APPLICATION FOR FURTHER APPROVAL OF WEST CLIFF EMPLACEMENT STAGE 3

VOLUME 1

ASSESSMENT OF ALTERNATIVE USES FOR COAL WASH

bhpbilliton
ILLAWARRA COAL

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Shaping the Future

Application for Further Approval of West Cliff Emplacement Stage 3

Volume 1 of 3
Assessment of Alternative Uses for Coal Wash

July 2007

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Application for Further Approval of West Cliff Emplacement Stage 3

Volume 1 of 3
Assessment of Alternative Uses for Coal Wash

Volume 1 - Assessment of Alternative Uses for Coal Wash
Volume 2 - Application Report
Volume 3 - Species Impact Statement (Biosis)

Report 001 Rev 3

Final Report
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ABBREVIATIONS

ACARP	Australian Coal Association Research Project
AEMR	Annual Environmental Management Report
CCC	Community Consultative Committee
CPI	Consumer Price Index
CRDC	Coal Resource Development Committee
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DECC	Department of Environment and Climate Change
DIPNR	Department of Infrastructure, Planning and Natural Resources
DoP	NSW Department of Planning
DPIM	Department of Primary Industries and Mines
EPA	Environmental Protection Authority
FBB	Fluidised Bed Boilers
FBC	Fluidised Bed Combustor
IC	Illawarra Coal
Mt	Million Tonnes
Mtpa	Million Tonnes per Annum
NPWS	National Parks & Wildlife Service
PKCPP	Port Kembla Coal Preparation Plant
ROM	Run of Mine
WC	West Cliff
WCCPP	West Cliff Coal Preparation Plant
WdSC	Wollondilly Shire Council

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EXECUTIVE SUMMARY

Illawarra Coal (IC) currently emplaces coal wash material from coal processing in the Stage 2 emplacement at West Cliff mine site.

The West Cliff emplacement was originally approved by Wollondilly Shire Council in 1975 and operates in accordance with a s126 approval issued under the Coal Mines Regulation Act. The Dendrobium Mine Project development consent (issued in 2001) required that the proposed Stage 3 emplacement be subject to further development approval by the Minister for Planning, after IC considered the feasibility of alternatives to the emplacement of coal wash in Stage 3.

The primary objective of this report (Volume 1 of 3) is to address consent condition 5.1(c) of the Dendrobium Mine development consent by assessing whether there are any feasible alternatives to Stage 3 of West Cliff coal wash emplacement.

There is significant and ongoing business incentive to seek alternative solutions to coal wash emplacement. The life of current mining operations exceeds the planned capacity of the West Cliff coal wash emplacement (including the proposed Stage 3 emplacement). New potential sites for surface emplacement are scarce within economically viable transport distances and/or not available at appropriate timeframes.

There is a recognised need to seek feasible alternative coal wash management options into the future.

In assessing alternatives, a range of options were examined, including:

- *Optimising existing emplacement site.*
- *Underground disposal.*
- *Coal wash brick making.*
- *Road pavement.*
- *Using coal wash as fuel for power generation.*
- *Civil fill applications and site rehabilitation.*

The assessment is based on the following criteria:

- *Technical feasibility – is current technology available to pursue an alternative option.*
- *Market demand – is there sufficient demand for the alternative use to significantly reduce the need to emplace coal wash.*
- *Market competition – does market competition allow a feasible long term option.*
- *Costs – do delivery costs prohibit the alternative use.*
- *Environmental risk – what is the environmental impact of the option compared to that of emplacement.*

The assessment found that:

- *Optimisation studies for the West Cliff Stage 2 emplacement have been undertaken and recommend a potential additional 3.8Mt of coal wash can be emplaced. The capability of the Stage 2 emplacement to accept this additional volume is predicated on Stage 3 being approved to enable safe working benches and treatment ponds to be developed. The Stage 2 emplacement is the only emplacement currently operated by Illawarra Coal. The proposed volume increase in Stage 2 provides a short term (2 years) capacity increase, but will not negate the need for the proposed Stage 3.*
- *Underground disposal (via overburden grout injection and/or goaf injection) is not yet technically feasible. IC is considering further research and trials on these technologies. The volumes of coal wash that may be used by these techniques are relatively small in comparison to the total annual production of coal wash. If underground disposal becomes technically feasible, it is most likely that the application would be used to facilitate subsidence reduction around high value infrastructure and/or natural features. Considerable technical, underground safety, cost and environmental management challenges need to be resolved before this technology becomes proven as a long term alternative to the emplacement of coal wash.*
- *Reuse of coal wash for brick manufacturing is technically feasible, but is subject to intense market competition by other materials. This competition is exacerbated by the high delivery costs of*

coal wash. These market factors largely limit reuse of coal wash to the local area and inhibit the utilisation of large quantities of coal wash. The marketability of the colour of bricks made from coal wash is a factor that limits the volume of coal wash that can be diverted to this alternative.

- *Coal wash as fuel for power generation requires further research due to the technical, economic and environmental risks associated with this alternative. There are particular concerns regarding the potential for air pollution (green house gas, NOx and particulates) emissions, water consumption, and waste management resulting from a coal wash powered electricity generation plant. The high ash content of coal wash means that large volumes of fly and bottom ash would be produced during power generation and would subsequently require disposal. Lightweight ash products pose greater environmental risks than coal wash when emplaced.*
- *Coal wash has some applications as a bulk engineering or select fill. IC has undertaken investigations to better understand the chemical and physical properties of coal wash in order to assist in the development of a market for coal wash fill. Substantial volumes of coal wash have been diverted to fill operations. Ongoing discussions with potential customers are recommended to ensure that all opportunities are considered and property assessed. If successful, diversion of coal wash to fill applications may increase the lifespan of the Stage 3 emplacement. However, it is estimated that the demand by potential customers will not negate the need for State 3 emplacement.*

The assessment found that whilst some options have their own merits and are able to utilise a small percentage of coal wash, none of the currently available options are capable of utilising sufficient volumes to negate the urgent need for the Stage 3 emplacement.

It is concluded that the West Cliff Stage 3 surface emplacement remains the only viable short to medium term option for coal wash disposal, supplemented by a range of possible reuse opportunities negotiated on a project by project basis.

Even with the approval of West Cliff Stage 3 emplacement, IC will continue to:

- *Undertake research and consider alternatives to coal wash emplacement.*
- *Pursue the use of coal wash as an engineering fill material.*
- *Continue to negotiation with owners of suitably located and available sites that could be used as alternative emplacement sites to extend the life of the Stage 3 emplacement.*
- *Report progress of these actions to the NSW Government in the Annual Environmental Management Report.*

1. INTRODUCTION

1.1. BACKGROUND

In November 2001, BHP Billiton Illawarra Coal (IC) obtained approval for an underground coal mine development at Dendrobium. The approval allowed extraction of 5.2 million tonnes (Mt) of run of mine (ROM) coal per year, and the construction and operation of the associated facilities, with coal wash to be emplaced at West Cliff mine (another colliery owned and operated by IC).

The application was assessed by a Commission of Inquiry, requested by the then Minister for Planning, Dr Andrew Refshauge. The Commission considered the potential environmental impacts associated with the project and examined all aspects of the proposal, ranging from the extraction work, coal processing, transportation, storage, dispatch and disposal, to the construction of related plants and infrastructure, their locations and operational requirements, and the final mine remediation activities. It recommended approval subject to a series of conditions.

The Minister, as advised by the Commission, issued a staged approval to the development. In relation to the West Cliff coal wash emplacement proposal, the approval required that extension to West Cliff Stage 3 emplacement would be subject to a further approval. The application for this further approval would be determined by the Minister for Planning.

The approval also imposed a series of annual reporting requirements that must be submitted by Illawarra Coal prior to applying for Stage 3 extension. These requirements include:

- A full evaluation on the technical and commercial aspects of using alternatives to the Stage 3 West Cliff waste emplacement area. The report was to be submitted by 31 December 2003;
- Annual progress reports detailing the progress in pursuing and marketing alternatives to emplacement options; and
- A report on the feasibility of any alternatives to Stage 3 emplacement area, including consideration as to whether modifications to the consent are required. The report is to be submitted by 31 December 2008.

The intention for these reporting requirements was to ensure that all alternatives are exhausted before further extending the boundary of the current Stage 2 emplacement site.

An extract of the Dendrobium project conditions of consent in relation to Stage 3 West Cliff emplacement activities is provided in **Figure 1**.

5. Coal Wash Emplacement Area, Waste, Hazards Management and Land Stability

5.1 Stage 3 Coal Wash Emplacement Area

Alternatives to Waste Emplacement Area No. 3 West Cliff and Reporting

(a) The Applicant shall fully evaluate the technical and commercial aspects of using alternatives to the proposed waste emplacement area No. 3 at the West Cliff site. The report with recommendations shall be submitted to the Director-General, NPWS, Waste Management Task Force (the existing task force which review BHP waste management), and WdSC* no later than 31 December 2003.

The report shall consider, but not be limited to:

- Filling up existing waste emplacement areas available to the Applicant;
- Underground disposal.
- Coal wash brick.
- Road pavement; and
- Power Station use.

(b) From the date of submission of the report, the Applicant shall provide an annual written report to the Director-General, NPWS, Waste Task Force, and WdSC, detailing progress undertaken during that period to pursue alternatives to the use of Emplacement Area No. 3. The Applicant shall provide any reasonable additional information relevant to these reports and any other reasonable requirements for the reports, if so requested by the Director-General.

(c) The Applicant shall submit a report by 31 December 2008 with recommendations to the Director-General, NPWS, Waste Task Force and WdSC whether any alternatives to Emplacement Area No. 3 are feasible. This will include consideration whether modifications will be required to this consent.

(d) The Director-General may, after considering any submission made by relevant government authorities, Waste Task Force and Community Consultative Committee (CCC) on the report, notify the Applicant of any requirements with regard to any recommendations in report. The Applicant shall comply with those requirements within such time as the Director-General may require.

** Wollondilly Shire Council*

Figure 1 - Conditions of Consent for Dendrobium Mining Project (extract)

Illawarra Coal has complied with these conditions by submitting the following reports (**Table 1.1**):

Table 1.1 – Compliance with Conditions of Development Consent

Condition No.	Compliance by Illawarra Coal
5.1 (a)	Management and Marketing Plans for Coal Wash were submitted 2002 and 2003 (refer **Appendices B and C**) to examine the alternatives to coal wash emplacement area No. 3. These reports assessed the following options: • Filling up existing emplacement sites • Underground disposal • New sites for long term emplacement • Residential and Civil Construction • Power Station use
5.1(b)	Three progress reports were submitted to relevant agencies on an annual basis from 2004-2006. These are attached as **Appendices D – F** of this report.
5.1(c)	This report addresses condition no. 5.1(c) by assessing the feasibility of alternative options to emplacement.

1.2. OBJECTIVES OF THE REPORT

The primary objective of this report is to address consent condition 5.1(c) by assessing whether there are any feasible alternatives to Stage 3 of West Cliff emplacement. The assessment will consider the market feasibility, technological constraints and logistical requirements of various options to use or dispose of coal wash.

The report aims to:

- Summarise previous reports relating to emplacement alternatives.
- Identify alternative options to emplacement based on current research.
- Investigate and compare the technical and commercial viability of available alternatives to coal wash emplacement.
- Conclude whether there are any feasible alternatives to Stage 3.

1.3. METHODOLOGY

The assessment on the feasibility of alternatives options will be carried out by considering their market, technological and cost constraints. It will involve:

- Review of existing national and international literature and experience.
- Consultation with relevant government agencies and stakeholders.
- Examination of market demand and constraints.
- Assessment of the implications to the proposed area of Stage 3.

1.4. STRUCTURE OF REPORT

The report is organised in the eight sections.

Sections 1 and 2 justify this investigation within the scope of the statutory obligations of Illawarra Coal under the existing development consent. It describes the existing emplacement operations of Illawarra Coal and investigates the issues relating to current practice. Section 2 concludes with a description of the current practice of Illawarra Coal to address the issues.

Section 3 reviews previous research and studies on alternative options to emplacement. Based on these studies, it identifies the available options for coal wash disposal other than emplacement and describes a framework to assess the feasibility of these options.

Sections 4 – 7 assess the various emplacement alternative options. These sections describe the technical nature of each option and investigates their feasibility.

Section 8 summarises the assessment of alternative options and concludes whether there are any feasible alternatives for Stage 3.

2. OVERVIEW OF THE EMPLACEMENT ACTIVITIES AT WEST CLIFF

2.1. OPERATIONAL OVERVIEW OF ILLAWARRA COAL

IC currently produces coal from three mines – Appin, West Cliff, and Dendrobium.

Coal extraction uses longwall underground mining technology. ROM coal extracted from the collieries is transported to the washeries for washing and processing. Two coal washeries are currently in operational – West Cliff Coal Preparation Plant (WCCPP) and Port Kembla Coal Preparation Plant (PKCPP) at Port Kembla BlueScope steel works (referred to in some instances as Dendrobium Washery).

The clean coal production from WCCPP is transported by truck to Port Kembla. The coal is supplied to the BlueScope Steel mills at Port Kembla and Illawarra Coke Co. batteries at Corrimal and Coalcliff or is delivered to export and other domestic (OneSteel at Whyalla and Zinifex at Port Pirie) markets.

The coal wash, which is the by-product of the coal preparation and washing processes, is transported by backloading trucks to the WC emplacement area for stockpiling and final disposal. Another emplacement site at Wongawilli, which accepted coal wash from PKCPP, was completed in 2005 and has been rehabilitated. The WC emplacement is the sole remaining emplacement within IC's operations.

Figure 2 depicts the relationships between the mining, washing and emplacement operations of IC.

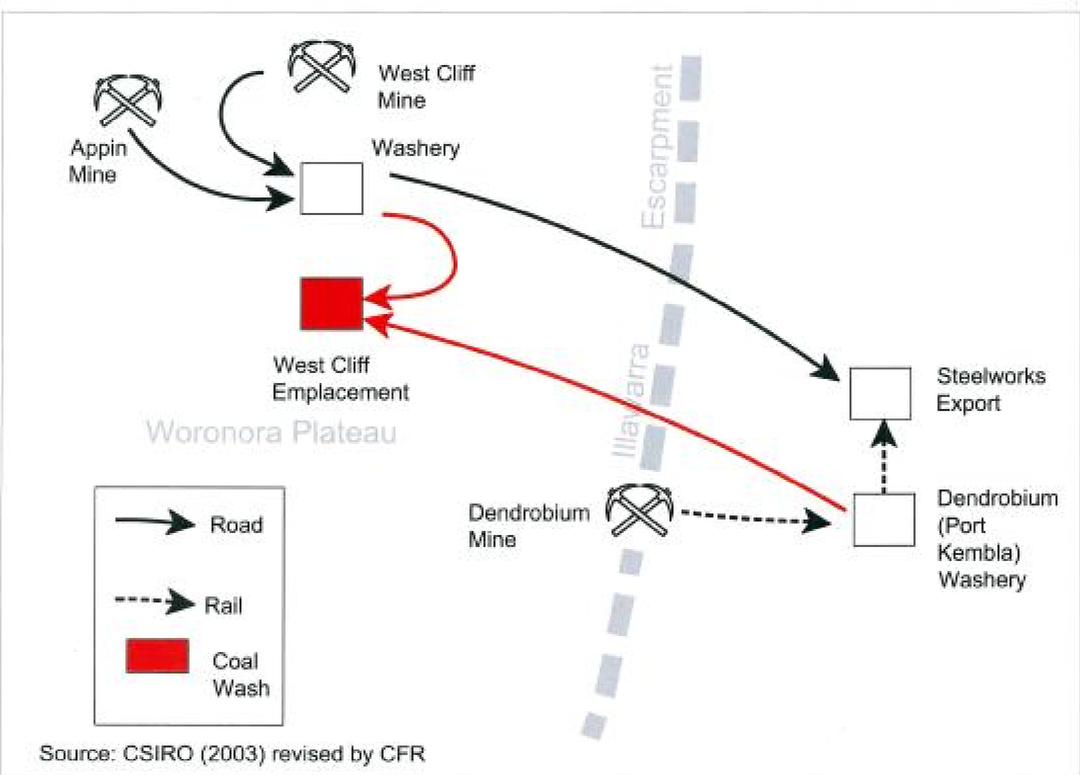


Figure 2 – Schematic of Present Illawarra Coal Operations

2.2. WEST CLIFF EMPLACEMENT OPERATIONS

The WC coal wash emplacement site is located in the upper reaches of Brennan's Creek. The site, originally named as the Brennans Creek Refuse Emplacement Area, was initially designed by Sinclair Knight and Partners in 1989. The emplacement footprint started from the West Cliff Mine South site and extended to the headwaters of Brennans Creek Dam. The formation height was planned to be limited to 24m, had a design capacity of 21Mt and an estimated life of 45 years (OEC 2006).

The original designs of Stages 1 and 2 have been revised on several occasions which have resulted in a considerable increase in the volume of coal wash emplaced above the initial design projections. A summary of the emplacement history is provided in **Table 2.1**.

Table 2.1 – Summary of Emplacement History

	MODIFICATIONS TO PLANNED EMPLACEMENT FORMATION	ESTIMATED EMPLACEMENT CAPACITY
STAGE 1		
1	Planned emplacement capacity	1.9Mt
2	Stage capacity increased following revision of the formation height limitation.	2.7Mt
Total Stage 1		**4.6Mt**
STAGE 2		
1	Initial planned emplacement capacity	9.25Mt
2	Planned increase in capacity following revision of the formation height limitation & installation of BC1 drain.	5.75Mt
3	Planned increase in capacity following revision of surface table drain opposite archaeological site BC1.	0.33Mt
4	Planned increase in capacity following revision of western perimeter drain arrangement.	1.7Mt
Sub Total Stage 2		**17.0Mt**
5	Planned increase in capacity following revision of Stage 2 final landform pending approval of Stage 3 emplacement	3.8 Mt
Total Stage 2		**20.8Mt**

Source: OEC 2006

- **Stage 1** covered an area of 21 ha and has an emplacement capacity of 4.6 Mt. Stage 1 is now completed and rehabilitated.
- **Stage 2** will cover an area of 29 ha when completed. It is anticipated that Stage 2 will reach its full capacity in 2008. Rehabilitation has commenced on some embankments of Stage 2 emplacement. Up to 20.8Mt has been planned in Stage 2 pending the approval of Stage 3.

- **Stage 3** is proposed to cover an area of 66.3ha and has a total emplacement capacity of approximately 33.5 Mt. 60.5ha is proposed to be cleared for emplacement operations.

Emplacement at WC was approved in 1975 by Wollondilly Shire Council. The approval also allowed transportation of coal wash from the Port Kembla washery to WC by truck using the existing road network to the WC emplacement area. Illawarra Coal have designed this freight task to utilise trucks returning from product delivery to minimise truck numbers used on these routes. Coal wash from the WC washery is delivered to the emplacement area by internal haul roads.

Consolidated Coal Lease 724 issued by the Minister for Mineral Resources in June 1991 in accordance with the Coal Mining Act (1973) describes the land and purposes which may be undertaken on the lease. This includes; the dumping or depositing of any overburden, coal, minerals, mine residue or tailings.

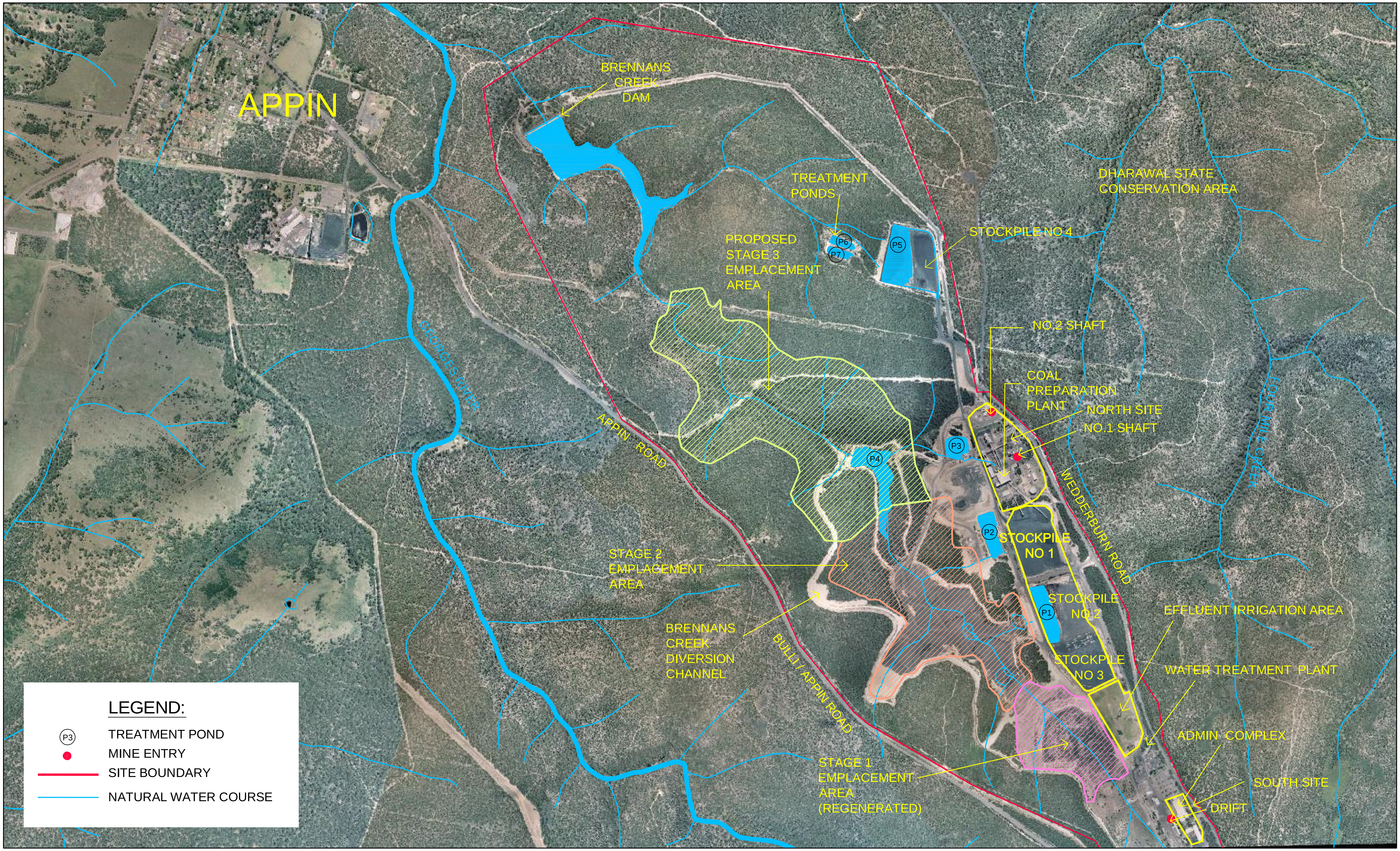
Emplacement currently occurring at Stage 2 follows a series of steps:

1. Topsoil and loose vegetative material is first stripped to competent rock for site preparation. The stripped material is used immediately for topsoiling or otherwise stockpiled close to the emplacement, to be placed on those areas ready for rehabilitation.
2. Coal wash is placed in layers and compacted.
3. Coal wash is deposited in benches across the valley and progressively down the valley.
4. As each section of fill reaches the designed height, the area is graded and trimmed to provide appropriate drainage. It is then covered with topsoil and re-vegetated. Clean water is diverted from the rehabilitated emplacement to Brennans Creek via a clean water diversion system.
5. Groundwater from the coal wash emplacement is carried via subsoil drainage to an emplacement dirty water pond immediately downstream of the emplaced material. From there, it is pumped back to the Primary Settlement Tank adjacent to the Washery for treatment.

The final landform created by the emplacement is planned to blend with the regional morphology and be screened by native vegetation to reduce visual impact.

Figure 3 illustrates the layout of the emplacement area. **Figures 4 and 5** show the Stage 1 and 2 emplacement areas. **Figure 6** shows the physical appearance of coal wash.

WEST CLIFF COLLIERY
PROPOSED STAGE 3 EMPLACEMENT AREA



SITE LAYOUT PLAN

FIGURE 3

bhpbilliton ILLAWARRA COAL

0 750
SCALE 1:15000
(A3 ORIGINAL)

N W E S

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CFR REF: 107045-01-1004_R0

Figure 4 - Stage 1 Revegetated Area

(Subject to Ongoing Monitoring and Maintenance)

Source: Blunden & Gray (2006)

Figure 5 - Stage 2 Coal Wash Emplacement

(Topsoiling at Front, Coal Wash Emplacement Occurring in Distance)

Figure 6 - Appearance of Coal Wash

2.3. ISSUES ASSOCIATED WITH COAL WASH EMPLACEMENT IN WEST CLIFF

Environmental and social issues related to the Stage 3 extension were thoroughly assessed by the Commission of Inquiry (Commissioners of Inquiry for Environment and Planning 2001). These are summarised below:

- **Ecological Issues**

  The extension will require additional land clearing of native vegetation in the Brennans Creek valley. The site contains threatened flora and fauna species and provides habitat for vulnerable species.

- **Aboriginal Archaeology**

  Eight aboriginal archaeological sites were discovered within the proposed boundary of Stage 3 at that time.

- **Water Management**

  Water management measures to address sedimentation and leachate from coal wash were considered satisfactory. The measures are supported by a regular water quality monitoring program.

- **Air Quality**

  Dust emission was considered to meet the environmental standard.

- **Noise Amenity**

  Operational noise was considered to meet the environmental standards during emplacement activities.

- **Visual Amenity**

  Visual impact was not considered a major issue.

The assessment concluded that the ecological value of the site was significant and that Stage 3 should only be used after further investigation by IC for feasible alternatives. Issues relating to water management, air quality, noise amenity and visual aspects were, however, not considered significant if managed properly.

2.4. THE NEED TO SEEK ALTERNATIVE SOLUTIONS

The three operating mine sites currently generate up to 2.5 million tonnes per annum (Mtpa) of coal wash. Nearly all coal wash is disposed of via surface emplacement. West Cliff is the only existing surface emplacement site since closure of the Wongawilli emplacement in 2005. Stage 2 will reach capacity in 2008. The proposed Stage 3 emplacement can only accommodate coal wash for another 10-15 years (GHD LongMac 2004) based on the projected production rate. However, the coal reserves available to IC have in excess of 30-50 years supply (GHD LongMac 2004). Therefore, the need for a long term, sustainable coal wash management solution for IC is critical.

The lack of long term viable solutions for coal wash disposal will result in direct impacts on the business operation of IC. The export markets, the domestic steel, smelter and coke-making industries and the related construction and engineering industries, and the local and regional workforces are all heavily reliant on IC's operations. Assessment of coal wash management mechanisms need to recognise these economic relationships and consider the flow-on economic impacts.

2.5. ILLAWARRA COAL'S COMMITMENT TO SEEK ALTERNATIVE SOLUTIONS

2.5.1. Summary of Achievements

To address the need for alternative emplacement options, IC has commissioned research and development to investigate a range of reuse options and alternatives to emplacement at West Cliff. IC also employs a Business Manager to promote coal wash as a reused material for different construction projects. Approximately 1.3 million tonnes of Coal Wash has been diverted from emplacement since the commencement of work towards alternative uses for Coal Wash (BHP Billiton Illawarra Coal 2002, 2003, 2004, 2005 and 2006). Refer **Appendices B – F**.

Some key achievements include:

- The development of a specification for coal wash product used as engineering fill. This will assist in the marketing of coal wash for a range of construction projects. It is intended that a specification for the use of coal wash as fill be developed in accordance with the requirements of the Protection of the Environment (Waste) Regulations once it is gazetted (Blunden & Gray 2006).
- Reusing approximately 280,000 tonnes of coal wash in the following projects (BHP Illawarra Coal 2005, 2006):

  - Approx.1500t for brick making by Boral.
  - 250,000t as residential fill in Hayward's Bay, Yallah.
  - 25,000t as engineered fill in the land development at Redgum Ridge Estate, O'Briens Road, Figtree.
  - 2,000t as road pavement in carpark for Lysaghts Oval redevelopment, Figtree.
  - 123t in farm road at Berry.
  - Approx. 15,000 tonnes used as soil mix for rehabilitation and beautification works at BlueScope Steel's Port Kembla plant.
  - 62t as soil mix trials for Dapto Sand & Soils.

- Improvement of the quality of coal wash to enhance its ability for reuse. A moisture meter on the coal wash bin at the preparation plan was installed to alert operators when Coal Wash moisture exceeds specific limits for the reuse option. Ongoing improvements are being implemented within the PKCPP to improve moisture control of coal wash (BHP Illawarra Coal 2006).
- Initiation of discussions with two operators of alternative emplacement sites that may become available within the medium term (5-10 years) to increase the lifespan of Stage 3 or reduce the footprint area of the proposed emplacement *(BHP Illawarra Coal 2006)*.
- Comprehensive research and development of grout injection technology for the subsurface stowage of coal wash as a means of mitigating mining induced subsidence. The research and development effort has matured to the point of undertaking a significant field demonstration of this technology. Notwithstanding the development of this technology, it is apparent that the volume of coal wash likely to be used in this process is relatively small in comparison to the overall production rate (BHP Illawarra Coal 2004-6).
- Pre-feasibility investigation of the commercial, technical and environmental merits of a coal wash fuelled power station at West Cliff (BHP Illawarra Coal 2006).

2.5.2. Summary of Investigations

The investigations conducted so far are summarised as follows:

1. Specialist Reports

Since the initial approval in 2001, IC has commissioned more than eight separate reports on alternative disposal options (refer **Table 2.2**), has prepared two Management and Marketing Plans for Coal Wash (refer **Appendices B and C**), and has prepared Annual Progress Reports to the Taskforce since 2004 (refer **Appendices D – F)**.

2. Improving Coal Wash Quality

In 2006, CCI Australia was engaged to conduct a comprehensive sampling, testing and analyses program to determine the characteristics of coal wash. The outcome of the analysis would assist in determining the potential uses of coal wash, in the marketing of the material and in increasing efficiency of current practice and reducing coal wash production (BHP Illawarra Coal 2006).

The preliminary research has already led to changes in the current process. For example, a moisture meter was installed to monitor the moisture level of coal wash so that coal wash delivered to the customers satisfy Illawarra Coal's product specification (*Blunden, 2006*). An ongoing process improvement program is underway in PKCPP to achieve improved moisture control on the coal wash product from that washery (BHP Illawarra Coal 2006).

3. Marketing Coal Wash Materials

To develop a market for coal wash materials and market them, a draft Metropolitan Construction Materials Strategy was developed and is currently under the consideration by the Department of Planning. (BHP-Billiton Illawarra Coal 2006). IC has made a submission to the Department of Planning seeking support for inclusion of coal wash in this strategy.

The discussion sought to reduce the pressure on natural sources of sand and hard rock aggregate in the Sydney market and promote the use of recycled products. Analysis on the characteristics of different waste materials and their suitability for recycling are provided.

IC has held discussions with the Department of Environment and Climate Change during 2006-07 to consider the methodology of preparing a fit for purpose specification for using coal wash as fill. It is envisaged that the specification will be "approved" in accordance with the 2007 amendments to the Protection of the Environment (Waste) Regulations. A draft specification was prepared which provided a comprehensive suite of chemical and physical property data to several customers prior to delivery of coal wash (Blunden and Gray 2006).

4. Poland Study Tour

In 2004, representatives of IC visited Professor Jan Palarski of the Technical University of Silesia in Poland. Professor Palarski is the head of The Chair of Clean Mining Technologies at the University and is the specialist in backfilling technology for subsidence minimisation (BHP Billiton Illawarra Coal 2004 and 2005). The tour sought to:

- Increase the knowledge of Illawarra Coal in managing subsidence as a result of underground mined out voids.
- Find alternatives to surface emplacement of coal wash.

Illawarra Coal subsequently engaged Professor Palarski to undertake a feasibility study into the application of the Polish backfill techniques to the Southern Coalfields (Palarski, 2005). Refer **Appendix E**. Professor Palarski visited Australia in 2005 (BHP Billiton Illawarra Coal 2005). His report analysed different technologies of subsidence control and the suitability of coal wash as injection materials. It concluded that polish goaf filling techniques such as Longwall backfilling and Goaf Grouting (via pipes in the mine roadway system) were unviable for southern coalfield conditions at present. It also recommended IC continue their investigations into overburden grout technology as the first priority. This research by IC is ongoing and is discussed in **Section 5.1**.

Table 2.2 – List of Specialist Research Commissioned by IC

Area of Research	Scope	Author
Review Of Alternatives To Emplacement	• Identified the options available to Illawarra Coal other than emplacement. • Assessed the viability and impediments in pursuing each option and recommend further research into specific mechanism or technology.	CSIRO (2003)
Existing Emplacement Sites	• Investigated the opportunity to optimise existing emplacement sites to reduce the destruction to existing bushland areas. • Assessed the impact of expanding the designed capacity of existing emplacement sites to consider the feasibility of revising the design. • Assessed alternative emplacement sites adjacent to and within West Cliff site. • Assessed any potential alternative emplacement sites within the local region.	GHD LongMac (2004), OEC (2006) Don Reed & Assoc (2003)
Underground Emplacement	• Assessed the feasibility to use coal wash as underground fill materials to manage mining subsidence. • Assessed the risk of the work. • Resulted in a funding application to develop technological requirements with a view to commit a trial in one of the operating mines.	MAMIC (2000), CSIRO (2005), Palarski (2005)
Power Generation	• Investigated the feasibility for existing power station and for purpose built power generator. • Investigated technological requirement, risks and environmental impact of developing on site power plant. • Established a strategic alliance with AbiGroup to consider the operational and economic feasibility to develop a fluidised bed boiler combustor. It is hoped that the results will be available by August 2007.	Holmes Air Sciences (2003), Lunagas Pty Ltd (2001), Ecoengineers (2001)
Reuse Coal Wash As Construction Materials	• Investigated the use of coal wash for road pavement and construction fill use. • Undertook laboratory testing on the chemical and physical properties of the coal wash and its suitability as a construction material. • Examined market demand and competition with other similar waste products. • Prepared draft product specification	Don Reed & Ass. (2003), Blunden & Gray (2006), Blunden (2006)
Brick Manufacturing	• Investigated the competition and feasibility of selling coal wash to the brick manufacturing industry. • Found the quantity of coal wash used in this process is extremely small (about 1,000 tpa).	Andrews (2001)

3. ALTERNATIVE COAL WASH DISPOSAL OPTIONS

3.1. PREVIOUS STUDIES AND FINDINGS

Alternative options for disposal and utilisation of coal wash have been the subject of several studies and inquiries over the years. Some of these works were specific to the Southern Coalfields and are applicable to the West Cliff emplacement area. This section reviews these studies.

3.1.1. Coffey Inquiry

In 1973, a public inquiry was held into the *"Preservation of the Natural Beauty of the Illawarra Escarpment"*. The inquiry was undertaken by Commissioner Coffey on behalf of the State Pollution Control Commission. The Commissioner stated in his finding and recommendations that,

> *"the evidence also shows that there is no reasonable alternative available now or in the immediate future other than to dispose of the refuse by surface emplacement."*

Commissioner Coffey specifically addressed the option of underground stowing and concluded that,

> *"there is nothing in the evidence which encourages one to believe that underground stowing of the refuse will develop a viable solution. Apart from the technical and economic impediments inherent in stowing, there is the important consideration that material rejected today may need to be reclaimed for use in the future. Once stowed in mine workings this would be virtually impossible."*

3.1.2. 1983 Coal Resource Development Committee Study

In 1983, the Coal Resource Development Committee (CRDC) investigated coal wash disposal in the Southern Coalfields. The report found that the availability of emplacement sites based on mine production projections would require space to dispose of approximately 104Mt of coal wash by the year 2000. The existing and planned emplacements could accommodate all coal wash, apart from around 30Mt, which would be generated from mines south of Wollongong. The report anticipated a major need for new coal wash emplacement sites to guarantee the survival of coal mining operations near Wollongong.

Four options of refuse disposal were examined:

- Offshore disposal.
- Underground disposal.
- Utilisation.
- Surface emplacement disposal.

Upon assessment of these options, the report concluded that while utilisation as structural land fill, road-making materials, for power generation via a fluidised bed combustor and the dumping of coal wash off-shore, all have some potential to partially solve the problems for the disposal of coal wash in the long term, the only viable short to medium term option is land emplacement. To encourage the development of alternative disposal and utilisation technologies, the report recommended the development of a manual or code of practice to provide specifications for the testing, supply and use of coal wash for structural and engineering applications.

The CRDC report also suggested that local councils and the appropriate government authorities should investigate the use of coal wash as a construction material. A Waste Management Task Force was established by the then Department of Infrastructure, Planning and Natural Resource (DIPNR, now Department of Planning) in 2001. However, due to resource shortage, the Task Force discontinued in 2004.

3.1.3. 1992 Coal Resource Development Committee Study

As a result of the 1983 report, a further report by the CRDC was prepared in 1992. The report suggested that:

> "*the disposal of coal washery reject is a major problem within the southern coalfields and the situation has not changed significantly since 1983 when the report 'Coal Reject Disposal in the Southern Coalfields' was released. In fact, for a number of coal mining operations, the situation has deteriorated.*
>
> *Of all the collieries operating within the Southern Coalfields, Metropolitan and South Bulli are urgently in need of new emplacement sites. The long term viability of these mines is jeopardised by a lack of certainty in guaranteeing the disposal of coal reject for the life of the mine."*

The report considered the following options:

- Land emplacement.
- Structural land fill.
- Road base.
- Off-shore disposal.
- Underground disposal/stowage.
- Fluidised bed combustion.
- Brick manufacture.
- Alumina processing.

The report recommended legislative changes to secure long term emplacement sites to be identified in planning instruments. It also suggested government authorities to work together to develop a manual or code of practice. This will provide soundly based specifications for the testing, supply and use of coal wash for structural and engineering applications.

However, these recommendations were not taken up by Government.

3.2. FEASIBILITY ASSESSMENT ON ALTERNATIVE OPTIONS

3.2.1. Alternative Options to Emplacement in West Cliff

Based on the latest research conducted by industrial experts and the continued investigation undertaken by IC, possible alternatives to emplacement in WC Stage 3 include:

- Surface Emplacement (optimising Stage 2 emplacement and locating other suitable sites).
- Reuse as engineering and construction fill (roadworks, quarries, residential fill or brick manufacturing).
- Underground Disposal (goaf filling and overburden grout injection for subsidence mitigation).
- Coal wash as fuel for Power Generation.

Sections 4 – 7 investigate these options.

3.2.2. Factors Influencing Coal Wash Disposal Options

These options will be assessed against the following criteria:

- **Technical Feasibility**

  Most options to reuse coal wash involve augmenting or constructing new infrastructure to process the materials. The technical feasibility to develop the infrastructure must be considered.

- **Volume Demand**

  Given the current need to emplace approximately 2.5 Mtpa coal wash to sustain IC operations, any feasible alternative option, or combination of options, must be able to accommodate this large volume to avoid the need to utilise WC Stage 3. This is the critical factor in the assessment of feasibility. Implementation of alternatives will increase the lifespan of the proposed Stage 3 emplacement.

- **Market Competition**

  Other construction materials have similar (or better) properties as coal wash. The market competition for coal wash can prevent its utilisation in construction projects in large quantities, especially if haulage distances are greater than about 40km.

- **Cost**

  The major cost factor influencing alternative options is transport (rail and road). CSIRO (2003) estimated the following transportation costs:

  - $25 per tonne (approximately $27 per tonne consumer price index (CPI) adjusted to 2007 figures) for 200km for road transport.
  - $12-$13 per tonne (approximately $13-14 per tonne CPI adjusted to 2007 figures) for 200km for rail transport.

  The added costs will limit the use of coal wash to the Illawarra and southern Sydney metropolitan area.

- **Environmental Risk**

  Coal wash material is not without its risk. While research shows that coal wash satisfies the criteria of inert waste, reusing coal wash for power generation can produce flyash which requires emplacement or reuse. Power generation alternatives also have significant water consumption and air pollution considerations. Transportation and processing of the materials also generate environmental impacts, which need to be considered. Alternative coal wash fill and emplacement sites must be assessed on their specific merits, and need to be managed to minimise water, noise and dust pollution.

4. SURFACE EMPLACEMENT

4.1. INCREASING CAPACITY OF THE STAGE 1 AND 2 EMPLACEMENT AREAS

Stages 1 and 2 were originally designed to maximise the emplacement capacity of coal wash. The capacity was determined by the following factors:

- Area of emplacement footprint.
- Location of archaeological sites.
- Depth of emplaced coal wash.
- Finished surface contour of the emplacement and stormwater drainage.
- Rate of compaction of fill material.

A study undertaken by OEC in 2006 reviewed the original design of the Stage 2 emplacement and examined the opportunity to increase its capacity. The result of the study, and a more recent review of emplacement depth, are summarised in **Table 4.1**.

Table 4.1 – Summary of Emplacement Capacity Modifications

Modifications to Planned Emplacement Formation	Estimated Emplacement Capacity
Stage 1	
Planned emplacement capacity (SKM 1989)	1.9Mt
Staged capacity increased following revision of the formation height (GHD-LongMac 1999)	2.7Mt
Total Stage 1	**4.6Mt**
Stage 2	
Initial planned emplacement capacity (SKM 1989)	9.25Mt
Planned increase in capacity following revision of the formation height and installation of the drain near archaeological site BC1. (OEC 2006)	5.75Mt
Planned increase in capacity following revision of surface table drain opposite archaeological site BC1. (OEC 2006)	0.33Mt
Planned increase in capacity following revision of western perimeter drain arrangement (OEC 2006)	1.7Mt
Planned increase in capacity following revision of Stage 2 final landform (pending approval of Stage 3 emplacement)	3.8 Mt
Total Stage 2	**20.8Mt** (subject to final design)

Source: OEC (2006) revised by CFR

4.1.1. Increasing Capacity of Stage 1

Stage 1 originally provided a capacity of 1.9Mt (SKM design in 1989). In 1999, Illawarra Coal engaged GHD LongMac to review the original height limit (24m). The review raised the maximum height by an additional 8m. The modified formation provided emplacement space for an additional 2.7 Mt of coal wash. Refer **Table 4.1**.

Stage 1 was completed in 1998 and is now rehabilitated with native vegetation that is endemic to the West Cliff site. Ongoing monitoring and maintenance occurs to ensure vegetation matures successfully.

The option to re-open a major part of emplacement stage 1 for further coal wash disposal would adversely impact on the current surface water drainage system and is not justified because:

- Increasing the capacity will result in additional dirty water overflow and run-off to the existing retention system. Increasing the capacity of stage 1 would direct additional dirty water to the pit top treatment system and require a redesign of the existing water management system.
- The site has been revegetated in the past 5 years. Reactivating the site will require removal of the existing vegetation grown in the regeneration area.
- The volume of additional coal wash able to be emplaced would be very small (<2Mt) given the size of the Stage 1 emplacement area and would not alter the requirement for alternate coal wash disposal options.

4.1.2. Increasing Capacity of Stage 2

The initial capacity of Stage 2 was 9.25Mt. Since its initial design, a modification to the existing stormwater drainage system widened the emplacement footprint on the western side and increased the space for an additional 5.75Mt coal wash. Refer **Table 4.1**.

OEC (2006) further reviewed the following design aspects to determine if additional emplacement capacity can be safely accommodated in Stage 2. The findings are summarised as follows:

<u>Increasing the Width</u>

A modification to the procedure of developing the emplacement side batter slopes can provide additional capacity. The modified procedure will require covering coal wash side batter slopes with topsoil as the formation is being developed, allowing run-off water to flow almost directly into the permanent by-pass drain and eliminating the need for a temporary perimeter drain. The modification can apply on the western side of the emplacement and will widen the emplacement fill area by up to 10m. The modification will provide emplacement space for a further 1.7Mt of coal wash.

<u>Increasing Emplacement Batter Grades</u>

Another option is to change the finished surface contour design parameters, taking into account the risk of erosion occurrence. Batter protection and grade control for stormwater run-off paths across the emplacement area require significant attention. Further steepening the batter slopes and table drain grades will increase erosion, scouring and sedimentation impacts. The large surface areas of emplacement batters and the extensive lengths of run-off drain would require considerable effort and materials to effectively control erosion after significant rainfall. If large scale erosion occurs, there is also a risk of contaminating the clean water drainage system.

The report recommended that the existing emplacement batter slopes and drain grades be maintained.

<u>Increasing the Depth</u>

The depth of the site is subject to ongoing review. A review of emplacement depth was undertaken in 2005 and resulted in additional emplacement space for 0.33Mt coal wash. The layout has a depth of 54m.

More recently, GHD LongMac reviewed the emplacement height limit based on the changes in coal wash product and the current deposition technique. The review assessed the impact of the increased overburden on ground water pipes, pits and formation stability.

Following the GHD review, OEC (2006a) estimated that the emplacement depth can be further increased to 60m, which provides additional capacity of up to 3.8Mt of coal wash for Stage 2. Refer **Table 4.1**.

While this option can provide extra capacity in the existing Stage 2 emplacement area, it is not a long term solution to negate the need for Stage 3 because the additional capacity in Stage 2 is insufficient to accommodate the 2.5Mtpa coal wash generated, beyond 2 years.

In fact, increasing the elevation of Stage 2 is reliant on extending the emplacement benches further down the valley into the Stage 3 area, in order to maintain safe working benches with an appropriate batter grade (1:4). This concept is illustrated in **Figure 7** which shows an indicative location of where the Stage 2 emplacement profile must extend into the Stage 3 area due to operational, safety and stability reasons.

The emplacement is subject to stormwater, structural and environmental constraints. The capacity indicated in **Table 4.1** represents the maximum emplacement capacity based on design constraints as they are currently understood.

4.2. OTHER EMPLACEMENT SITES AT OR ADJACENT TO WEST CLIFF

Other sites within the West Cliff surface lease area have been considered. GHD LongMac conducted a study in 2004 to identify opportunities in and around West Cliff Colliery for future coal wash emplacement. Other than the currently planned areas in Stages 2 and 3, the following additional options were considered (GHD LongMac 2004):

1. Stage 4 occupying the unnamed eastern tributary valley;
2. A merged emplacement area covering main and tributary valleys of Brennans Creek;
3. A maximum footprint emplacement which fully occupies Brennans Creek and consumes Brennans Creek Dam;
4. Various valleys in the surrounding area.

The report considered some critical issues in assessing these options. For example, if an emplacement consumed Brennans Creek Dam, an alternative water supply would be required.

All options would require extensive environmental, ecological and feasibility assessments. The alternative valley filling sites considered off the West Cliff lease are within conservation areas relatively untouched by past/current mining related activities and emplacement in these locations would pose significant impacts to natural and cultural heritage values.

Given the urgent timeframe of the emplacement operation, the extent of available data, consideration of the various constraints and the location of the existing emplacement, analysis by Illawarra Coal has concluded it is sensible to extend the West Cliff emplacement in the already highly disturbed Brennans Creek valley.

WEST CLIFF COLLIERY
PROPOSED STAGE 3 EMPLACEMENT AREA

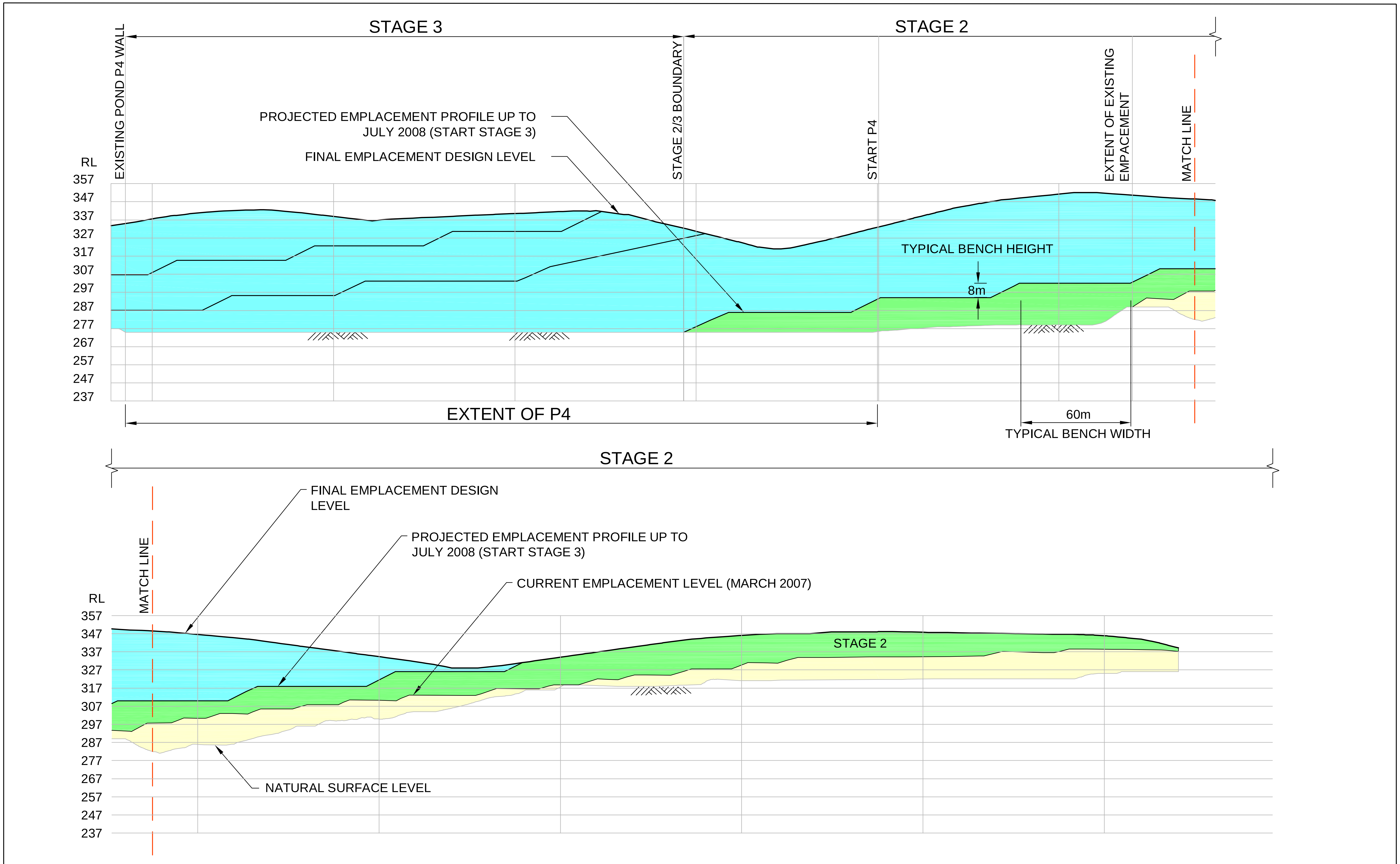


FIGURE 7

GENERAL STAGE 2 EMPLACEMENT LONGITUDINAL SECTION SHOWING EMPLACEMENT DEVELOPMENT INTO STAGE 3

bhpbilliton ILLAWARRA COAL

Cardno Forbes Rigby

CFR REF: 107045-01-1054_P0

4.3. OTHER POTENTIAL EMPLACEMENT SITES OUTSIDE WESTCLIFF

IC (then BHP Steel) operated a coal wash emplacement at Wongawilli (near West Dapto) during the 1985-2005 period. The emplacement received coal wash generated from the processing of run of mine coal from the Elouera Colliery. The development consent for this emplacement expired in 2005 and the Wongawilli emplacement site (which has been fully rehabilitated) has been sold. It is therefore not an alternative to West Cliff Stage 3.

Currently no alternative emplacement sites have been identified. Illawarra Coal has been investigating the availability of hard rock quarry sites in Dunmore and Bombo (Shellharbour, Kiama LGA's) however these sites will not be available in the near future, and if secured will involve approval lengthy consultation and approval processes. Discussions in this regard are continuing and Illawarra Coal is continuing to seek alternative emplacement sites.

5. UNDERGROUND DISPOSAL

Longwall coal mining can cause surface subsidence. After extracting coal, overlying strata collapse. As the strata relay and/or collapse the surface can deform, sometimes causing damage to surface facilities and the natural environment.

To date, subsidence control is mainly achieved by leaving large blocks of unmined coal in tact (ie. setting back mine layouts from sensitive surface features). This method is inefficient as it sterilises the coal resource. Further, remedial measures to manage the damage caused by subsidence can be a major cost to the mining operations.

The two techniques of underground disposal being investigated to address subsidence impacts (and dispose of coal wash) are:

1. Overburden Grout Injection.
2. Goaf Injection.

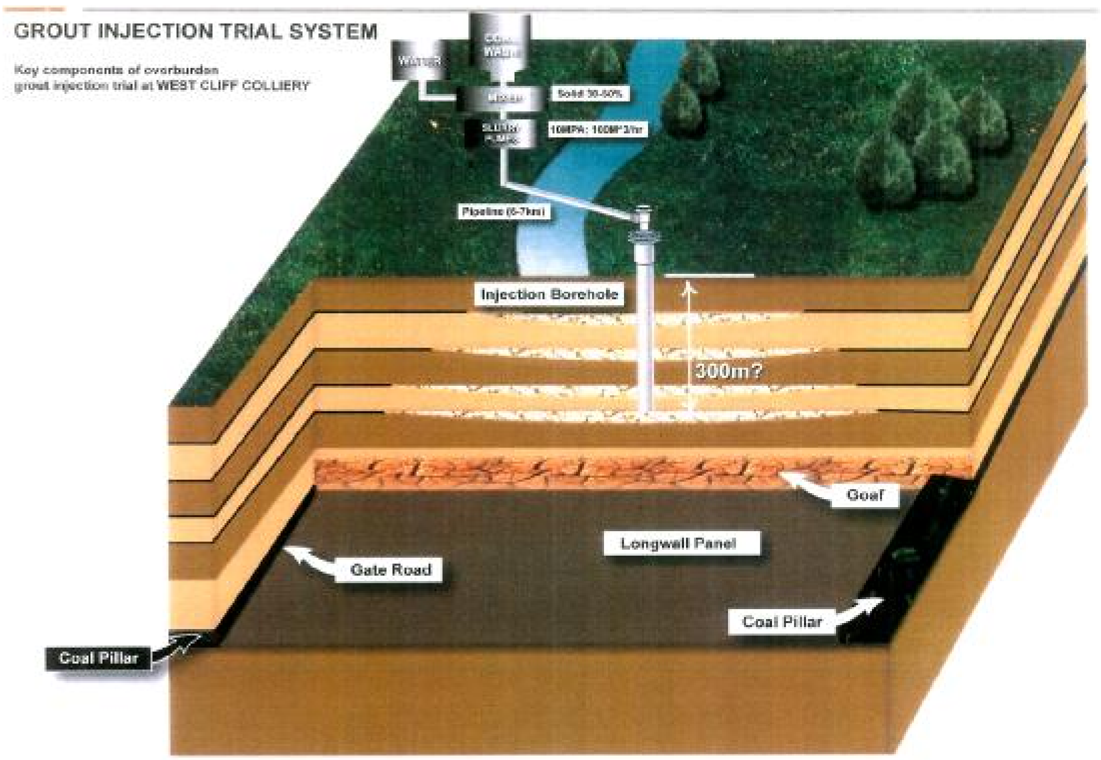
5.1. OVERBURDEN GROUT INJECTION

Overburden grout injection technology seeks to control coal mine subsidence by injecting waste material into the overlying strata during and immediately after longwall mining. The materials fill the bed separation gaps and reduce the risk of overburden movement to the surface. The technology was developed in the late 1980’s in China and it has been successfully used in many mines in China with reported subsidence reductions of up to 60% (CSIRO 2005).

Key design aspects of this technology include (CSIRO 2005):

- **Bed separation** – separation horizons, magnitude and timing in the overburden of the specific mine;
- **Hydraulic barrier** – location and thickness of water conductive zone above the goaf;
- **Grout material** – material availability, physical properties and flow properties;
- **Injection system** – pump capacity requirements, injection horizons, material delivery and mixing requirements;
- **Monitoring system** – flow rate, injection pressure and ash content.

The general concept of grout injection technology is diagrammatically illustrated in **Figure 8**.



Source: BHP Billiton –IC 2005

Figure 8 – Grout Injection System

This technology has two potential benefits:

- It may reduce mine subsidence by up to 60% and dispose of approximately 240,000 tonnes of fine coal wash in an injection area of 300m – 500m (CSIRO 2005).
- It may help dispose of most of the fine coal wash and reduce the cost and need for surface disposal.

The difficulty of this process is to predict the volume and time of void creation in the separated bed horizons. The injection is not a controlled process and hence the grout may spread and settle in all directions if not managed properly.

A successful injection will therefore require accurate analysis of the geology of the mining area, how the layers are separated in reality and how the void for injections of materials is formed. To inform this analysis, a pilot study is critical to assist in calculating the injection pressure, selection of density, grain size and composition of grouting mixture (CSIRO 2005).

5.1.1. Application in Australian Conditions

Research funded by the Australian Coal Association Research Project (ACARP) in 2005 assessed the feasibility of using overburden grout injection technology in Australian mine conditions to control subsidence (CSIRO, 2005). The project studied experience from China which used flyash (a similar by-product to fine coal wash, usually generated in power stations) as the grout injection material. However, flyash is not readily accessible in Australian mines due to the distance between the colliery and the power station.

Desktop and laboratory assessments were then carried out to assess whether fine coal wash can be used as grout material in WC Colliery. It concluded that the best injection material for West Cliff Colliery is to use a combination of coal wash and flyash.

The research concluded that:

- The concept of overburden injection using flyash is sound and the technology is feasible and applicable to some of the mine sites in Australia.
- The coal mines in the Southern Coalfield are considered to be the most suitable for application of this technology because they have similar overburden depth and geological conditions to those of the successful Chinese operations.
- Both flyash and fine coal wash of less than 0.6mm can be used as a grout injection material.
- The distance between West Cliff and the nearest power station preclude the accessibility of flyash. If coal wash is used as grout material, a long pipeline or surface haulage route is required to transport coal fines from the coal processing plant to the injection site (about 7km).
- Only fine coal wash with particle size of less than 0.6mm can be used as grout. This is less than 10% of the amount currently generated by IC.

5.1.2. Using coal wash as injection material

Following the ACARP research, CSIRO and IC jointly funded a site specific investigation and designed an injection system for a full scale trial at West Cliff Colliery. The study successfully installed a deep hole surface extensometer in the Bulgo Sandstone to measure the strata movement during undermining in the injection target zone. It also undertook a series of laboratory tests and slurry pipeline loop tests to determine the appropriate mix of coal washery rejects as injection materials (CSIRO 2005).

It was found that coal washery fines from the WCCPP and PKCPP are suitable for injection as grout materials.

The study raised some outstanding technical issues that need to be addressed before IC can commit to a first full scale trial in Australia. These issues include:

- The potential of the overburden grout injection method to reduce subsidence movements and provide protection to surface features such as rivers, pipelines, roads, railways and bridges need to be assessed and quantified.
- The hydraulic barrier between the injection horizon and the underground workings needs to be optimised to minimise the risk of grout, water and gas migration to the longwall face and goaf.
- The option of using a wide range of coal washery wastes needs to be assessed.

5.1.3. Future Research and Development

Following the joint CSIRO/Illawarra Coal research, IC submitted a funding application to ACARP, (which was approved in Jan 2007) to address some critical design issues for the trial project (BHP Billiton Illawarra Coal 2006).

The research will:

- Address the key technical issues identified for the first full scale trail at WC Colliery, including determination of the safe and effective grout injection horizons, and assessments on the effects of grout injection to improve the stability of surface features;
- Provide feasibility assessments for Moranbah North Mine and Mandalong Mine, based on the existing data at these mines and knowledge and findings of WC Colliery;
- Provide detailed economic analysis of grout injection operations in different site conditions to highlight the benefits and costs of the technology of each site;
- Investigate the feasibility of using a wide range of coal washery wastes as the injection material.

It is expected that the research will be completed in 2008.

5.1.4. Assessment – Overburden Grout Injection

The technology is still in its early stage of feasibility assessment and operational investigation. If successful, it has the potential to contribute to long term solutions in reducing the need for surface emplacement during the lifetime of the mining operation, noting that only the coal wash fines, which represent about 10% of coal wash generated are suitable for this technology.

It must be noted that the technology is sophisticated and complex. While the technology was reported to return significant economic and environmental benefits in previous experiences in China, the cost of the technology needs to be considered as part of the feasibility assessment. The anticipated cost and benefit of the project in Australian conditions are summarised in **Table 5.1**.

Table 5.1 – Potential Benefits and Costs of Overburden Injection Technology

Advantages	Disadvantages
• May reduce remedial treatment costs for sensitive surface features. • May reduce or eliminate production loss associated with longwall relocation or setbacks to avoid subsidence impacts. • May reduce or eliminate coal sterilisation. • May reduce environmental risks associated with coal wash emplacement.	• Site specific geotechnical investigation and injection system design. • Injection equipment purchase or hiring. • Injection operation and monitoring • Risk of increased gas/water migration into the goaf. • Risk of borehole causing water contamination of groundwater resources. • Safety issues associated with grout migration to the underground workings. • Surface environmental impacts associated with injection bore, pipe and pump infrastructure. • High water consumption. • Difficulty in achieving private property access and access in protected lands.

These benefits and costs are highly site specific. The pending research to be undertaken by CSIRO and IC will provide economic analysis of future applications. It will also provide benchmarks to apply this technology in all mines with similar conditions.

The technology still needs significant development to be considered as an alternative for coal wash emplacement, and it will be several years before its viability is fully determined. Clearly, it is not a viable alternative for West Cliff Stage 3 and the volume of coal wash that may be able to be disposed of by this method (ie. approximately 10% of the total coal wash produced) is limited.

5.2. GOAF INJECTION

Another technique to control mine subsidence is to backfill or grout the goaf area with fill materials during longwall mining operation. This method aims to limit rock mass deformations to only the caving and collapse of the immediate roof, with the main overlying strata being supported by this caving rock grouted with fined-grained material delivered from the outside. Grouting material can be delivered to the goaf area directly from pipelines fixed behind the longwall support or from gates, or through boreholes drilled from the surface to the goaf.

Key design elements are summarised below:

5.2.1. Placement Considerations

The best results of filling mining voids from the point of view of roof support and environmental benefits are obtained when a void is filled almost immediately after the extraction of coal has been carried out. Difficulties of roof mass movement control increase proportionally to the increased depth of mining operations. The problem can be reduced by the design of mining layouts and methods for minimum roof subsidence. The filling of longwalls, both in the case of full backfilling and grouting of roof fall in a goaf area should ideally be carried out simultaneously with mining of a deposit by means of short-step backfilling.

5.2.2. Grout Material

European coal mines have successfully used sand, waste rock from mining operations and coal combustion by-product (ashes and slags) since the end of the 19th century to provide roof support and to fill underground voids. Fills used in Polish coal mining have evolved from early loosely dumped rock (pillars constructed from rock) and hydraulically placed sand backfills (since 1893), through pneumatic (1920) and throwing (1947), up to today's hydraulically transported, densified and cemented fills with fly ash and flue-gas desulphurisation by-products (1967) (Palarski 2005).

5.2.3. Goaf Injection in Illawarra Coal mines

A study undertaken by Palarski (2005) suggested that to apply goaf injection within Illawarra Coal operations to control subsidence will require further research on the mining technology. Refer **Appendix E**.

It concluded that:

Taking into account the following conditions occurring in the Illawarra region, ie:

- *geological conditions, in particular the depth of the coal seam and roof conditions, which are characterised by low strength and a tendency to immediate caving and roof collapse behind the support (goaf formation),*
- *infrastructure of mines, and in particular large distances between the proposed mining of the coal seam and the localisation of shafts and treatment plants,*
- *achieved technological parameters, and in particular the high coal production rate and advance of the longwall face,*
- *the equipment and machines used,*
- *lack of experience of the miners in the backfill technology,*
- *difficulties in supplying mines with considerable amount of water needed for backfilling,*

It should be stated that at present the use of traditional hydraulic and high density fill (cemented fill) in existing longwalls of a very high output is from a technological point of view, impossible.

In addition to the considerations outlined above, goaf injection must be able to be carried out in a manner that achieves compliance with contemporary Australian safety standards and BHP Billiton safety requirements. Underground mining safety standards in Australia are amongst the most stringent in the world and considerable attention to the safety of placing a slurry immediately behind a working longwall will need to be undertaken before approval for this mining practice would be approved by mining safety regulators (BHP Billiton Illawarra Coal 2004 and 2005).

The study however suggested the following research and pilot projects could be pursued:

1. Partial mining – shortwall with backfill.
2. Extracting pillars between longwalls.
3. Grouting goaf area – longwall with grouting.
4. Grouting of goaf area through boreholes.
5. Injection of material through boreholes into separating voids.
6. The use of other mining methods.

Currently, Illawarra Coal has incorporated the knowledge from this research into the overburden grout injection work referred to in **Section 5.1** (BHP Billiton Illawarra Coal 2006).

6. REUSING COAL WASH

Coal wash is classified as inert waste under the EPA Waste Guidelines. Previous research shows that coal wash may be used in the following applications:

- As fill materials for civil engineering and construction projects.
- As fill in quarries for site rehabilitation.
- As a component of construction materials such as brick manufacturing.
- A component for soil media.

6.1. MATERIAL SPECIFICATIONS

All construction materials produced and marketed by the quarrying, recycling and slag processing industries are covered by material specifications, principally in regard to the mechanical and chemical properties. The general requirements for these materials are:

- **Armour rock, rip rap, gabion, ballast and coarse and fine aggregate** products are required to meet stringent specifications (eg. Australian Standard) in relation to product strength, soundness, durability, grading, particle shape, chemical inertness, etc.
- **Mortar sands** are tested against the above characteristics, as well as colour and 'workability'.
- **Road pavement materials** are tested in regard to fines ratios, plasticity and compaction.
- **Brick shales** are specified according to chemical properties and firing characteristics.
- **Select fill** specifications vary according to individual job requirements but typically include grading and compaction requirements as well as strength and durability parameters (eg. GreenSpec).
- **Fill materials** are generally required to be inert (particularly in relation to acid sulphate potential) and compactable.

6.1.1. Coal Wash Properties and Specifications

Coal wash is a by-product of the coal preparation and washing process. It consists of soft sedimentary rock, clay, silt, sand and a small amount of residue coal that has been separated from excavated natural ROM coal. It is produced when ROM coal from the colliery is washed in the coal preparation plant, which separates coking coal, energy coal and coal wash. The Southern Coalfields produce an average percentage of 80% coal and 20% coal wash, although the product yield from the Dendrobium Mine is lower due to higher in situ ash content and non coal dilution resulting from mining the thicker Wongawilli Coal Seam.

The quality of coal wash is highly dependant on the depositional environment in which the coal seam was laid, and the washery that processes the raw coal and produces the residual coal wash. It is therefore impossible to generalise about the properties of coal wash without testing the material from the individual washery.

In April-May 2006, a program of representative sampling from both the WCCPP (West Cliff coal wash) and PKCPP (Dendrobium coal wash) was undertaken to determine the chemical and physical properties of coal wash (Blunden & Gray 2006). Refer **Appendix F**. The results of the sampling are summarised below:

Chemical Properties

- The coal wash from IC is not contaminated with manufactured chemicals or sulfidic minerals, nor is it mixed with any other wastes.
- Major constituents in the coal wash are typical sedimentary rock clay minerals comprising high proportions of silicon, aluminium and iron.
- The coal wash generated from both WCCPP (West Cliff coal wash) and PKCPP (Dendrobium coal wash) complies with the specifications for Inert Waste described under the EPA Environmental Guidelines: Assessment, Classification and Management of Liquid and Non-liquid Waste.
- The coal wash satisfies the standards for airborne crystalline silica concentration and poses a low risk to workers and the community if appropriate dust control and construction methods are used when handling.
- Combustible content in the Coal Wash is relatively low and complies with the Wollongong City Council Technical Policy 2.40 for New Coal Washery Refuse in Subdivisions.
- Total sulphur concentration is low and indicates that the coal wash is not pyritic and has a low potential to produce acidity.
- pH level of coal wash is high due to the high bicarbonate content.

Physical Properties

- The coal wash is marginally outside the Resource NSW Specification for Supply of Recycled Material for Pavements, Earthworks and Drainage (the Greenspec) in terms of particle size at the 0.02mm size fraction only, but complies with the requirements of plastic behaviour.
- Dendrobium coal wash (from PKCPP) has a Plasticity Index (10) within the range specified in the Greenspec (12). West Cliff coal wash is not a plastic material and therefore complies with Greenspec for plasticity.
- The dry density and moisture content of both coal wash satisfy the threshold recommended by Greenspec.
- Compaction to 95% of the maximum dry density can be achieved by regular earthmoving equipment under field conditions (Blunden & Gray 2006).

IC recently prepared a draft specification for coal wash as a fill material (Blunden & Gray 2006). The specification is provided in **Appendix A**. The specification will be used by IC to market coal wash.

The coal wash was tested to compare against the specifications of a range of construction materials. It was concluded that coal wash is suitable as fill and in some cases, 'low-spec-select fill'.

6.2. COAL WASH REUSE AS FILL OR CONSTRUCTION MATERIAL

In the past, coal wash has been used in the following projects as fill material.

- **Northern Distributor** – up to 300,000 tonnes of coal wash was used as the sub-base with an estimated saving of $3 million.

- **Picton Road – Mount Ousley Interchange** – about 100,000 tonnes of coal wash was used as selected granular fill adjacent to a large steel plated arch over 100m in length. Approximately cost saving of about $1million.
- **Port Kembla Harbour Access** - used as a general fill and heavily bound sub-base for the heavily trafficked access road.
- **Haywards Bay, Yallah** – about 1,250,000 tonnes of coal wash was used as fill material used to complete the residential development.
- **Redgum Ridge Estate, O'Briens Road, Figtree** – about 25,000 tonnes of coal wash was used as engineered fill.
- **Lysaghts Oval Figtree** – approximately 2,000 tonnes of coal wash was used to raise the height of the car park as part of the soccer ground redevelopment.

(Source: BHP Billiton-IC 2006).

The main factors influencing the applications of coal wash in construction and engineering projects include:

- The properties of coal wash have to comply with the prescribed material specifications for such use.
- Market competition and demand for construction materials.
- Delivery costs of coal wash from the source to the project location have to be competitive with other materials (eg. sand and rock).
- Compliance with the planning, environmental and waste regulatory regimes in NSW.

6.2.1. Market Competition and Demand

Coal wash as a fill material competes with other construction material currently being used in the construction industry in NSW. **Table 6.1** shows locations of current suppliers (Don Reed and Associates 2003).

The report estimated that these suppliers can produce 3.85 to 12.8Mt of construction materials per year.

In terms of market demand for fill materials, Don Reed (2003) identified three main types of construction projects suitable for coal wash application:

- Major construction projects (rail, road, airports): demand quantity unknown.
- Other construction projects (industrial, housing): 5,000 – 10,000 tonnes per annum.
- Major remediation sites (quarries, landfills, swamp areas): demand quantity unknown.

Most projects demanding fill materials are located in the Sydney Metropolitan area with a small proportion located in Western Sydney and the Illawarra region.

Table 6.1 – Supply of Construction Materials and their Locations

Types Materials Producers	Business Locations
Hard rock quarries	Kulnura, Peats Ridge, Bombo, Dunmore, Bass Point, Albion Park, Wallgrove, Hornsby, Erskine Park, Prospect, Exeter, Hartley, Marulan and Compton Park
Sand and gravel quarries	Penrith
Crushed sandstone quarries	Glenfield, Brownlow Hill, Mt Hunter, Kurrajong, Cattai, East Kurrajong, Menangle and Wallacia
Friable sandstone quarries	Penrose, Southern Highlands, Calga, Central Coast, Bell, Blue Mountains and Maroota
Construction sand producers	Kurnell, Windsor, Yarramunda, Narellan, Elderslie, Dunmore and Gerroa
Brick shale quarries	Bringelly, Badgery's Creek, Cecil Park, Kemps Creek, Mulgoa, Erskine Park, Horsley Park, Marsden Park and Schofields
Landfill operators	Glenfields, Kemps Creek and Erskine Park
Slag producers	Port Kembla
Recyclers	Independent recyclers supplying recycling materials across NSW
Earthwork contractors	Independent contractors undertaking demolition or excavation projects across NSW

The Don Reed and Associates 2003 report concluded that.

> *"the supply far exceeds demand for fill materials within the Sydney Metropolitan and Illawarra areas, even before long term disposal of coal wash is taken into account. Such conclusion is evidenced by the facts that:*
>
> - *Contractors have been unable to place all fill from Cross City Tunnel & Chatswood to Carlingford rail project, with overflow going to Glenfield landfill as well as being delivered (at cost) as backfill to the worked out brick shale quarries at Moorebank and Eastwood.*
> - *Regional sandstone quarries have suffered declining sales and mature/static demand since the mid to late 1990's and particularly since 2000.*
> - *Brick quarries are currently unable to secure fill contracts for off-site disposal of overburden at cost.*
> - *Landfills are experiencing the same problems as the quarry industry".*

6.2.2. Delivery Cost

Don Reed and Associates (2003) calculated the average cost per tonne per km for transporting fill materials from WCCPP and PKCPP to Sydney metropolitan area. The report assumed an average cost per tonne of $0.15 per tonne/ km and is based on the 2003 value:

<u>Dendrobium to Sydney</u>

- $12.00 to $15.00 into Sydney's southern suburbs.
- $14.00 to $18.00 into Sydney's western suburbs.
- $18.00 to $21.00 into Sydney's eastern and northern suburbs.

West Cliff to Sydney

- $6.00 to $9.00 into Sydney's southern suburbs.
- $7.50 to $11.00 into Sydney's western suburbs.
- $12.00 to $14.00 into Sydney's eastern and northern suburbs.

Assuming that 60% (1.5Mtpa) of coal wash would need to be transported ex Pt Kembla, and 40% (1Mtpa) transported ex West Cliff, the weighted average cost of transport of IC coal wash into Sydney Metropolitan areas would range as follows:

- $9.60 to $12.60 into Sydney's southern suburbs.
- $11.40 to $15.20 into Sydney's western suburbs.
- $15.60 to $18.20 into Sydney's eastern and northern suburbs.

From the above-noted transport cost figures it can be seen that the cost of transporting coal wash from West Cliff and Pt Kembla to disposal sites in the Sydney Metropolitan area will range between:

- $6.00 per tonne ex West Cliff into Campbelltown; and
- $21.00 per tonne ex Pt Kembla into Sydney's eastern and northern suburbs.

This means that even if all material were able to be disposed of (as fill) in Sydney's southern suburbs, IC would incur additional transport costs of between $20.25M and $41.75M per annum. If we assume an average transport cost of $14.00 per tonne, then the increase in transport cost would be $31.25M per annum, based on Don Reed and Associates (2003) data.

Taking into account delivery costs, the following projects are currently considered feasible for coal wash reuse. They are subject to current discussion by IC (BHP-Billiton IC 2006):

- Light & Hope Clubhouse, Unanderra to use coal wash as fill materials.
- Local golf course may take 8,000Mt coal wash for landfill.
- West Dapto urban release area (medium to long term opportunity).
- Local land development opportunity for 200,000 Mt of coal wash as engineered fill.
- Local degraded site rehabilitation with potential for 1 million tonnes of coal wash as fill.
- Quarry rehabilitation (medium and long term opportunities).
- Port Kembla Port Expansion project.
- Possible use as road sub-grade blending and general fill material by RTA (subject to further analysis).

There are financial incentives to divert coal wash from West Cliff emplacement to appropriately located development sites. However, the cost of transportation is limiting the volume of potential reuse of coal wash for this purpose.

6.3. COAL WASH FOR BRICK MANUFACTURING

6.3.1. Coal Wash Replacement for Shales in Brickmaking

Use of coal wash for brickmaking has been considered many times in the Southern Coalfield. The first significant analysis looked at the potential to use washery refuse as an economically viable replacement material for shales commonly incorporated into the feedstock for brickmaking. This analysis was conducted by GHD in conjunction with C. W. Marshall and Associates and ACIRL in 1985 (GHD 1985).

The earliest trials of brickmaking incorporating Bulli Seam coal wash were conducted at Clark Brick and Bulli Brick in the 1970s and 1980s and even as most recently as 2006, 592 tonnes was supplied by BHP Billiton Illawarra Coal to Boral Brick as a trial shale substitute.

Over 1996 – 7, Dr. S. Short (then employed by Forbes Rigby Pty Ltd.), in collaboration with a local commercial pottery and advised by a former Chief Account Officer of Boral Brick conducted extensive trials with <1 mm coal wash sourced from the BHP Port Kembla washery, producing in excess of 160 test blocks which were assessed for density and colour and tested for unconfined compressive strength. A provisional patent (PO5407) was held for a period of 18 months from February 1997 covering a method of producing bricks comprising up to approximately 50% by weight Bulli Seam coal wash.

6.3.2. Cost Constraints and Opportunities

Experience has shown that the principal economic constraints and opportunities apply to the use of coal wash in brickmaking are as follows:

1. Cost of haulage to brickworks distant from the source of the coal wash and hence significant competition from shales which are mined at, or closer to the brickworks if the latter are available. With washeries located 30 – 140 km from Sydney Metropolitan areas, the average transport costs of approximately $0.15 per tonne/km (Don Reed 2003 estimate) is prohibitive to delivering coal wash to Sydney Basin brickworks, most of which are located in the Western Sydney Area (e.g. Bringelly, Prospect, Badgerys Creek, Horsely Park, Cecil Park). Conversely, in recent years, supplies of shale have become less readily available in the vicinities of Western Sydney brickworks areas due a rise in land values arising from pressures for suburban expansion.
2. In the case of Southern Coalfield coal wash, it has been found that there is a potential limitation on the maximum proportion of Bulli Seam coal wash that can be used due to an unfavourable alumina to silica ratio affecting vitrification temperature and fired strength. Hence there is a need to incorporate one or more fluxing additives to correct the vitrification temperature and hence provide adequate fired strengths to maximise coal wash usage whenever the proportion of coal wash incorporated in a brick rises above about 25% by weight (S. Short, unpublished studies, 1997).
3. Due to its *in situ* combustibles content, coal wash improves the sustainability of brick manufacture by reducing energy costs by about 0.75 kilowatt hour per kilotonne coal wash used.
4. The particle sizing requirements to incorporate coal wash into bricks are a material size of less than 0.5 mm or at most 1 mm. This indicates that the tailings fraction produced by coal preparation plants would generally be the most suitable fraction for reuse as a shale substitute in brickmaking. Coal wash tailings are generally the most difficult to emplace and if all tailings could be routinely hauled off site for reuse in a brickworks this would

improve the overall cost of tipping and emplacement practices for the majority middlings and coarse fractions.

6.3.3. Environmental Impact

Transport of coal wash tailings to brickworks would require the use of sealed trucks to avoid spillage on roads and highways.

The use of coal wash as a shale substitute in brickmaking has been estimated to increase greenhouse gas emissions by up to 30% (University of Newcastle 2001, CSIRO 2003).

6.3.4. Market Needs and Feasibility

The main products made from clay shale resources around the Sydney region are bricks and pavers (93%) and roofing tiles (7%). Based on trends in clay shale production and in production of bricks and pavers, demand for clay shale in the Sydney Region is declining. The decline in demand is thought to be due to more efficient use of clay shale raw materials by using extrusion method of brick production and increased usage of clay and shales from excavations for construction sites (MacRae 2001).

Demand for clay shale over the life of the emplacement is likely to be about 2Mtpa. Resources currently held under consent are sufficient to supply the Sydney Region for another 30 years, and unsecured reserves of over 250Mt are sufficient to supply the Sydney and NSW market for clay shale for over 100 years. This low demand, coupled with the significant available and potential resources in the Sydney region means that there is no pressure for new extraction areas to be developed. However, there are no suitable substitutes for natural sources of clay-shale in the construction industry other than coal wash. This implies that if a secure, bulk source of fine-grained coal wash was available in close proximity to a new brick, tile and paver manufacturing plant, that material would then become potentially cost competitive with the as-mined 'natural' supply (BHP-Billiton IC 2006).

The region south of Campbelltown fringing the Hume Highway, Great Southern Railway and Nepean and Bargo Rivers, including the areas of Menangle, Appin, Wilton, Douglas Park, Tahmoor, Thirlmere, Bargo etc are areas of relatively strong and growing suburban expansion.

As brickmaking is only ever likely to take a small fraction (<10%) of any coal preparation plants total coal wash production, it would be most rational to have that fraction invariably be the tailings as its effective sizing obviates the need for any further crushing or sizing, improving competitiveness against ‘natural’ shales sourced at or near brickworks which must be crushed and sized.

If there were (say) future development of brickworks in (say) the Menangle – Douglas Park – Appin area to support that suburban expansion use of coal wash tailings sourced from West Cliff Colliery could possibly become a viable substitute for locally mined Wianamatta Shale on the grounds that:

1. It was already of a suitable particle size.
2. It had a moisture content suitable for direct hydraulic admixture with clay.
3. It had a supply cost lower than that of crushed and sized shale sourced at or near the brickworks.

Ongoing discussion should be engaged between IC and major brick manufacturers to consider future opportunities to develop brickworks in the regions.

From the summary provided above, it is clear that coal wash reuse for brickmaking cannot provide a feasible alternative for the West Cliff stage 3 emplacement due to the small demand volumes, high delivery cost and market competition, and the fact that only the tailings portion of the coal wash is of an appropriate particle sizing.

6.4. COAL WASH FOR AGGREGATE PRODUCTION

Another opportunity to reuse coal wash is to use the different streams of coal wash in aggregate production. Blunden (2006) carried out laboratory testing to analyse whether the coal wash from PKCPP meets the *Australian Standard* for aggregates and rocks.

A series of representative sampling were collected to assess:

- Particle size distribution.
- Particle shape.
- Weak particles.
- Particle density and bulk density.
- Drying shrinkage.
- Loss on ignition.

The analyses concluded that coal wash is an unsuitable material for crushing and screening to make aggregate because the constituent rocks that form the mineral component of coal wash is too soft and well structured to form appropriately strong aggregate. Refer **Appendix F**.

6.5. CONCLUSIONS

Whilst it is difficult to quantify long term opportunities for the disposal of coal wash, some important factors should be noted:

- From the analysis of coal wash properties, it appears that Illawarra coal wash is suitable as an alternative fill material for placement on major civil projects.
- There are limited sites identified within the region that will be capable of receiving substantial quantities of fill in the long term.
- Compounding this problem is the fact that there is massive competition for spoil disposal space within Sydney at present. Principal competition comes from contractors needing to dispose of excavated spoil from earthworks for major infrastructure projects.
- Fill material supply is a competitive market. For coal wash to compete in the market, the cost of the material must remain relatively low compared to other material supplies.
- The principal determining factor to supply bulk fill is delivery cost and the location of the source material relative to fill site. With washeries located 30 – 140 km from Sydney Metropolitan areas, the average transport costs are prohibitive to delivering coal wash to regional fill sites.

- To date, the delivery of coal wash as fill material will only be commercially viable for sites located within relatively close proximity to the washery.
- Whilst the option to reuse coal wash as fill is technologically sound and environmentally friendly, the uncertainty in the market demand does not justify it as the sole long term solution for coal wash disposal. However, it can supplement a long term strategy, and be pursued when opportunities arise.
- It is clear that even with a significant increase in the demand for coal wash as a fill/construction material, the supply of coal wash from IC operations far outweighs the volume that can be accommodated by current civil projects, and therefore coal wash reuse is not a viable alternative for the West Cliff Stage 3 emplacement area.

7. COAL WASH AS FUEL FOR POWER GENERATION

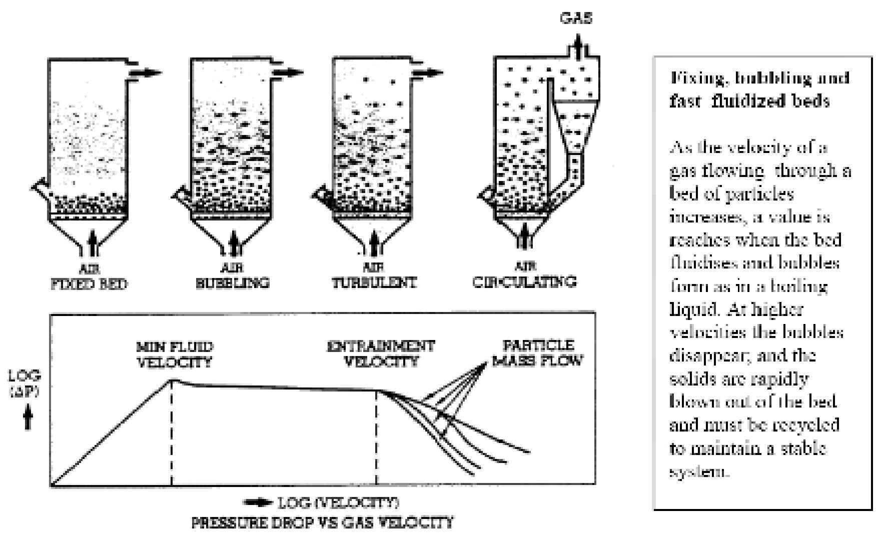
Using coal wash in existing NSW power stations is not competitive with locally available coal on a cost per energy unit basis. The high cost of transport to the existing power stations is prohibiting the use of coal wash in these stations (BHP-Billiton IC 2003).

Fluidised Bed Boilers (FBB) provide an alternative to existing power stations. A FBB is a purpose built on-site combustor that allows low quality, low energy level fuels, such as coal wash, to be converted to energy for electricity production. This technology has the potential to consume a significant portion of the coal wash produced by the WCCPP and PKCPP (BHP-Billiton IC 2005).

FBB technology utilises the mechanism of fluidised bed combustion as a way to produce energy. Fluidisation occurs when an evenly distributed air or gas is passed upward through a finely divided bed of solid particles such as sand supported on a fine mesh. As air velocity gradually increases, a stage is reached when the individual particles are suspended in the air stream and the bed is fluidised.

The boiler facilitates fluidisation of air or gas through a bed of solid particles such as sand. The sand particles in a fluidised state are heated to the ignition temperature of coal wash and coal wash is injected continuously into the bed. At about 840°C to 950°C, fluidised bed combustion takes place and the coal wash will then burn rapidly.

The principle of fluidisation is illustrated in **Figure 9**.



Source: Bureau of Energy Efficiency (undated)

Figure 9 - Fluidisation process in a Fluidised Bed Boiler

7.1. OVERSEAS AND AUSTRALIAN EXPERIENCES

The first fluidised bed combustor (FBC) pilot plant in Australia was constructed and operated by CSIRO/Joint Coal Board at Glenlee. The system has shown successful recovery of coal wash for energy conversion. The pilot combustor has a capacity of 2 tonnes per hour. It was shown that the process can generate large quantities of energy from the wastes (BHP Billiton-IC 2004). Refer **Appendix D**.

Another experience is the Redbank Power Station near Singleton in the Hunter Valley engineered, procured and constructed by Alstom Power. The Redbank Power Station uses a mist fine coal recovered from coal wash as fuel. However, the scheme failed to obtain approval due to environmental concerns.

There are also over 25 different fluidised bed combustors operating around the world (Australia, China, Finland, Germany, Japan, Mexico, Netherlands, Philippines, South Korea and the USA). Most of these installations were however established for the burning of coal, not coal wash. West Germany and the USA have successfully operated fluidised bed combustors using coal washery tailings. In some instances, the fluidised bed combustor is incorporated with a normal coal fired power station. Generally the fluidised bed combustors for coal wash comply with emission standards and establish an economic return.

7.2. ENVIRONMENTAL ISSUES ASSOCIATED WITH FLUIDISED BED BOILERS

7.2.1. Coal Wash Ash

The fluidised bed combustor produces an ash product comprising flyash and bottom ash. Flyash is the fine fraction of the produced ash that is collected in the bag houses or electrostatic precipitators. Bottom Ash is the coarse fraction of the produced ash. Disposal of the ash products is the main environmental issue. The particle size distribution of ash from fluidised bed combustion depends on the particle size distribution of the feed to the combustor.

The fluidised bed combustor in Glenlee produced 50% bottom ash and 50% flyash. The Redbank Power Station produces an ash comprised of 20% bottom ash and 80% flyash. The ash is slurried with water to around 70% by weight ash slurry and pumped back into the open cut Warkworth Mine for mine void backfill.

Limited alternative use options for the ash could be pursued. In the case of West Cliff, the environmental impact for the disposal of the ash (eg. surface emplacement) is similar to coal wash emplacement. (Ecoengineers P/T 2001).

7.2.2. Disposal of Ash from Fluidised Bed Combustor

The main way to dispose of ash from FBC is in land emplacement site. A small amount of ash may be utilised as substitute for coarse soft rock, gravel, fine soft rock, aggregate (lightweight), sand, clay, shale, stone flour, lime, cement and low grade bauxite. Around 10% of the total ash is solid. Due to the fineness of the material, particular attention needs to be paid to dust control (Holmes Air Sciences 2003, Lunagas Pty Ltd 2001).

The amount of ash generated is comparable to the amount of coal wash that would be emplaced. Whilst the combustion of coal wash will reduce the total weight, there is little reduction in volume. It is estimated that for coal wash from the Southern Coalfields, the overall reduction in weight will not exceed 30% and the overall reduction in volume would be much less (Holmes Air Sciences 2003).

7.2.3. Environmental Issues associated with Fluidised Bed Combustor

A FBC, in operation, can be expected to have similar environmental impact to a conventional pulverised coal power station of similar capacity. However, issues relating to FBC include:

- Airborne dust is likely to be a major issue. Ash delivered from the furnace will be loaded, transferred and discharged in emplacement areas. The usual method of controlling airborne dust is with water sprays. Alternatively, it can be controlled in an enclosed system. Care needs to be taken to ensue that the potential respiration hazard is addressed (Lunagas Pty Ltd 2001)
- Air emission from the combustor needs to be monitored carefully to comply with the standards of the Protection of the Environment Operations Act. The Sydney basin airshed and in particular South-West Sydney is already under stress from airborne pollutants. Any FBC would be a significant contributor of NOx, SOx, fine particles and greenhouse gases.
- Visual impact will depend on the location and size of the power station.
- Fresh water consumption for cooling and steam generation.

7.3. OPPORTUNITY TO DEVELOP FLUIDISED BED BOILERS

Discussion is underway between Illawarra Coal and an interested party to develop a FBC in WC to convert coal wash into electricity (BHP Billiton-IC 2005 and 2006). Refer **Appendices E and F**.

Initial investigation was undertaken to construct a power station of 120 – 150 MW capacity using circulating fluidised bed technology. The station could consume up to 1.8Mt coal wash per year. The construction cost is estimated to be $120-$150 million.

A strategic alliance was formed between IC and another company to pursue the project. The economic and operational feasibility is being investigated, including the ways to address environmental issues such as greenhouse, air pollution, water consumption and coal wash and flyash management (BHP-Billiton IC 2006).

From the analysis above, it can be concluded that this option will not result in significant environmental benefits compared to coal wash emplacement. The need for emplacement will still exist because of the production of ash waste. The volume of ash waste is only slightly lower than the volume of the coal wash. The land requirement for such emplacement is similar to coal wash emplacement.

There could be economic advantages in generating power through lower grade coal and coal wash, however, it is clear that this option cannot provide an alternative to emplacement and is not a feasible alternative to the Stage 3 emplacement.

8. CONCLUSION

This report has addressed consent condition 5.1(c) of the Dendrobium consent by assessing whether there are any feasible alternatives to stage 3 of West Cliff coal wash emplacement.

A range of options from existing research and literature were examined, including:

- Increasing the capacity of existing emplacement sites or utilising alternative sites.
- Underground coal wash disposal by goaf filling and overburden grout injection technology.
- Reusing coal wash as a fill material in civil works, quarry rehabilitation, or as a constituent in brickmaking.
- Utilising coal wash for power generation (Fluidised Bed Boiler Combustion technology).

The analysis on the feasibility of these options took into account the technical feasibility, demand, market competition, costs and environmental risks. **Table 8.1** summarises the outcomes of the assessment.

The assessment found that whilst some options have their own merits to utilise a percentage of coal wash, *none of the current options on their own or in combination are capable of negating the need of the Stage 3 emplacement*. This is due to the lack of market demand for the quantity of coal wash generated by IC's washeries, the current technological constraints in developing the infrastructure for alternative disposal methods (eg. Underground stowage or power generation) or lack of other suitable surface emplacement sites within the region.

The use of coal wash as an engineering fill in civil works has been the only alternative use that has had success in diverting significant volumes from surface emplacement.

Until there is sufficient development of the technology and certainty in the outcomes for overburden grout injection and fluidised bed combustion, surface emplacement remains the only viable short to medium term option for coal wash disposal, to be supplemented by a range of possible reuse opportunities negotiated on a project by project basis. The longevity of surface emplacement though can be extended by maximising opportunities for using coal wash as fill.

The long term management of coal wash by Illawarra Coal will concentrate on minimising the environmental impact of emplacement, by attempting to locate more suitable emplacement sites such as exhausted quarries, while marketing reuse options, and continuing to research the technology to pursue alternative options.

Table 8.1 – Summary of Feasibility Assessment of Alternate Options

Alternative Option	Technical Feasibility	Demand	Market Competition	Delivery Cost	Environmental Risks	Feasibility as an Alternative to Stage 3
Other Surface Emplacement Sites						
Optimise Stage 2	Possible	N/A	NA	Low	Low	No, will be exhausted in 2008. An additional 3.8Mt emplaced if Stage 3 approved.
Other emplacement sites in West Cliff	Subject to further research on the characteristics of individual sites	NA	NA	Low	High	No. Would reduce volume of stage 2, yield lower capacity and require extensive investigation. High environmental impacts.
Other emplacement sites outside West Cliff	Possible	NA	Variable	Variable	Very high	No sites currently available. Sites in protected land.
Underground disposal						
Overburden Grout Injection	Not currently. Subject to further research and trial testing	To be determined. Consideration of technology where high value infrastructure, natural or cultural features may be impacted by mining.	NA	High	Subject to further investigation but thought to be medium. Large consumer of water. Significant infrastructure disturbance of surface land.	No. Can only utilise tailings (<10% coal wash volume). Requires more research and field trials

Goaf injection	No	To be determined	NA	High	Subject to further investigation but thought to be low	No. Major safety considerations to be overcome.
Reusing coal wash						
Fill Materials	Yes	Highly variable and project dependent	Intense	High	Low	No. Insufficient demand to utilise whole volume produced by IC.
Aggregate Production	No. Does not comply with specifications.	Moderate	Intense	High	Low	No.
Brick manufacturing	Yes	Low	Intense	High	Low	No. Insufficient demand to utilise volumes produced by IC.
Power generation	No, subject to further research and development	High	High	Location dependent. Low if combustor is located in WC	High. Flyash disposal has similar environmental impacts as coal wash emplacement.	No. Capital costs are extremely high and flyash requires emplacement.

9. STATEMENT OF COMMITMENT

IC will continue to evaluate the feasibility of reuse mechanisms and pursue the following actions:

- Prepare and implement an End of Resource coal wash strategy within 5 years of the issue of the Stage 3 emplacement approval. The strategy should be reviewed every three years thereafter. The strategy should be provided to the Department of Planning (DoP), Department of Environment and Climate Change (DECC) and Department of Primary Industries – Minerals (DPIM).

- Give priority to the development and implementation of coal wash management solutions and strategies that maximise the beneficial use of coal wash and offer long term, large volume and sustainable opportunities.

- Maximise the reuse of coal wash in development sites. Reusing should be carried out in a safe, practical and commercially acceptable way.

- Report the volume of coal wash reuse and the annual progress on the development of coal wash management solutions to the Government via the West Cliff Coal Preparation Plant Annual Mining Environment Report (AEMR), submitted to DPI and copied to the DoP and DECC.

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As of 7 April 2006 Forbes Rigby Pty Ltd merged with the Cardno Group and was re-named Cardno Forbes Rigby Pty Ltd. Any reference to Forbes Rigby is to be read as a reference to Cardno Forbes Rigby, a wholly owned subsidiary of Cardno.

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