Chain Valley Colliery adjoins the Mannering Colliery holdings to the east together with the Wallarah and Moonee Collieries.

The Myuna Colliery adjoins to the north-east and the Cooranbong Colliery to the north-north-west, whereas the Mandalong Colliery holdings are to the north-west.

Moonee Colliery which is located close to the coast near the village of Catherine Hill Bay, commenced operations shortly after World War II, mining the Wallarah Seam as a bord and pillar operation. When the reserves of the Wallarah Seam were exhausted the mine was relocated to the Great Northern Seam but bord and pillar mining proved uneconomic and the mine was placed on care and maintenance in 1993. The mine was reopened as a longwall mine in the Great

Northern Seam in early 1997 but ceased operations in 2002. The longwall blocks are 90m wide, that is, they are relatively narrow due to mine subsidence restrictions. Depth of cover above the Great Northern Seam ranges from 100-160m.

Wallarah Colliery located on the eastern shore at Grangan Bay in Lake Macquarie operated from 1979 and was placed on care and maintenance in 2002.

Both the Wallarah and Moonee Collieries were operated by Lake Coal Pty Ltd.

Chain Valley Colliery mined the Great Northern Seam from the early 1960s using bord and pillar extraction techniques. The mine is currently developing declines to undertake mining of the Fassifern Seam.

The Myuna Mine is currently mining the Wallarah and Fassifern Seams using bord and pillar techniques. Mining at Myuna commenced in 1981.

The Cooranbong Colliery is a bord and pillar and longwall mine with mining in the Great Northern Seam. It has been in operation since 1980. Work at Cooranbong wound down in 2004 as work at the adjoining Mandalong Mine to the south-west commenced.

Development consent to extend the underground mining operations from the Cooranbong Colliery into the Mandalong Valley was obtained in 1998. Mining of the first longwall panel at Mandalong commenced in January 2005. Mining is achieved through the longwall mining method with coal currently being extracted from the converged Wallarah/Great Northern (WGN) Seam.

The Myuna, Cooranbong and Mandalong Mines are owned by Centennial. The history of mining in the area as provided by Centennial is summarised in Table 3 below.

Table 3: SUMMARY OF MINING OPERATIONS IN VICINITY OF MANNERING

Colliery Holdings	Collieries	Commenced Operation	Ceased Operation	Seams Mined	Mining Method
Mannering (Wyee)	Mannering	early 1960's	currently operating	Great Northern Fassifern	Bord and Pillar Longwall
	Newvale	early 1960's	1992 (sealed)		
Munmorah	Munmorah	early 1960's	Current?	Great Northern	Bord and Pillar
	Endeavour (Newvale No. 2)	early 1960's	Dec. 1999 (sealed)		
Chain Valley	Chain Valley	Early 1960's	currently operating	Fassifern Great Northern	Bord and Pillar
Moonee Colliery	Moonee	late 1940's	1993	Wallarah Great Northern	Bord & Pillar
		1997	2002	Great Northern	Longwall
Wallarah	Wallarah		2002	Great Northern	Bord and Pillar?
Myuna	Myuna	1981	Currently operating	Wallarah Great Northern Fassifern	Bord and Pillar
Cooranbong	Cooranbong	1981	Currently operating	Great Northern	Bord and Pillar Longwall
Mandalong	Mandalong	2005	Currently operating	Great Northern	Longwall

7.0 PREVIOUS STUDIES

An extensive study was undertaken by Forster and Enever (1992)[2] at the Wyee State Mine (Mannering), to assess the impact of longwall mining on the hydrogeological properties of overburden strata. The studies were undertaken because of the widespread expansion of residential and light industrial development of the Central Coast, the effect of underground mines on this development in the form of increasing incidences of mine subsidence problems, and the pressure to fully utilise the coal reserves that are situated beneath the residential areas, the coastal lake system and the Pacific Ocean. Forster and Enever (1992)[2] state that *"initially most mining beneath the lakes in the region was limited to first workings (bord and pillar) however more recently panel and pillar mining has been utilised in several mines",* to maximise the percentage of coal extracted from each seam.

The study focused on undertaking detailed investigations directed at providing a better understanding of the hydrogeological conditions which prevail above underground mines employing maximum extraction methods with the objective of determining *"the optimum mining solution which minimises the risk of hydraulic connection"*

The investigation focussed on two sites at the Wyee State Mine, that is, the Mannering Colliery which is the focus of this report, viz:

- The proposed Longwall 4 in the Fassifern Seam with a depth of cover varying between 190-200m. At the location the Great Northern Seam lies about 25m above the Fassifern Seam and had been totally extracted in bord and pillar workings following by pillar removal; and
- The North 3D panel in the Great Northern Seam extracted by continuous miner. The depth of cover at the site is about 185m.

The results of the studies are discussed in this report and are used in the assessment of the impact of the Project on the groundwater regime.

8.0 HYDROGEOLOGICAL REGIME

Based on a review of existing data, a conceptual model of the hydrogeological regime of the Project Area and surrounds has been developed. There are potentially three aquifer[3] systems; alluvial aquifers, the shallow weathered zone and aquifers of the Triassic/Permian Formations.

This section of the report discusses the aquifer systems and the data used to develop the conceptual model.

[3] An aquifer is defined as a groundwater bearing formation sufficiently permeable to transmit and yield water in useable quantities.

8.1 Alluvial Aquifers

8.1.1 Distribution

The alluvium in the area is associated with the creeks that discharge into Lake Macquarie. They are described on the Sydney 1:250,000 Geological Sheet[4] as consisting of gravel, sand, silt and clay. There is no data on the thickness of the alluvium or the lithology in the Project Area, however it is considered, based on experience in the region, that the maximum thickness would be less than about 15m and that the composition would be variable, with probably a basal sand or gravel layer. The distribution of the alluvium in the Project Area is shown on Figure 1.

8.1.2 Groundwater Occurrence, Recharge and Flow

Within the Project Area the water table in the alluvium probably reflects that of the water level in Lake Macquarie. Observations made during the site visit indicate that the creeks and alluvium are relatively flat and are influenced by tidal fluctuations in Lake Macquarie. Recharge of the alluvium in the Project Area is therefore from surface flow in the creeks, but primarily from lateral seepage from Lake Macquarie.

The water table in the alluvial sediments in the Project Area is probably within 1-2m of the surface and possibly is at the surface during periods of creek flow and/or high tides. The water table is expected to be essentially flat but may have a shallow gradient towards the creek channels and towards Lake Macquarie, which is in a downstream direction.

8.1.3 Hydraulic Properties and Yield

Umwelt (1998)[5] state that in the Lake Macquarie district numerous bores and wells draw water from the alluvial aquifers with yields from the wells mostly ranging from 0.1L/s to 9L/s. This suggests that the aquifer has a variable, heterogenous and anisotropic permeability distribution consistent with the alluvium varying from clayey sands to clean sands and gravels.

8.2 Regolith – Shallow Bedrock Aquifer

The regolith/shallow bedrock aquifers comprise surficial soils and weathered bedrock. The depth of the aquifer is likely to be variable and depends on such factors as:

- depth of weathering; and
- extent and frequency of permeable fracture systems.

It is likely to include perched aquifers at the interface between soils and bedrock, and zones of locally increased permeabilities due to bedrock weathering. It would appear that the aquifer is localised and not laterally extensive. Recharge is by direct infiltration of rainfall.

[4] Department of Mines (1966) *"Sydney 1:250,000 Geological Series Sheets SI 56-5",* Ed. 3.

[5] Umwelt (Australia) Pty Ltd, (Nov. 1998), "*Environmental Impact Assessment, Newstan Colliery Life Extension Project"*, Appendix 5.

In summary, the shallow bedrock is similar to the deep bedrock aquifer but is characterised by a higher degree of weathering and is probably perched above the prime water table.

8.3 Triassic and Permian (Bedrock) Aquifers

The Triassic and Permian strata may be categorised into the following hydrogeological units:

- hydrogeologically "tight" and hence very low yielding to essentially dry sandstone and lesser siltstone and shale that comprise the majority of the interburden/overburden; and
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

8.3.1 Distribution

The Triassic and Permian strata occur across the whole of the area as a regular layered sedimentary sequence dipping at about three degrees to the south-south-west, but locally with steeper dips.

8.3.2 Groundwater Occurrence, Recharge and Flow

Groundwater storage and flow is predominantly associated with the coal seams with their interconnecting cleats and joint pattern. The overburden and interburden rocks of the Newcastle Coal Measures are of extremely low permeability with groundwater only occurring in localised areas due to secondary or fracture permeability.

Forster and Enever (1992)[2] state that *"neither the Narrabeen Group nor the Newcastle Coal Measures contain any significant quantities of groundwater and their permeabilities are known to be generally low (<10^{-7}m/s). Any permeable zones which do occur are usually due to jointing, faulting or shearing on bedding planes. Because of the extremely low permeability of the rock substance, groundwater flow through the overburden strata is almost exclusively by interconnecting defects such as joints and bedding. For this reason, coal seams with their interconnecting cleat and joint patterns, are often found to be "aquifers" relative to the surrounding strata. Despite this, most underground coal mines on the Central Coast are quite dry, and rarely have any major groundwater problems".*

Recharge of the aquifers probably occurs via rainfall infiltration in areas of sub-crop or via vertical seepage from the regolith along joints and fractures.

The piezometric surface of the bedrock aquifers within the EA boundary most probably reflects the topography, with slightly elevated water levels/pressures in higher topographic areas distant from major drainages and Lake Macquarie. Overall it is expected that the pre-mining piezometric surface in the Project Area would have been around lake level, that is about RL0m.

Mannering and existing mines surrounding the colliery will have resulted in a zone of depressurisation in the piezometric surface of the aquifer systems of the Wallarah, Great Northern and Fassifern Seams to the east, south, north and west of the Project Area.

8.3.3 Hydraulic Parameters and Yield

The following permeability data obtained by various studies undertaken within the Project Area and surrounds have been summarized by Forster et al (1997)[6].

A groundwater study involving water pressure testing of 24 boreholes undertaken by Braybrooke (1980)[7], of the proposed Eraring Open Cut area which lies immediately north of the Cooranbong Colliery, found that:

- of 75 tests on the Teralba Conglomerate 80% gave a permeability of less than 10^{-7}m/s. The highest permeability of 2 x 10^{-5}m/s was associated with an irregular open joint;
- of 18 permeability tests carried out in the Great Northern Seam, seven had a permeability of less than 10^{-7}m/s. Three tests indicated a permeability of 10^{-5}m/s;
- based on groundwater inflow data at the Awaba Colliery (to the immediate north of Cooranbong), the vertical permeability of the overlying strata was estimated to be 1.7 x 10^{-8}m/s.

Similarly a detailed groundwater investigation was undertaken by Mong (1987)[8] during development of the Cooranbong Colliery. Outcomes of that study were:

- of 80 water pressure tests on the overburden strata above the Great Northern Seam only two associated with open joints of fractures measured a high permeability. The remainder indicated a permeability of <10^{-7}m/s;
- out of 26 tests carried out in the Great Northern Seam, four yielded high permeability results.

Forster et al (1997)[5] undertook both pump-out and injection tests in the area of what is now known as the Mandalong Mine. The tests were undertaken in various horizons in the Triassic and Permian sequence in two boreholes using straddle packers, to confirm their assessment that *"there are no widespread aquifers present in the overburden above the Wallarah/Great Northern Seam, apart from the surface weathered rock aquifer and the alluvial aquifer"*. The tests on the Wallarah/Great Northern Seam gave permeabilities of 2.2 x 10^{-9} and 7.4 x 10^{-6}m/s while seven tests in the overburden strata gave permeabilities in the range 3.1 x 10^{-9} to 1.9 x 10^{-11}m/s.

Forster et al (1997)[5] concluded that the testing program *"confirmed the very low permeability of the overburden strata above the Wallarah/Great Northern Seam. In addition, it has demonstrated that while the permeability of the Wallarah/Great Northern Seam can be low, there are areas of high permeability and the seams form a relative aquifer in the local groundwater regime".*

Packer permeability tests undertaken in the stratigraphic profile at Wyee (Mannering) Colliery indicated that *"the overburden rocks above the Great Northern Seam have a very low natural permeability"* (Forster and Enever 1992)[2]. The pre-mining permeability of the rock was found to be less than 10^{-8}m/s except in the upper 20m to 25m where the permeability was 10^{-7} to 10^{-8}m/sec.

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[6] Forster I., Wall B., and Karabansinis L., (Nov. 1997), *"Cooranbong Colliery Life Extension Project – Overburden Strata Groundwater Study", Pacific Power International",* Report No. GEO 100.

[7] Braybrooke J., (1980) *"Eraring Coal Project Groundwater and Permeability"*, E.C. NSW Report No. PD61, May 1980.

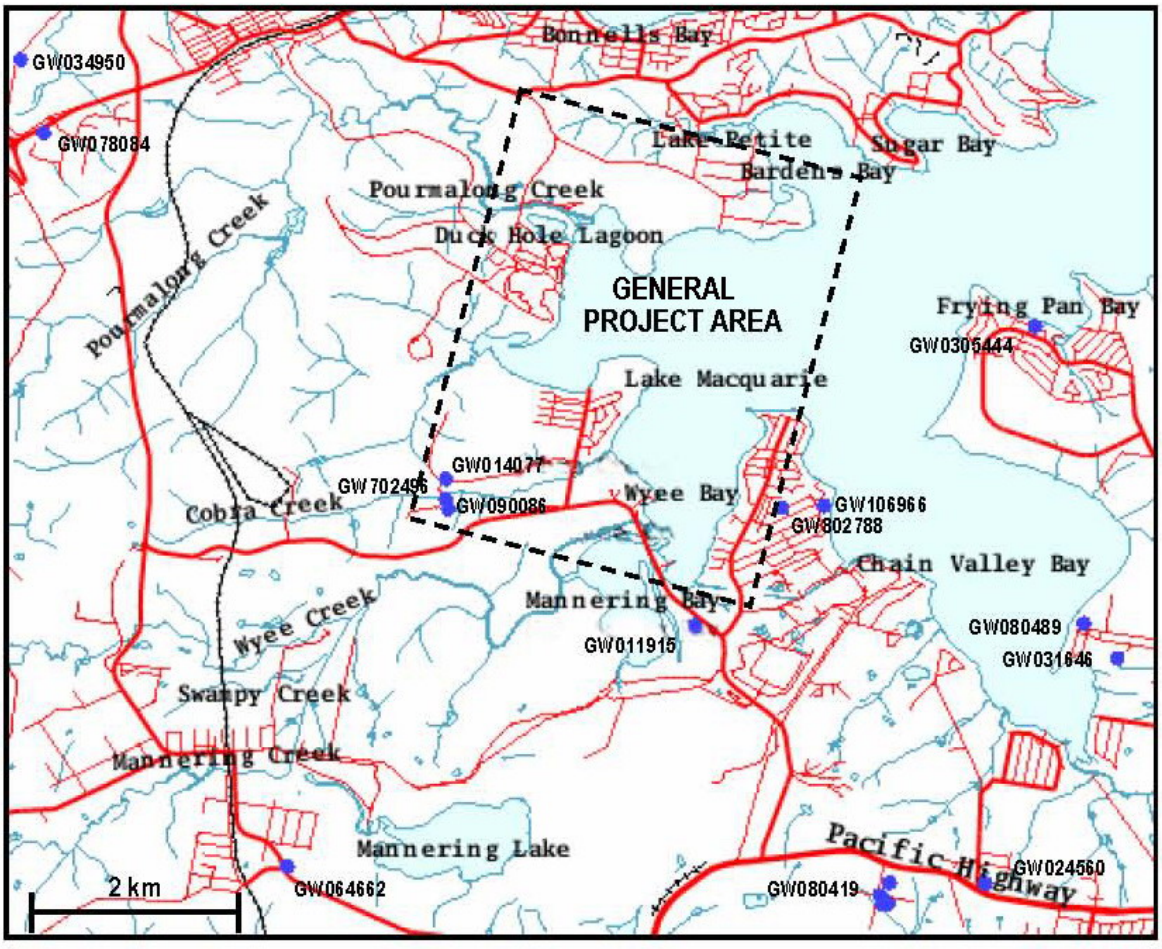
[8] Mong J., (1987), *"Cooranbong Colliery Groundwater Monitoring",* ECNSW Technical Memorandum No. DE316, June 1987.

The data indicates that the hydrogeological characteristics of the overburden strata above the Great Northern and Fassifern Seams is consistent throughout the area and data from one mine can generally be applied to another. The overall conclusion that can be reached from the above studies is that apart from the coal seams forming *"relative aquifers",* the overburden is of very low permeability with the exception of occasional zones of higher permeability associated with joints, fracture zones and faults.

9.0 GROUNDWATER USE, QUALITY AND ENVIRONMENTAL VALUE

9.1 Groundwater Use – DNR Database

A search of the Department of Natural Resources (DNR) database of registered bores and wells within a radius of about 6km of the Project Area was undertaken. The data indicates that there are fifteen registered bores within this radius as shown on Figure 2. Relevant data obtained of the registered bores is shown in Table 4 which indicates that there are thirteen (13) bores that are licensed for domestic and stock supply, one (1) bore licensed for industrial use and one (1) unlicensed monitoring bore.



(after New South Wales Groundwater Works - DNR bore database)[9]

Figure 2: Registered Bores (blue dots) Surrounding Project Area

[9] http://waterinfo.nsw.gov.au/gw/index.html

The bores generally vary from about 16m to 85m in depth and obtain a relatively small supply of less than 1L/s from sandstone and conglomerate, which is the Munmorah Conglomerate. Two bores however report quite good supplies of 4-5L/s. The water quality is generally reported as being “fresh” or “good”.

None of the bores are reported as obtaining groundwater from alluvium although a 5.4m deep well licensed for poultry supply is most likely situated in alluvial deposits. Only three of the registered bores overlie the Project Area, these are GW014077, GW702496 and GW090086 which are all located near the south-west corner as shown on Figure 2. The majority of the bores are at distances of greater than 3km from the Project Area.

While it is recognised that not all existing bores are registered, the database gives an indication of groundwater usage in the area. This can be summarised as usage for stock and domestic purposes from generally low yielding bores set in the upper part of the Munmorah Conglomerate. Fractures and joints in the upper part of the conglomerate are likely to be more open than with depth, hence providing a secondary porosity and permeability that transmits groundwater is useable quantities to the bores. This information supports the conclusions reached by Forster and Enever (1992)[2] and Forster et al (1997)[5].

Overall it is concluded that the importance of and reliance on groundwater by local landowners and residents is limited.

Table 4: DNR DATA OF REGISTERED BORES WITHIN 6 KM OF MANNERING

Reg No	Licence No	Location		Authorized Use	Depth (m)	SWL (mbns)	Salinity (µS/cm)	Yield (L/s)	Aquifer/Comments
		mN	mE						
GW034950	20BL027960	6335260	356860	stock, domestic	76.2	14.9	poor	0.25	conglomerate
GW078084	20BL166612	6334507	357041	stock, domestic	62.0	5.0	fresh	2.0	sandstone
GW014077	70BL131212	6353926	369262	stock, domestic	84.7	56.50	fresh	0.63	sandstone
GW702496	70BL229980	6310630	390130	stock, domestic	60.5	31.0	300	4.0	sandstone
GW090086	-	6303871	376295	monitoring bore	30.0	-	-	3.0	gravel?
GW106966	10BL164555	6288853	247003	stock, domestic	-	-	-	-	no details
GW802788	80BL242024	6312260	253545	-	80	-	-	-	bore abandoned
GW305444	30BL183952	6542551	484820	domestic	30.5	10	1030	0.76	broken basalt?
GW011915	30BL004727	6329410	362900	poultry	5.4	-	-	-	- (well)
GW064662	20BL137176	6326835	359330	domestic	24.0	7.0	-	-	sandstone
GW080489	20BL168924	6329485	366304	domestic	-	-	-	-	-
GW031646	20BL024637	6329125	366640	stock, domestic	16.70	3.0	excellent	0.13	-
GW024560	20BL014878	6326730	365495	industrial	15.20	6.0	good	0.03	conglomerate
GW080419	20BL168505	6326740	364623	domestic	30.0	6.0	good	5.0	conglomerate
GW200173	20BL168715	6326521	364652	stock, domestic	-	-	-	-	-

Notes: i) mbns – metres below natural surface ii) SWL – static water level
iii) ? – drillers description, would not appear to be correct.
iv) easting for GW305444 incorrectly recorded by DNR

9.2 Groundwater Quality and Environmental Value

9.2.1 Terminology

An assessment was made of the groundwater quality in terms of ANZECC criteria and environmental value. The ANZECC (2000)[10] guideline refers to "environmental value" rather than "beneficial use" which is often used, and states that the term beneficial use has lost favour because of its exploitative connotations. For this reason the term "environmental value" has been adopted by the National Water Quality Management Strategy (NWQMS). The following environmental values are recognised in the NWQMS Guidelines:

- aquatic ecosystems;
- primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods);
- recreation and aesthetics;
- drinking water;
- industrial water;
- cultural and spiritual values

The guidelines state that *"where two or more agreed environmental values are defined for a water body, the more conservative of the associated guidelines should prevail and become the water quality objective".* The assessment of "environmental value" given in this report is based on this guideline.

9.2.2 Alluvial Aquifer

There is no data available for groundwater quality in the alluvial aquifers, however as discussed above, the alluvium associated with the creeks in the Project Area is very flat lying and appears to be subject to tidal fluctuations and possibly inundation. It is therefore assumed that groundwater contained within the alluvial aquifers is highly brackish to saline. It is also assessed that it cannot be provided with an environmental value as ecosystems within the low-lying alluvial area would be dependent on the tidal flushings and water quality of Lake Macquarie, rather than the very small groundwater fluxes that may discharge to the creeks in the low lying sections encompassed by the Project Area. In the upper catchment areas where the alluvial groundwater is not influenced by tidal flushings of Lake Macquarie, the environmental value would be "aquatic ecosystem".

9.2.3 Regolith – Shallow Bedrock

As discussed most of the registered bores in the Project Area and surrounds are completed in regolith and shallow bedrock; the upper part of the Munmorah Conglomerate. The DNR database (Table 4) indicates that in the majority of the bores the water is fresh and is used for stock and domestic use. As such the environmental value would be classified as "primary industries". However where fresh groundwater discharges into gullies and creeks or as springs that are not impacted by the tidal fluctuations of saline water from Lake Macquarie, the environmental value in these localised areas may be classified as "aquatic ecosystem". Areas of fresh groundwater

[10] Australia and New Zealand Environment and Conservation Council, (2000), *"Australia and New Zealand Guidelines for Fresh and Marine Water Quality".*

discharge from the regolith/bedrock aquifer may also occur in upper catchment areas outside of the Project Area.

9.2.4 Coal Seam Aquifers

A detailed analysis of groundwater quality of the coal seam water is not available however Mannering monitors the quality of water discharged from Mannering at licensed discharge points LDP001 and LDP002. This water will be a slightly better quality than the coal seam groundwater as it is a mixture of groundwater that discharges into the mine from the coal seams and potable water that is used in the mining operations, the latter comprising about 10% of the volume of water discharged. Monitoring during 2006 indicates a pH range of 6.7 to 8.1 and an Electrical Conductivity range of 22,900 to 38,200µS/cm. The reason for the variability is unknown but may reflect the amount of potable water that is used in the mine at any one time. It is well documented that coal seams in the area in general contain poor quality, brackish to saline water, confirmed by the above data.

Table 4 indicates that there area no registered bores that obtain a groundwater supply from the coal seams and given the depth, very poor quality and general low permeability, and hence low yield of the coal seams, it is again considered that within the Project Area the coal seam groundwater has no environmental value.

10.0 PROPOSED MINE PLAN AND POTENTIAL IMPACTS AND RISKS

Centennial propose to seek approval to continue to mine a total of 11.6 million tonnes of coal from the Fassifern Seam at a rate up to 1.1 million tonnes per annum (Mtpa) run of mine (ROM) coal for a 10 year period, using the bord and pillar (first workings) mining method. The proposed underground mine plan shown on Drawing Nos. 1 and 2 (see Appendix A) is predominantly positioned beneath Lake Macquarie and some residential areas.

Surface facilities present at Mannering include a small crushing plant, administration buildings and workshops. The existing ROM stockpile of 25,000 tonnes will also continue to be relied upon, and the ROM coal will be continued to be transported by overland conveyor to the Vales Point Power Station. These surface facilities are discussed in the main volume of the EA.

The depth of the workings, that is, the thickness of cover above the roof of the Fassifern Seam ranges from about 150m in the north and west, to 205m in the south and east, as shown on Drawing No. 5 in Appendix A. The maximum vertical subsidence has been assessed by Seedsman Geotechnics Pty Ltd, 2006[11] (Seedsman) to be less than 20mm. The 10 year conceptual mine plan has been designed so that essentially the workings will not be below existing workings of the Great Northern Seam.

Based on the description of the hydrogeological regime and the assessed environmental values of groundwater within and around the Project Area, the following potential impacts and risks have been identified with respect to the groundwater regime:

[11] Seedsman Geotechnics Pty Ltd, (2006), *"Centennial Mannering Pty Ltd – Subsidence Predictions for Long-Term Mine Plan",* Mannering 24.

- the impact of subsidence and whether subsidence cracking will provide hydraulic connectivity between the mine workings and overlying aquifers, particularly the alluvial, regolith and shallow bedrock aquifers, leading to dewatering of these aquifers;
- impact on other groundwater users both human and groundwater dependent ecosystems;
- the impact of dewatering of the Fassifern Seam aquifer as mining progresses;
- groundwater inflow to the mine and impact on mine operations;
- potential for saline intrusion from Lake Macquarie as a result of subsidence and/or mine dewatering, and the risk of degradation of groundwater of higher environmental value; and
- contamination of groundwater due to fuel or chemical spill.

The following sections discuss these potential impacts.

10.1 Impact of Subsidence

The major subsidence studies that have been undertaken in the area have been associated with longwall mining where surface subsidence of 2-3m can occur, depending on the width of the longwall panels. This leads to vertical cracking of the overlying strata which can extend to heights in excess of 100m and corresponding hydraulic connection and draining of overlying aquifers to the mine workings.

Forster and Enever (1992)[2] found that based on the detailed studies undertaken at the Wyee State Mine (Mannering Colliery), longwall mining of the Great Northern Seam produced the following changes in the hydrogeological properties of the overburden strata:

- Upper strata – more than 115m above the Great Northern Seam, the hydrogeological properties of the strata after mining were generally similar to those measured prior to mining. Some strata showed a temporary drop in piezometric pressure, suggesting parting of bedding planes.
- Intermediate strata – 65-115m above the Great Northern Seam experienced significant permanent pressure increases with one exception. The reason for the increase in pressure was uncertain however Forster and Enever (1992)[2], concluded that *"since the intermediate strata have not lost piezometric pressure, it is certain that significant vertical drainage has not occurred from these strata and they form an effective barrier against vertical hydraulic connection between the surface and the mine".*
- Lower strata – less than 65m above the Great Northern Seam showed significant increases in permeability and permanent decreases in piezometric pressure.

Forster and Enever (1992)[2] concluded that many of the measured changes in the intermediate and upper strata units are due to minor strata movements and the formation of discontinuous fractures, and that therefore these strata units would form a barrier to vertical drainage.

The data indicates that for longwall mining the piezometric pressure in aquifers between 65-115m above the mine was impacted but that there was no hydraulic connectivity to the mine via vertical cracking, leading to draining of the aquifers. Aquifers at greater than 115m above the mine were not impacted at all.

A further study which demonstrates that the shallow aquifers were not impacted by longwall mining is described by Forster and Enever (1992)[2], viz:

For many years, Wyee State Mine has extracted coal from the Great Northern Seam, some of it from under the Mannering Creek Ash Dam. Just recently the Fassifern Seam has also been extracted beneath the Ash Dam and the totally extracted Great Northern Seam, in three longwall panels (longwalls 4, 5 and 6). The total extracted thickness of these two seams amounts to five metres with a minimum depth of cover to the Great Northern Seam of about 150 metres beneath the ash deposits.

Work by Holla and Buizen (1990) at Wyee has shown that extraction of the Fassifern Seam in Longwall 1 beneath the totally extracted Great Northern Workings produced subsidence at the roof of the Great Northern Seam equivalent to 80% of the Fassifern extraction height. Assuming the strata beneath the ash dam have behaved similarly, the Great Northern Seam roof has subsided approximately 4.4 metres. The subsidence effects would therefore be equivalent to those caused by the extraction of a 4.4m seam at the Great Northern horizon.

Any significant vertical cracking caused by mining would produce water inflows into the mine from the ash dam. It is important to note that no significant inflows occurred during mining, although slightly increased water flows did occur in the Great Northern Seam workings during the extraction of Longwall 4 in the underlying Fassifern Seam. These flows gradually reduced over time and the Fassifern workings were relatively dry. The inflow which did occur was probably as a result of increased fracturing above the Great Northern Seam tapping groundwater held in the confined strata above the goaf.

The ash dam, Great Northern Seam workings and cover thickness above the deeper Fassifern Seam are shown on Drawing No. 5 in Appendix A.

The above example illustrates that, even with a depth of cover of only 150m (above the Great Northern Seam), longwall mining at Mannering has not caused vertical cracking that would impact shallow aquifers.

The proposed continuation of mining at Mannering however will use the bord and pillar mining method, not longwall mining, in an area where the cover thickness is between 150-205m. Existing bord and pillar mining operations indicate that there is minimal vertical subsidence and cracking of the overburden strata, and Seedsman (2006)[11] concluded from subsidence studies undertaken for the Project, that the predicted subsidence is less than 20mm *and "there are no predicted impacts on the surface".*

Given that the proposed bord and pillar mining is much less disruptive to overburden strata than longwall mining and that even for subsidence associated with longwall mining, it has been shown that the intermediate and upper strata form a barrier to vertical drainage, it can be concluded that the Project will not impact on the alluvial and regolith/shallow bedrock aquifers.

The lack of impact of both longwall and bord and pillar mining in the area on overlying aquifers has been demonstrated over the past 50-60 years since mining began in the area. Mining at Wyee State Mine (Mannering) and in the surrounding mines has been undertaken successfully without impacting overlying aquifers.

This conclusion is further supported by the evidence that neither longwall mining nor first workings in the Great Northern and Fassifern Seams have induced leakage through the overburden from Lake Macquarie. Water sample testing undertaken by Centennial in longwall panels underlying Lake Macquarie indicated water with an EC range 20,000 – 25,000µS/cm, that is similar to water

discharged from the mine, as discussed in Section 9.2.4, whereas the EC of the lake water is about 50,000µS/cm (P. Williams pers. com). This indicates that the water entering the mine is coal seam groundwater that has possibly mixed with minor amounts of potable water that is used by the mine machinery.

As stated, the overall conclusion based on detailed studies and monitoring that have been undertaken at Mannering, is that the Project will not impact the overlying alluvial and regolith/ shallow bedrock aquifers.

10.2 Impact on Other Groundwater Users

As discussed in Section 9.1 there are about 15 registered bores within a 6km radius of the mine, most of which obtain groundwater from the upper part of the Munmorah Conglomerate from depths ranging between 16-85m. There are three bores overlying the footprint of the Project Area, the deepest being 85m. Based on the extensive studies undertaken in the past at Mannering and for the Project, and the history of mining in the area, it is assessed that the Project will not impact on other groundwater users, either human or groundwater dependent ecosystems.

10.3 Impact of Dewatering the Fassifern Seam

Extensive mining has been undertaken at Mannering and in surrounding collieries, both in the Great Northern and Fassifern Seams over the past 50-60 years. This has lead to depressurisation of both seams with the potentiometric surface declining to the base of the seams in areas where coal has been extracted, and a cone of depression extending radially outwards from the workings. In some closed mines which have been sealed, the workings may have flooded with groundwater levels showing partial local recovery. However, the current on-going mining in the area suggests that at a regional level the piezometric surface/groundwater level will remain depressed into the future.

The impact of the Project which will continue mining of the Fassifern Seam to the north-west will dewater the Fassifern Seam and extend the cone of depression in these directions. The overlying Great Northern Seam has however been depressurised to some extent in this area by the Cooranbong and Mandalong Collieries which are about 3km to the north-west of the EA boundary.

It is therefore concluded that the Project will only have minor additional impact on the piezometric surface of the Fassifern Seam, which has already been extensively impacted by the existing mines in the area.

10.4 Inflow from Coal Seams

10.4.1 Monitored Inflow to Mannering

Centennial monitor the volume of water pumped from the mine and the potable water use daily. The data indicates that for the period 1 April 2005 to 10 August 2006, a total of 0.934ML/day was discharged from the mine, whereas potable water used for the period was 0.107ML/day, of which about 0.90ML/day was used underground. This data therefore suggests that groundwater inflow to the mine is about 0.844ML/day.

In comparison the Annual Environmental Management Report (AEMR) of 2005[12] for Mannering Colliery states that for the year, 293,641KL (293.6ML) was pumped from the mine (0.804MLday) and that the annual potable water use was 27,182KL (27.2ML) equivalent to 0.074ML/day.

It is assumed based on this data that groundwater inflow to the mine from both the existing workings of the Great Northern and Fassifern Seams is about 0.80-0.85ML/day.

10.4.2 Analytical Assessment of Current and Future Inflow to Mannering

In order to assess potential future groundwater inflows to the mine, an analytical assessment was made of inflow to the current workings and to the proposed workings of the Project.

Inflow of groundwater to the workings of the Fassifern seam is expected to be derived from vertical seepage from the overlying Great Northern Seam, and from the Fassifern Seam, as the seam is progressively extracted in accordance with the conceptual mine plan.

A simplified model has been developed for assessing the rate of discharge from both the Great Northern Seam via the existing workings and from vertical seepage to the Fassifern Seam workings, and from the face of the Fassifern Seam around the perimeter of the mine workings. The model is based on the Darcy Equation and is illustrated on Figures 3 and 4.

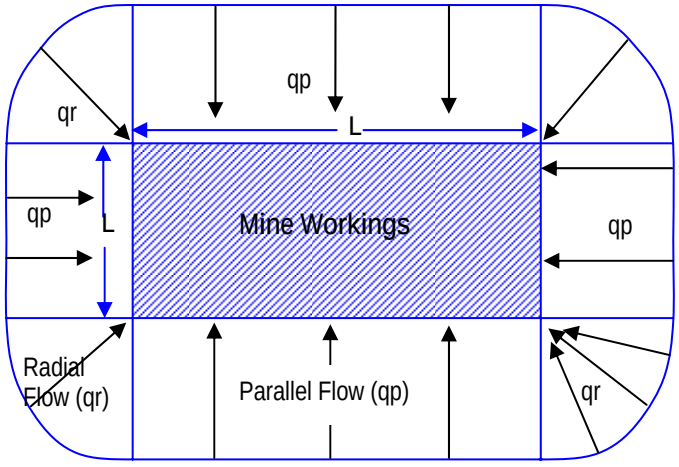


Figure 3: Conceptual Plan of Groundwater Inflow to Underground Workings

[12] Centennial Mannering, (March 2006), *"Mannering Colliery Annual Environmental Management Report for the Period January 2005 – December 2006".*

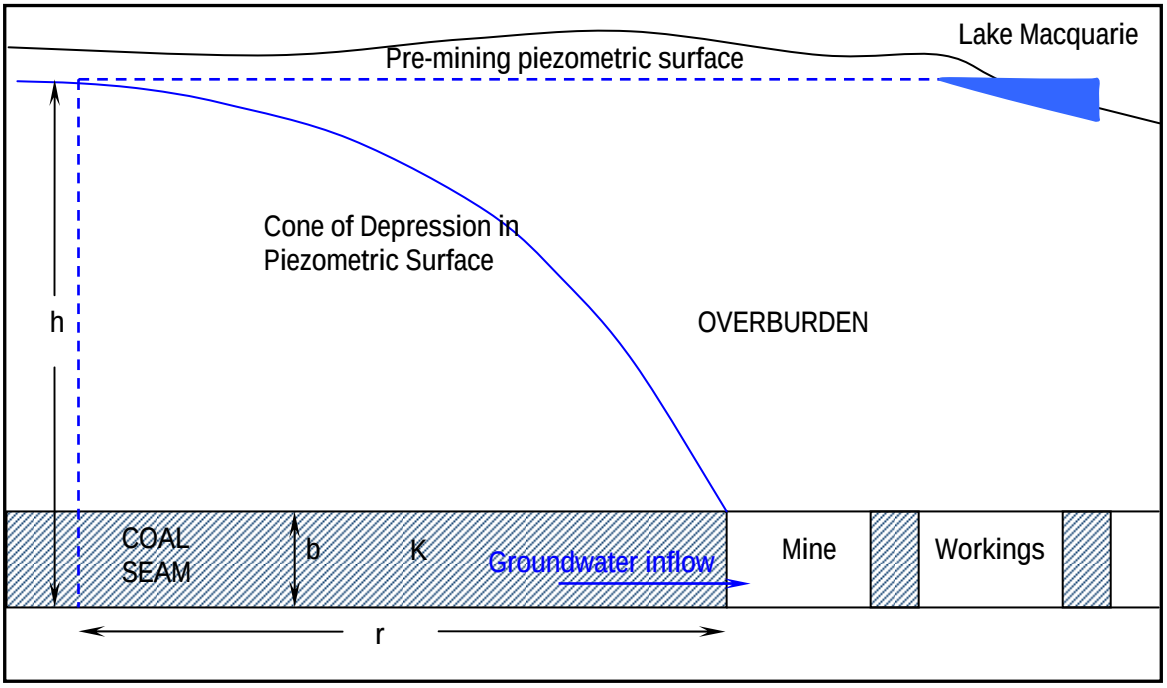


Figure 4: Analytical Model for Inflow from Coal Seam

The Darcy equation is given in the form of:

$$Q = K\left(\frac{h-hi}{r}\right)b.L. \qquad m^3/day$$

where:
- K = hydraulic conductivity = 0.1m/day
- b = thickness of the confined aquifer, that is, the coal seam
- h = pre-mining elevation of piezometric surface above the base of the aquifer, assumed to average RL1m
- h_i = elevation of the piezometric surface at the mine face, assumed to average RL-180m
- L = length of the coal seam exposed by existing and proposed workings
- r = radius of influence of the mine behind the coal face = 2000m based on Mong (1987)[8]

The following assumptions were made:

- the radius of influence or extent of the "cone of depression" behind the highwall was conservatively assumed to be 2000m based on a study undertaken by Mong (1987)[8] at the Cooranbong Mine. Mong reported that *"drainage of groundwater in the mine workings from the Great Northern Seam impacted on the piezometric pressure in the seam up to 1.6km away".* The seam is deeper at Mannering and hence the radius of influence of depressurisation is likely to be greater;
- the Great Northern and Fassifern Seams are the only seams that contribute to groundwater inflow;

- there are no groundwater bearing strata within the interburden and overburden of the coal seams that are likely to be impacted by mining and drain into the mine;
- the Great Northern Seam has an average thickness of 2.5m and the Fassifern Seam is an average of 6.0m thick;
- the average permeability of the coal seams is 10^{-6}m/sec (0.1m/day) as discussed in Section 8.3.3 of this report;
- the approximate extent of workings of the Great Northern Seam is simplified to a rectangular shape of 3.5km x 5.0km, (See Figure 3 above);
- the approximate extent of the current workings of the Fassifern Seam is simplified to a rectangular shape of 3.5km x 3.5km, (See Figure 3 above);
- the approximate extent of the proposed future workings in the Fassifern Seam is simplified to a rectangular shape of 6.0km x 3.5km, (See Figure 3 above).

Based on the assumptions outlined above, the steady state inflow to the existing Fassifern Seam mine area is assessed as follows:

Inflow from east and west:

$$Q = \left[0.1\left(\frac{1-(-180)}{2000}\right) \; x\, 6.0\; x\, 3500 \right] x\, 2 \;\; m^3/day$$

= 380m^3/day (0.38ML/day)

Inflow from north and south:

$$Q = \left[0.1\; x\; \left(\frac{1-(-180)}{2000}\right) \; x\, 6.0\; x\, 3500 \right] x\, 2 \;\; m^3/day$$

= 380m^3/day (0.38ML/day)

The total estimated inflow to the existing Fassifern Seam workings is 0.76ML/day and similarly the estimated inflow to the existing workings of the Great Northern Seam is 0.384ML/day. The total assessed inflow to the mine at present is therefore about 1,144m^3/day or 1.14ML/day, which is considered to be in reasonable agreement with the estimated volume of groundwater pumped from the mine of 0.80-0.85ML/day, described above.

The estimated maximum inflow to the workings of the Fassifern Seam including the proposed future workings covered by this EA is assessed to be 1.03ML/day. That is inflow from the Fassifern Seam will increase from the current 0.76ML/day to about 1.03ML/day, and the total volume of water inflow from both the Great Northern and Fassifern Seams from the current 1.14ML/day to 1.41ML/day.

In summary it is concluded, based on monitoring of groundwater pumped from the existing workings, and the analytical assessment of inflow using a simplified model and basic assumptions, that groundwater inflow to the mine may increase from 1.14ML/day to 1.41ML/day as a result of the Project. Mannering has an Environment Protection Licence (EPL) 191 which allows them to discharge 4ML/day and based on the above analysis it is concluded that the Project will not result in this licensed discharge volume being exceeded, although this is permitted in times of high rainfall events.

10.5 Potential for Saline Intrusion from Lake Macquarie

The investigations and case studies described above demonstrate quite conclusively that the proposed bord and pillar mining of the Fassifern Seam will not cause subsidence that will impact the shallow aquifers. As such groundwater levels in these aquifers should not be lowered allowing potential for saline intrusion from Lake Macquarie.

10.6 Potential for Groundwater Contamination

The potential for groundwater contamination exists from spills of chemicals, fuels, oils etc, both at the surface and underground in the mine workings. The surface facilities are contained in a relatively small area comprising administration offices, workshops, crushing facility, two above ground 14,000L diesel storage tanks, water management structures, ventilation shafts, a small coal stockpile and tarred parking areas and access roads.

The AEMR of 2005[12] for Mannering states that:

> ***"Ground water pollution***
> *Water underground is generated from groundwater which is released from the strata into underground mine workings. The collected water is pumped through an extensive goaf system that allows filtration and settlement. The water is then pumped from the mine into the surface settlement pond systems prior to discharge via EPA licensed discharge point 001. Continual monitoring of this discharge has recorded analysis within the EPL requirements.*
>
> ***Contaminated polluted land***
> *To date no contaminated surface lands have been found as a result of underground operations.*
>
> *Potential areas where historic operations may have contaminated land have been identified. A hydrocarbon contamination investigation program has been developed and will be implemented in the 2006 report period".*

Leaching of contaminated soil by infiltration of rainfall or direct migration of contaminants to the water table has potential to contaminate the shallow aquifers, however Centennial are in the process of identifying the extent of historic contamination and remediating these sites. The sites of the diesel storage tanks are bunded to contain any spills and management plans have been developed in case of future spills. The AEMR (2005)[12] states that *"emergency spill stations are positioned in five locations around the site surface and provide hydrocarbon spill containment equipment".*

Based on the above discussion, it is concluded that while there is a risk of groundwater contamination from the operations of the mine, as is the case with all mines, Mannering has undertaken monitoring and have implemented strategies that significantly reduce this risk.

11.0 SUMMARY AND CONCLUSIONS

Based on:

- the description of the hydrogeological regime of the Mannering Mine and surrounding areas;
- the depth of the proposed area of continuation of mining (the Project) in the Fassifern Seam;
- the proposed bord and pillar method of mining; and
- the extensive impact on the groundwater regime that has occurred from existing and past mining operations at Wyee State Mine (Mannering Colliery), and from surrounding collieries;

it is concluded that there is little risk that the alluvial aquifers and shallow regolith/bedrock aquifers will be adversely impacted by the Project. These shallow aquifers are the prime aquifers used in the area for stock and domestic supplies, (although there are relatively few users), and on which aquatic ecosystems may be dependent.

The deep coal seam aquifers have been extensively impacted by the current and past mining operations in the area resulting in a large cone of depression in the piezometric surface around the mines. The Project may result in further depressurisation of the Fassifern Seam to the north-west however this is assessed to be a relatively small cumulative impact on that which has already occurred.

The coal seam aquifers contain poor quality water which it is assessed has no environmental value.

Groundwater monitoring has not been required to date at Mannering and based on this impact assessment, it is considered that monitoring will not be required in the Project Area going forward.

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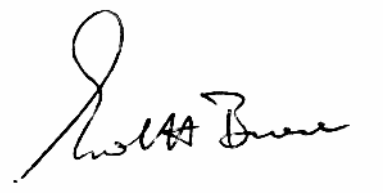


ERROL H. BRIESE
Managing Director/Principal Hydrogeologist

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Hansen Bailey Pty Ltd in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 7 July 2006.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

This study was undertaken between 29 October 2006 and 22 January 2007 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

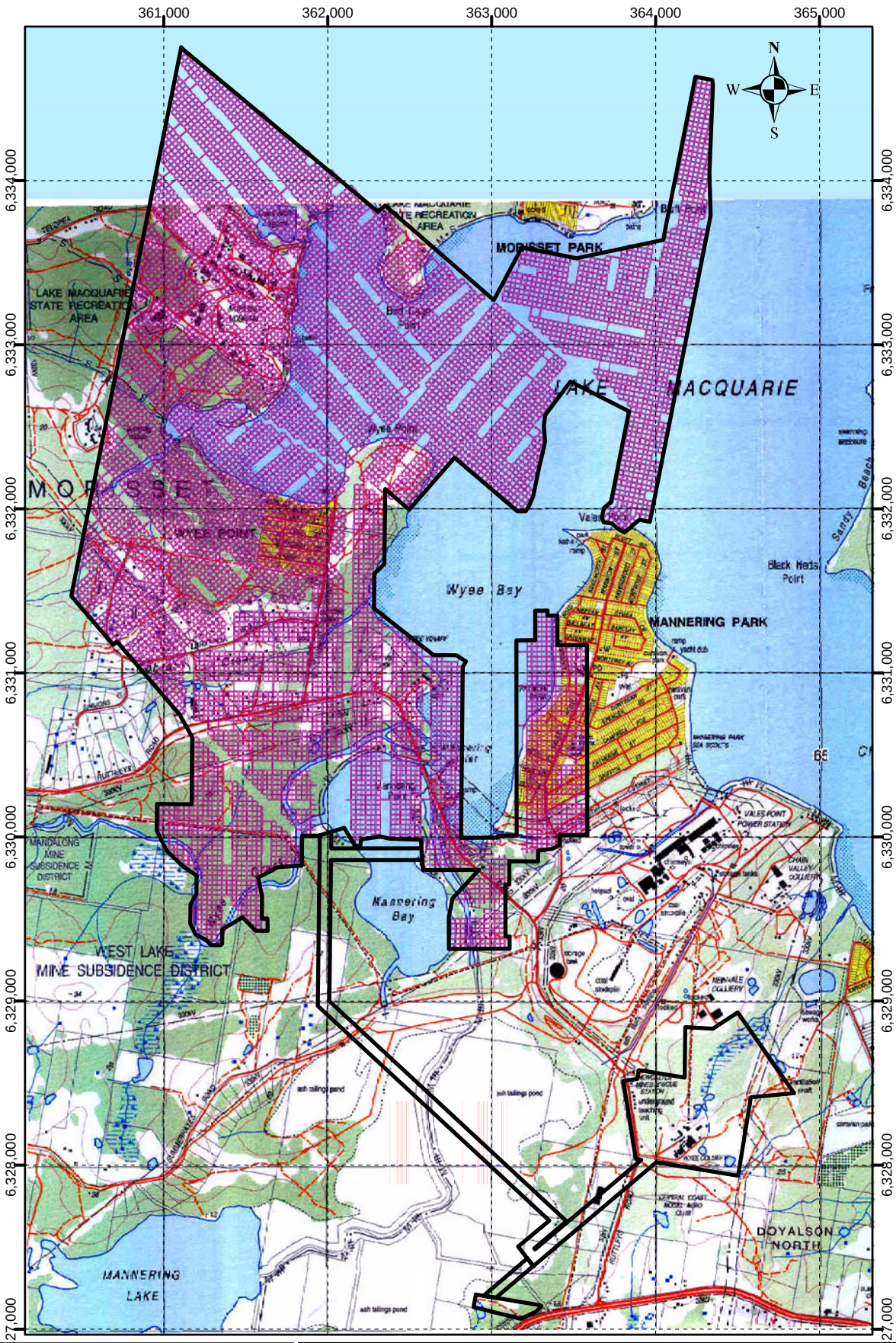
This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

APPENDIX A

Drawings



Legend

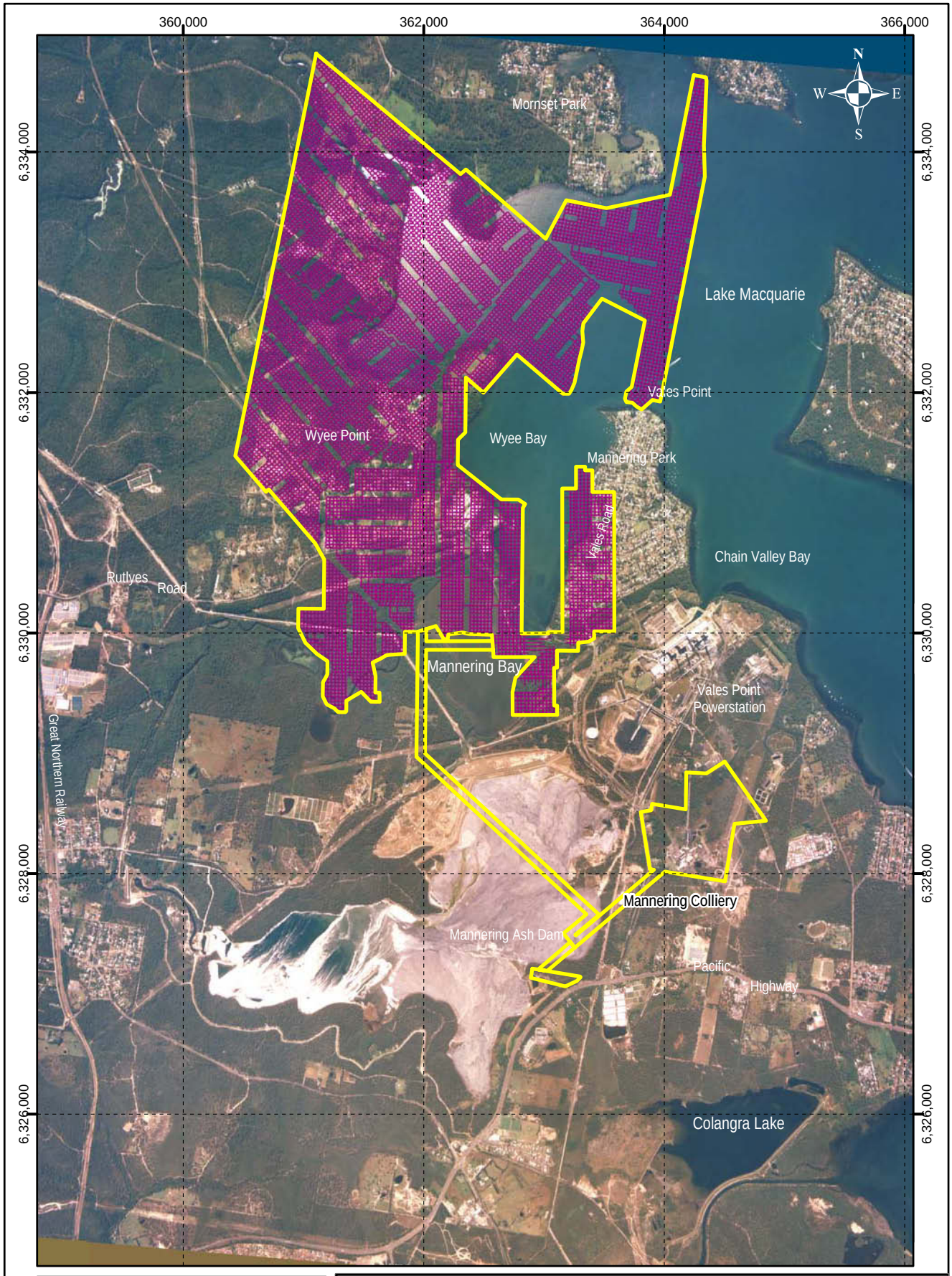
10 year conceptual mine plan (The Project)

EA Boundary

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: MANNERING CONTINUATION OF MINING ENVIRONMENTAL ASSESSMENT - GROUNDWATER CONCEPTUAL MINE PLAN - FASSIFERN SEAM

CLIENT: Hansen Bailey Pty Ltd			**Office:** Brisbane
DRAWN BY: TMM	**SCALE:** 1:35,000 (A4)	**PROJECT No:** G1373	**DRAWING No:** 1
APPROVED BY:		**DATE:** December 2006	



Legend

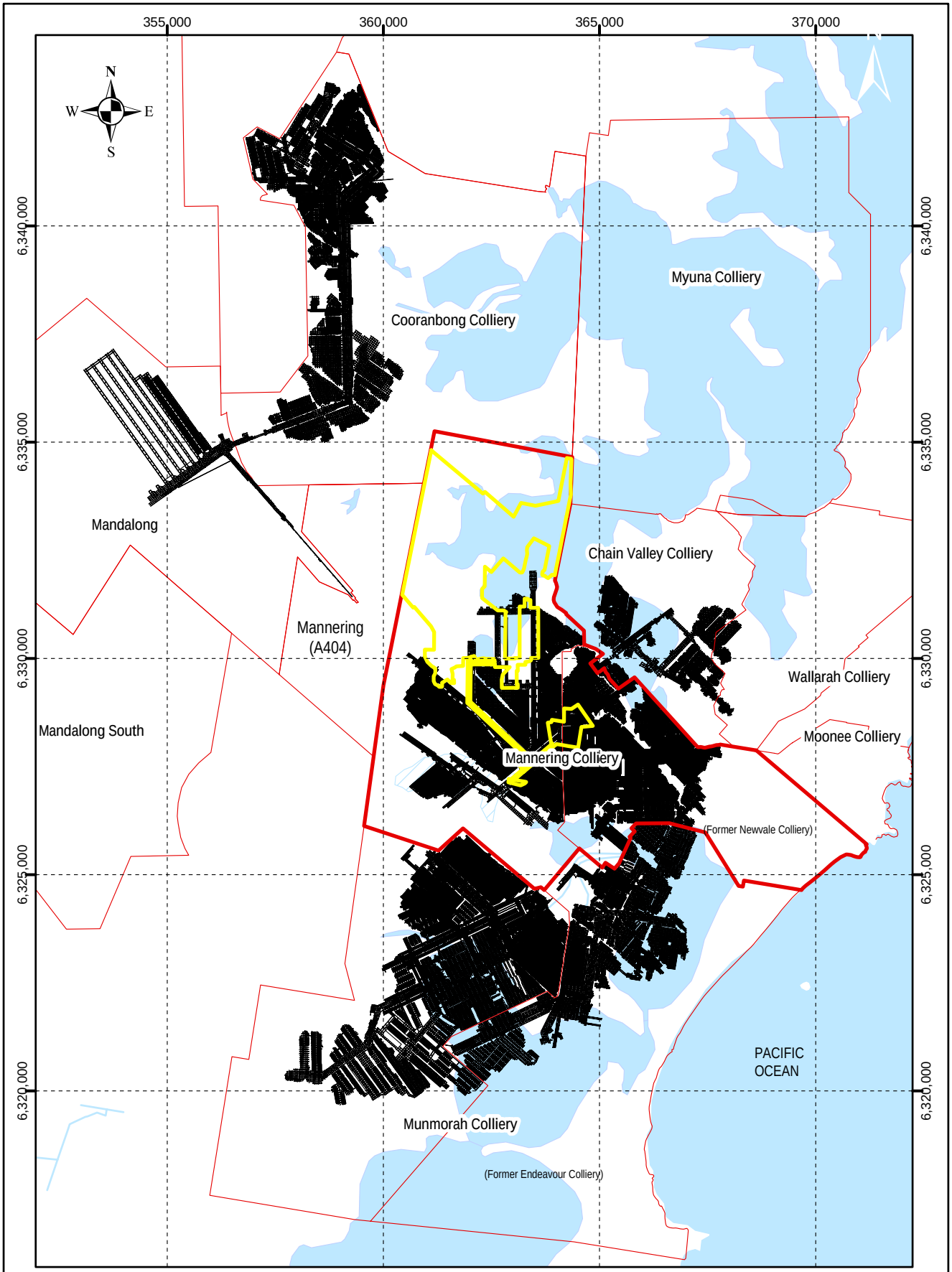
10 year conceptual mine plan (The Project)

EA Boundary

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: MANNERING CONTINUATION OF MINING
ENVIRONMENTAL ASSESSMENT - GROUNDWATER
AERIAL PHOTOGRAPH WITH CONCEPTUAL MINE PLAN

CLIENT: Hansen Bailey Pty Ltd			**Office:** Brisbane
DRAWN BY: TMM	**SCALE:** 1:45,000 (A4)	**PROJECT No:** G1373	**DRAWING No:** 2
APPROVED BY:		**DATE:** December 2006	



Legend

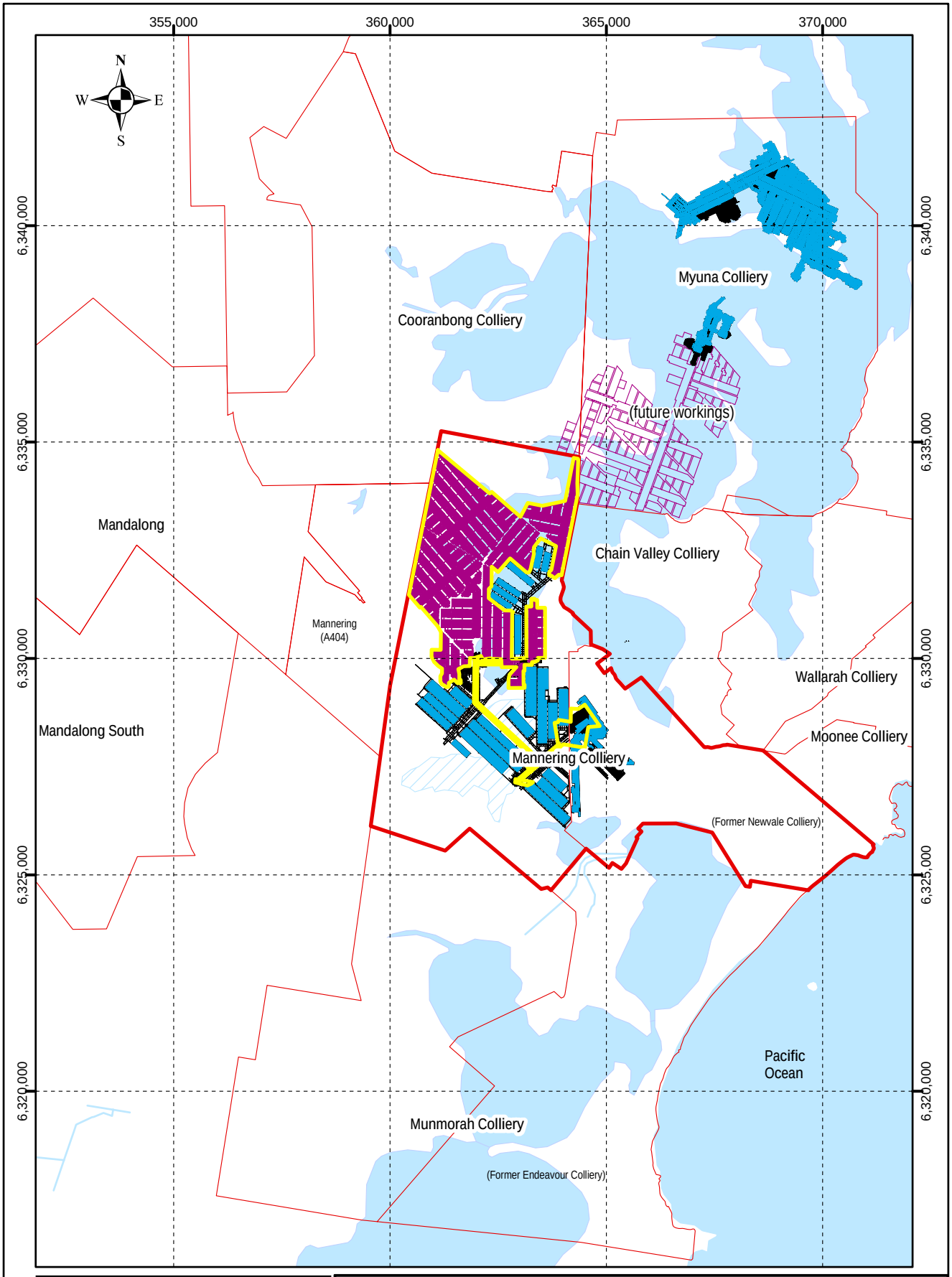
- Mannering Colliery Holding boundary
- EA Boundary

Note: Myuna, Wallarah and Moonee Colliery workings not shown (not available)

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: MANNERING CONTINUATION OF MINING ENVIRONMENTAL ASSESSMENT - GROUNDWATER GREAT NORTHERN SEAM - EXISTING WORKINGS

CLIENT: Hansen Bailey Pty Ltd			**Office:** Brisbane
DRAWN BY: TMM	**SCALE:** 1:125,000 (A4)	**PROJECT No:** G1373	**DRAWING No:** 3
APPROVED BY:		**DATE:** December 2006	



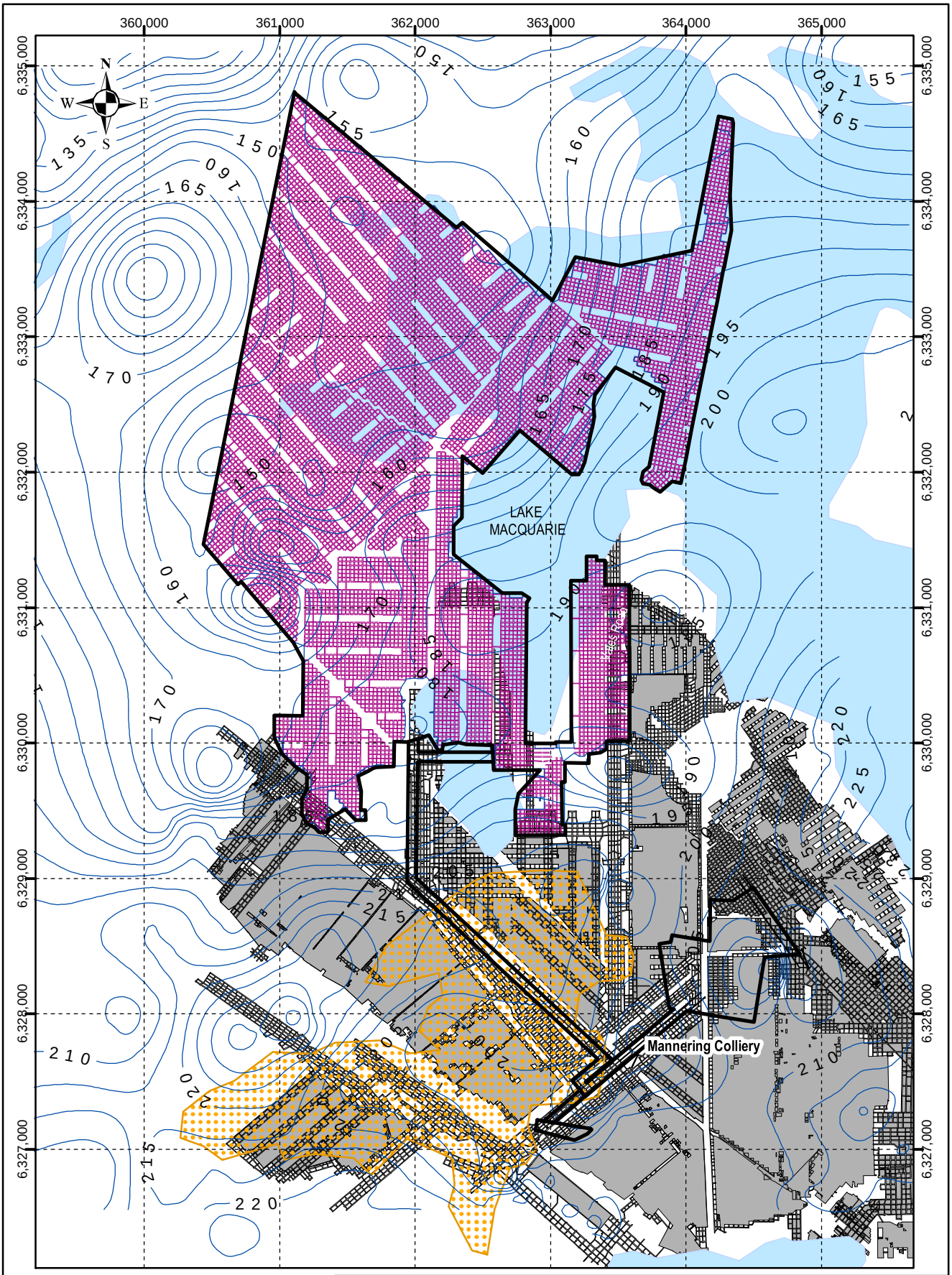
Legend

- Mannering Colliery Holding boundary
- Conceptual Mine Plan (The Project)
- Existing Workings
- EA Boundary

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: MANNERING CONTINUATION OF MINING ENVIRONMENTAL ASSESSMENT - GROUNDWATER FASSIFERN SEAM - EXISTING AND PROPOSED WORKINGS

CLIENT: Hansen Bailey Pty Ltd			**Office:** Brisbane
DRAWN BY: TMM	**SCALE:** 1:125,000 (A4)	**PROJECT No:** G1373	**DRAWING No:** 4
APPROVED BY:		**DATE:** December 2006	



Legend

- EA Boundary
- Conceptual Mine Plan (The Project)
- Existing Workings
- Overburden Isopachs (m)
- Ash Dam

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: MANNERING CONTINUATION OF MINING
ENVIRONMENTAL ASSESSMENT - GROUNDWATER
OVERBURDEN (COVER) THICKNESS - FASSIFERN SEAM

CLIENT: Hansen Bailey Pty Ltd			**Office:** Brisbane
DRAWN BY: TMM	**SCALE:** 1:40,000 (A4)	**PROJECT No:** G1373	**DRAWING No:** 5
APPROVED BY:		**DATE:** December 2006	