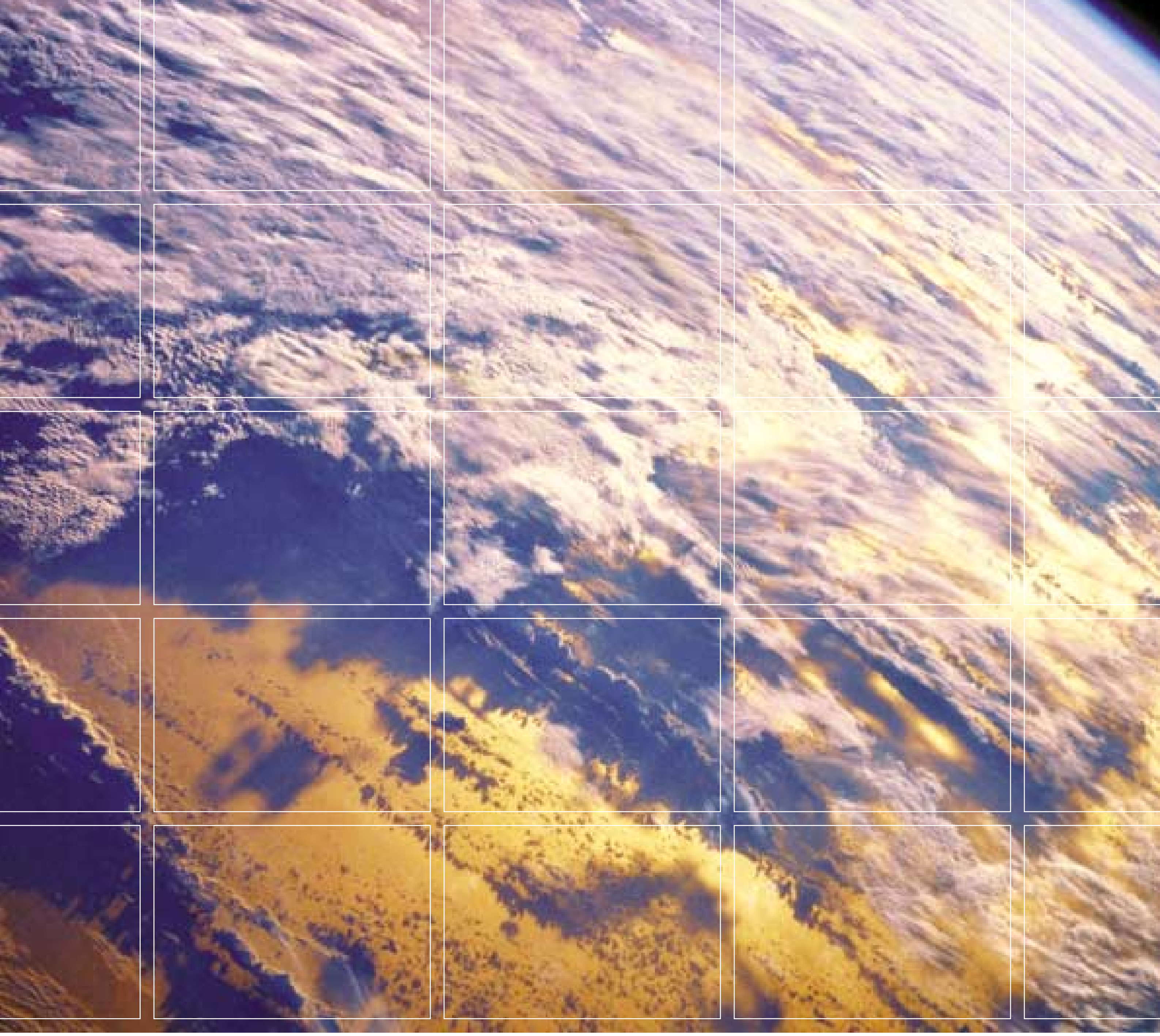

Supporting Annexes for the Carrington Pit Extended

Statement of Environmental Effects - Volume 2

Coal & Allied Operations Pty Ltd

October 2005

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ERM

Approved by:	*Luke Stewart*
Position:	Project Manager
Signed:	
Date:	*24 October, 2005*
Approved by:	*Ian McCardle*
Position:	Project Director
Signed:	
Date:	*24 October, 2005*

Environmental Resources Management Australia Pty Ltd Quality System

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FINAL REPORT

Coal & Allied Operations Pty Ltd

Supporting Annexes for the Carrington Pit Extended *Statement of Environmental Effects*

October 2005

Environmental Resources Management Australia
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CONTENTS

Annex A

Legal Advice & Correspondence with Department of Planning

SPARKE HELMORE LAWYERS

Memorandum

To: Sarah Fish

Firm: Coal & Allied Operations Pty Limited

From: Naomi Simmons / David White

Date: **24 August 2005**

Subject: Advice regarding Carrington Extended Mine

Dear Sarah

You have sought advice as to what approval would be required under the EP&A Act for the proposed extension of the Carrington Pit.

1 Position/background

1.1 The existing development consent is DA 450-10-2003 (the North of the River Consent)

1.2 The DA area is within the yellow line on the attached map.

1.3 Mining operations were approved within the clear red hatched area of that map ("the approved mining area").

1.4 Coal and Allied now proposes to conduct operations within the area marked with red hatching and black dots ("the proposed mining area").

1.5 The proposed method of mining will be essentially the same as now approved:

(a) mining method and process will be the same (truck and shovel);

(b) the rate of removal will be the same (10 Mtpa);

(c) mining will be in the same seams (Broonie, Bayswater and remnant Vaux); and

(d) dust and noise emissions will be unchanged.

1.6 The only difference between the proposed and approved mining operations will be the area to be mined and the final landform which will involve a larger void in a different location but within the overall HVO North of the River mining area.

1.7 There will be no greater impacts at non company owned properties from operations within the proposed mining area than the impacts for the approved mining operations.

1.8 The extended mining is substantially within the DA to the east of the existing approved mining area but as to a smaller area to the south of the approved mining area is outside that area.

2 What approvals are available?

The available approvals are, potentially, either a new development consent or a modification under s96 of EPA Act.

3 New Development

3.1 A new development application would be for *"State significant"* (see Declaration under Section 76A(7), gazetted 2 July 2001) *"designated"* and *"integrated"* development. The Minister would be the consent authority and provisions of the EP&A Act relating to integrated development and designated development (unless excluded under Part 2 Schedule 3 as referred to below) would apply.

3.2 The proposed development would constitute an alteration or addition to existing approved development and may therefore not be designated development if the consent authority determines that "*the alterations or additions do not significantly increase the environmental impacts of the total development*" (Clause 35 in Part 2 of Schedule 3 of the EP&A Regulations; *Timbarra Protection Coalition Inc v Ross Mining NL* (1999) 46 NSWLR 55).

3.3 In deciding as referred to in 3.2 the consent authority must take into account the factors listed in Clause 36 in Part 2 of Schedule 3 to the EP&A Regulations. You should refer to clause 36 and note the relevant issues. These have been referenced in prior advices.

3.4 Any request to the Minister to apply clause 35 of the Regulation will need to be supported by an environmental assessment of and report on the clause 36 issues.

3.5 If the Part 2 Schedule 3 approach is to be taken an early discussion should take place with DIPNR to seek its preliminary view as to what may be the position of the Minister on such a request. If that view is favourable the clause 35/36 assessment (to support the Minister's decision to apply clause 35) may be the same SEE as is used for the final decision of the Minister on the application for approval.

3.6 If the proposed development is not designated development an SEE rather than an EIS will be required and the following will apply with respect to notification:

(a) The proposed development would be defined as "State Significant advertised development" under clause 5(1)(a) of the EP&A Regulation (ie. it is development declared to be State Significant pursuant to section 76A(7)(b) of the EP&A Act).

(b) State significant advertised development must be advertised in the same manner as designated development – in accordance with Section 79 of the EP&A Act (Clause 82 of the EP&A Regulation).

(c) Section 79 of the EP&A Act sets out notification requirements, including an exhibition period of at least 30 days.

(d) Clauses 83 to 84 of the EP&A Regulation contain additional requirements for notification of State significant advertised development.

4 Modification

4.1 The Minister may modify the consent pursuant to Section 96(2) of the EP&A Act if:

(a) she is satisfied that the modified development is substantially the same development as the development for which consent was originally granted;

(b) she has consulted with the relevant approval bodies and those approval bodies have not objected;

(c) the application has been notified with accordance with the regulations or irrelevant DCP; and

(d) she has considered submissions made concerning the proposed modification.

4.2 An EIS will not be required to accompany an application for modification to designated development (*Concrite Quarries – see below*), however a Statement of Environmental Effects should accompany the modification application.

<u>Substantially the Same Development</u>

4.3 *"Substantially the same"* means *"essentially or materially or having the same essence"* and requires a comparison between the development as originally approved and the development as proposed to be modified (*Vacik Pty Ltd v Penrith CC* (unreported, 18 February 1992).

4.4 The modified development must be essentially or materially the same as the originally approved development.

4.5 Modification may be available, even though the proposed operations are outside the area originally identified in the North of the River Consent. The Land and Environment Court has indicated that variation of a development application by relocation of a proposed development to include adjoining land would not constitute substantially different development or "radically transform" the character of the development (*Rose Bay Afloat Pty Ltd v Woollahra Municipal Council* (2002) 126 LGERA 36). By the same rationale, it would be reasonably open for a consent authority to determine that modification of a development consent to include adjoining land is "substantially the same development" provided other factors of the proposal are also "substantially the same".

4.6 In this case given the elements of the proposed mining operations are the same as those originally approved, we are of the opinion that it would be reasonably open for the consent authority to find that the modified development is substantially the same as the currently approved development.

Consultation with approval bodies

4.7 We note the development subject to the North of the River Consent was integrated development. Accordingly, the relevant integrated development approval bodies will be consulted in relation to any modification application.

4.8 If the approval body consulted has not objected within 21 days after being consulted the consent authority may grant a modification.

Notification

4.9 Notification requirements for modification of designated development are set out in Cl 118 of the EP&A Regulation and include:

(a) publication in a newspaper;

(b) notification of each person who made a submission in relation to the original development application;

(c) a period of at least 14 days for inspection and submissions.

Consideration

4.10 The consideration of the modification application may open the whole of the consent that is sought to be modified for consideration by the Minister.

5 Summary / Recommendation

5.1 The proposed further mining area will require approval.

5.2 Approval may be either by modification of the existing North of the River Consent or by a new development application.

5.3 The development may be non designated (no EIS) requiring only an SEE if the Minister applies clause 35 of the Regulation. There is a basis for her to do so but environmental assessment will be needed to provide a basis for her to so decide.

5.4 Advertising and notification to the public/objectors and integrated approval bodies are required for both a new development application (whether designated development or not) and a modification application.

5.5 An exhibition period of at least 30 days would be required for a new development application and a period of at least 14 days would be required for inspection and submissions in relation to a modification application.

5.6 If a new development application is submitted and it is sought to have it processed as non designated development, Coal and Allied will also need to address each of the factors in Clause 36 of Part 2 of Schedule 3 of the EP&A Regulation for the Minister to reach an opinion as to whether the additional works will cause a significant increase in environmental impacts for the total development.

5.7 It is a matter for Coal and Allied which approval path is preferred, however, in our view the modification process provides a more appropriate approval path.

5.8 We note that this advice differs from our recent advice regarding a similar proposal, to mine the Barry Land. The Barry Land advice recommended you seek approval to mine the Barry Land by way of a new development application for non designated development. Both proposals are similar in size and involve small areas relative to the approved North of the River consent area. However, the Barry Land advice is distinguished from this advice on the basis that the Barry Land proposal was entirely outside the approved consent area. In relation to Carrington Extended, only a relatively small portion of the proposed mining area lies outside of the approved consent area. As such, we recommend approval be sought pursuant to s 96(2) of the EP&A Act.

Please do not hesitate to contact us for any further clarification.

Thank you for your instructions.

Yours faithfully

David White
Partner

Contact: Naomi Simmons
Lawyer
02 4924 7325
naomi.simmons@sparke.com.au

SPARKE HELMORE LAWYERS

Memorandum

To: Dan Eason / Sarah Fish

Firm: Coal & Allied Operations Pty Limited

From: Naomi Simmons / David White

Date: **15 October 2004**

Subject: Advice regarding Carrington Extended Mine

Dear Dan

We refer to our previous memo dated 16 September and your email requesting further advice on the above matter.

You have sought advice as to whether further changes can be made to the Carrington mine, in addition to those previously advised and whether a Section 96(2) modification would be available to approve all of the now proposed changes.

1 Position/background

1.1 The additional changes are:

(a) South Levee

(b) Gully Levee

(c) Arch Levee (the northern side of this levee is already approved under the original Carrington consent)

(d) The section of the drainage line outside the current development consent

(e) A services buffer area outside the extraction limit to allow for room for services such as cables, pipelines and access trucks.

2 Substantially the Same Development?

2.1 We refer to the principles relating to modification under Section 96 of the EP&A Act outlined in our previous memo, including the test of "*substantially the same development*".

2.2 The mine as now proposed, that is the changes previously advised and the additional changes now advised, must altogether leave the mine essentially or materially the same as the mine as it was originally approved.

2.3 It is our understanding that the additional changes constitute an extension or relocation of similar types of infrastructure identified in the Carrington EIS and / or the North of the River EIS. The additional changes do not materially alter the essence of the mine as approved and the relocation or extension of such infrastructure is incidental to the proposed changes to the mining area as previously advised.

2.4 It would be open for the Minister to determine that the now further changed proposal is substantially the same as the development originally granted and may be approved by modification under the EP&A Act, subject to environmental assessment. A Section 96(2) Modification Application could be submitted for the proposed changes to the mine, including the additional alterations.

Please do not hesitate to contact us for any further clarification.

Thank you for your instructions.

Yours faithfully

David White
Partner

Contact: Naomi Simmons
Lawyer
02 4924 7325
naomi.simmons@sparke.com.au

Memorandum

To:	Sarah Fish
Firm:	Coal & Allied Operations Pty Limited
From:	Naomi Simmons / David White
Date:	**8 November 2004**
Subject:	Advice regarding Carrington Extended Mine

Dear Sarah

You have sought advice as to what approval would be required under the EP&A Act for the proposed extension of the Carrington Pit.

1 Position/background

1.1 The existing development consent is DA 450-10-2003 (the North of the River Consent)

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Please do not hesitate to contact us for any further clarification.

Thank you for your instructions.

Yours faithfully

David White
Partner

Contact: Naomi Simmons
Lawyer
02 4924 7325
naomi.simmons@sparke.com.au

12th November 2004

Department of Infrastructure, Planning and Natural Resources
GPO Box 3927
Sydney NSW 2001

Attention: David Kitto

Dear David

APPLICATION TO MODIFY HUNTER VALLEY OPERATIONS

DEVELOPMENT CONSENT DA-450-10-2003

Introduction

Coal & Allied (CNA) are proposing an extension of mining at Hunter Valley Operations (HVO) Carrington Pit. HVO is located approximately 18km north west of Singleton NSW. The extension is proposed immediately to the south of the existing Carrington Pit, and will then extend east though existing spoil to access the Bayswater coal seam that was not previously mined. To be consistent with the current pit design, approval for the extension is required by October 2005. The location of the extension is shown on the attached plan.

History

Consent for the establishment of the Carrington Pit as a truck and shovel operation was granted in 2000. The pit was approved for the production 6 mtpa ROM and also included the construction of two levees and the relocation of an unnamed creek.

The Carrington development consent (106-6-99) was modified in 2003 to extend the hours of blasting and was then consolidated into the HVO North of the Hunter River consent (450-10-2003) in 2004. The original Carrington Pit consent (106-6-99) will be surrendered in accordance with the HVO North of the River consent.

The Proposal

It is proposed to extend the Carrington Pit for a maximum of 650m to the south and then for the pit to progress eastwards to recover coal in the Bayswater seam that was previously considered to be uneconomical. The total area of the extension of mining is approximately 140ha of which 44ha is located in previously undisturbed land.

The extension will require 1 additional levee to be constructed as well as the relocation and/or extension of the already approved levees. The unnamed creek will also be required to be relocated to the west of the mining operation rather than to the east as originally proposed. The proposal also allows for the provision of a services zone that would typically be used for light vehicle access, pipelines and cables outside of the mine extraction area.

The extension is required to maximise the recovery of the coal resource within CL360, CCL 755, ML1500 and EL 5418. Approximately 15 million tonnes of recoverable coal is expected to be recovered as part of the proposal. The pit will continue as a truck and shovel pit, operating 24 hours a day 7 days a week. There is no proposal to increase the amount of equipment operating or the rate of coal mined therefore, it is expected that the impacts of the proposal on the environment will be limited. The life of the pit will be extended by approximately 3 years to approximately 2011 however mining may extend to 2014 depending on market conditions.

Approval Path

As the proposal is substantially the same as the already approved mining operations and the proposal is not expected to significantly increase the environmental impacts of the total development, CNA are seeking that the proposal be considered under Section 96(2) of the *Environmental Protection & Assessment Act (1979)* and that the application to modify the consent be accompanied by a Statement of Environmental Effects (SEE). We would like to request from the Department their requirements to be addressed in the SEE.

Legal advice has been sort on the appropriate approval path to enable the Extension of Carrington Pit. A copy of the advice is attached.

Should you have any queries or require any additional information, please do not hesitate to contact me on 6570 0058.

Yours sincerely

Sarah Fish
Environmental Specialist – Reporting, Approvals & Projects

Enc: Carrington Extended Proposal Figure
Legal Advice

Department of
Infrastructure, Planning and Natural Resources

Mining & Extractive Industries
Major Development Assessment
Phone: (02) 9762 8162
Fax: (02) 9762 8707
Email: david.kitto@dipnr.nsw.gov.au
Level 4 Henry Deane Building
20 Lee Street
GPO Box 3927
SYDNEY NSW 2001

Ms Sarah Fish
Environmental Specialist – Reporting, Approvals and Projects
Coal and Allied Operations Pty Ltd
PO Box 315
SINGLETON NSW 2330

Dear Sarah

Application to Modify Hunter Valley Operations Development Consent (DA 451-10-2003)

I refer to your letter, dated 12 November 2004, asking whether the proposed extension to the Carrington pit should be considered as a modification to the Hunter Valley Operations development consent (DA 451-10-2003) under section 96(2) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The Department has reviewed the information in your letter, and agrees that the proposal should be dealt with under section 96(2) of the EP&A Act. This application should be accompanied by a Statement of Environmental Effects (SEE) that addresses the following matters:

- **Description of the Proposal**: Describe the proposal in detail, clearly identifying the resource, the proposed site, the proposed works (including rehabilitation works), the proposed intensity of operations, the ongoing management responsibilities for the proposed site, and the likely inter-relationship between the proposed operations and the existing or approved mining operations at Hunter Valley Operations.
- **Justification for the Proposal**: Provide a detailed justification for the proposal, including:
  - consideration of alternative mine plans and project layouts to reduce the environmental impacts of the proposal;
  - justification for the final land form/void and land use in relation to the land capability and the strategic land use objectives for the area; and
  - a clear description of the benefits of the proposal (including social and economic benefits).
- **Statutory Instruments**: Assess the proposal against any relevant statutory provisions.
- **Key Issues**: Assess the following potential impacts of the proposal during construction and operation, and describe what measures would be implemented to manage, mitigate, or off-set these potential impacts:
  - surface and groundwater;
  - noise, blasting and vibration;
  - air quality;
  - heritage, both Aboriginal and European;
  - flora and fauna (including aquatic ecology, critical habitats, threatened species, populations or ecological communities); and
  - visual amenity.
- **Cumulative Impacts:** Assess the potential air, noise, surface and groundwater cumulative impacts of the proposal (particularly at nearby non-mined owned residences), taking into account the existing and proposed development at Hunter Valley Operations and other mines in the area.
- **Environmental Monitoring & Management:** Describe how the existing environmental monitoring and management programs/plans at Hunter Valley Operations would be revised to accommodate the proposed modification.

Water Resources

The Department is particularly concerned about the potential impacts the proposal may have on the Hunter River and its associated alluvium. Consequently, the Department would like you to pay particular attention to the potential surface, groundwater and flooding impacts of the proposal, and give detailed consideration to the proposal's consistency and compliance with relevant water management legislation and policies (see Attachment 1). In addition, the Department would be happy to discuss these issues further with you during the preparation of the SEE.

Consultation

During the preparation of the SEE, you should consult with the relevant local and State government agencies (including the Department of Primary Industries, Department of Environment and Conservation, and Singleton Shire Council), and surrounding landowners/occupiers that are likely to be affected by the proposal.

The SEE must include a report indicating who was consulted, what consultation occurred, and what issues were raised in this consultation.

Administration

You should notify the Department at least 2 weeks before you lodge the application, so that it can make the necessary arrangements to exhibit the SEE. When you lodge the application, you must include:

- at least 20 hard copies of the SEE, and 10 copies of the SEE on CD-ROM; and
- a cheque for the modification fee (see clause 258 of the EP&A Regulation), made payable to the Department.

Enquiries

If you have any enquiries about the above, please contact Mike Young on 9762 8154.

Yours sincerely

DKitto 23/2/05

David Kitto
Manager
Mining & Extractive Industries

ATTACHMENT 1

INTRODUCTION

- The following information requirements have been prepared by the Resource Access Unit of the Department of Infrastructure, Planning and Natural Resources (DIPNR) Hunter Region as a guide for applicants and consultants in the preparation of development proposals.
- Whilst this document has been prepared as a guide there may be circumstances that on formal referral of a proposal, DIPNR Hunter Region will require additional information to be provided.
- Details of the principal legislation administered by DIPNR (Natural Resources), gazetted Water Sharing Plans (WSP), relevant NSW State Government natural resource management policies and departmental EIS Guidelines, form an annexure to this document.
- If the development / activity lies within a gazetted WSP under the Water Management Act 2000 (WMA), any proposal to access water needs to satisfy the rules of the WSP.
- The Environmental Planning and Assessment Act 1979 (EPAA) and its Regulation 2000 (EPAR) underpin the planning and approval processes for all development proposals in NSW.

INFORMATION

Existing Approvals

- Details of existing development consent, including delineation of setback areas and protection zones
- Details of any existing approvals issued under the Water Act 1912, or the Rivers and Foreshores Improvement Act 1948

Land Status/Ownership

- Land title description and if proposal includes Crown land (eg. bed of waterway) or Crown roads
- Land tenure (eg. lease/ license) and if under mining lease or Crown leasehold
- Details of the registered owner/s of the property and applicant/s
- Evidence of the land owner's consent (eg. to lodge development application)
- Details of existing zonings (map to be included)

Site Information/ Survey

- Site location with north point and scale
- Layout plan
- Survey plan of the existing site
- Survey plan to provide cross sectional details of the site as compared to the Hunter River, connected alluvial aquifer and hard rock aquifer systems
- Topographic contours of the site, and the subcrop and depth of extraction of coal on the site
- Site features - watercourses, lakes, wetlands, vegetation, buildings, tracks, infrastructure etc.
- Details on direction of flow, water levels, high bank, low bank, major aggradation / erosion for any watercourses, flood runners, terraces and other geomorphological features
- Plan to identify 1: 100 year flood level
- Identification of any 'proclaimed mine subsidence districts'

Project Description

- Description of the *proposed* and *existing* development including all ancillary works (stormwater drainage, access, bridge, causeway, pipeline etc.)
- Photographs panoramic (multiple frames) for development site. Note: If watercourses are impacted upon or in the vicinity of the development, include photographs also looking upstream and downstream
- Site layout plan that indicates the location of photographic reference points

Operational Information

- Operational plan detailing the ongoing operation including staging/ sequencing of extraction, backfilling and rehabilitation of the pit and extraction and storage of groundwaters encountered during extraction
- Assessment of salinity hazards, including both short term operational salinity management and long term salinity contamination hazards
- Rehabilitation plan that details the progressive and final restoration/ rehabilitation of landform, revegetation, surface water, groundwater and maintenance
- Monitoring program for assessment on fluvial geomorphology and surface water bodies
- Monitoring program for assessment on groundwater
- Contingency plans, and linkages to monitoring objectives

Geomorphology/ Watercourses

- Assessment of the impact of the proposal on the existing flow regime (ie. flow quantity, velocity, frequency and duration) for all rainfall and flood events up to a 100 year Average Recurrence Interval, both for existing and proposed flood exclusion levees, and cumulative impacts for other existing and proposed flood exclusion works on the Hunter River within five (5) kilometers of the site
- Assessment of impact on the fluvial geomorphology of the watercourse including any erosion and sedimentation likely to be caused by the development
- Measures to be implemented to guard against actual and potential environmental disturbances during the construction and operation of the proposal

Groundwater

- Details of any proposed groundwater extraction, including purpose, location and construction details of all proposed bores and expected annual extraction volumes
- Details of any proposed works likely to intercept groundwater
- Description of different aquifer systems including their extent and inter-relationships (including inter-relationships with surface water bodies and dependent ecosystems)
- Description of the flow directions and rates and the physical and chemical characteristics of the aquifers
- Details of the predicted impacts of any final landform on the groundwater regime
- Details of the existing groundwater users within the area of the proposal and any potential impacts on these users, including the environment (Groundwater Dependent Ecosystems)
- Details of the predicted highest groundwater table at the development site
- An assessment of the quality of the groundwater for the development site
- Identify water application areas and method of application
- Details of proposed method of disposal of tailings or waste water
- Details of the results of any models or predictive tools used, including inputs, limitations for models used and any sensitivity analyses conducted
- A discussion of relevant groundwater-related policies (Groundwater Quantity, Groundwater Quality and Groundwater-Dependent Ecosystems Policies) and the Hunter Regulated Water Source Water Sharing Plan
- Justification of the proposal in terms of defined protective setbacks and other measures to prevent the degradation of existing groundwater sources, diminution of connected surface/groundwater resources and impacts on existing groundwater users, including the environment

Surface Water

- Details of any proposed surface water extraction, including purpose, location of existing pumps, dams, diversions, cuttings & levees & expected annual extraction volumes
- Identify sources of surface water
- Location and design specifications for all clean water diversions including channels, detention basins and outlet fixtures
- Location and design specifications for dirty water/contaminated water circuit including channels, detention basins and outlet fixtures
- Provide details regarding any dirty water/contaminated discharge resulting from the proposed development
- Provide information on detailed water balance including inflows and imports / exports to and from the proposed development
- Details of the integrated water management system, including an assessment of changes to the water balance under a range of conditions (including 10%, 50% and 90% wet years and severe storm events)
- Details of the proposed use of the Hunter River Salinity Trading Scheme, including discharge procedures to match high flows, flood flows and any potential for transfer of waters to adjacent sites

Water Storage Structures

- Details of proposed water storage structures, including purpose, location, design specifications (crest, bywash, discharge, low flow bypass provisions)
- Calculation of the catchment area, water storage structure capacity (ML) and water storage surface area.
- Calculation of the Maximum Harvestable Right Dam Capacity (MHRDC)
- Details of stream order (using the Strahler System) for any watercourse which lies within the site
- Estimate of evaporation rates and annual evaporation losses
- Details of pumps and intended extraction volumes from the water storage structure/s
- Details of any other persons/ party to be supplied (eg. volume, rate, purpose)
- Identify impacts on other licence users or 'basic rights'

Floodplain

- Detail any works on a *declared* floodplain
- Detail flood hazard management provisions

Monitoring requirements

- Details of monitoring programs, including:
  - objectives of the monitoring program
  - distribution of monitoring networks for surface and/or groundwater
  - frequency of monitoring

- parameters to be monitored

Details of mitigation and contingency plans with respect to groundwater contamination and identification of triggers for implementation of these plans.

Detail the presence of groundwater dependent ecosystems in the surrounding areas, including the identification of flora and fauna and their dependence on groundwater.

Identification of required buffer zones for any groundwater dependent ecosystems.

Identification of auditing and reporting schedule.

Water Sharing Plans

- Water Sharing Plan for the Hunter Regulated River Water Source

Note: Further information can be accessed at www.dipnr.nsw.gov.au

Policy Guidelines

- NSW State Rivers and Estuaries Policy
- NSW Wetlands Management Policy
- NSW Groundwater Policy Framework Document - General
- NSW Groundwater Quantity Management Policy
- NSW Groundwater Quality Protection Policy
- NSW Groundwater Dependent Ecosystem Policy
- NSW Weirs Policy
- Farm Dams Policy

Note: Natural resource policies can be accessed at www.dipnr.nsw.gov.au

Annex B

Carrington Pit Extended Newsletter

CARRINGTON EXTENDED
Hunter Valley Operations
newsletter
1
April 2005

COAL & ALLIED
A Rio Tinto Group Company

Introduction

Coal & Allied are proposing to extend their existing mining operations in Carrington pit at Hunter Valley Operations (HVO). Environmental Resources Management (ERM) has been commissioned by Coal & Allied to prepare the Statement of Environmental Effects (SEE) for the proposed extension to support an application under Section 96(2) of the ***Environmental Planning and Assessment Act (EP&A Act, 1979)*** to modify the existing consent.

The purpose of this newsletter is to inform the community of the proposed extension, the statutory planning approvals process, the issues that will be addressed as part of the SEE and the planned public consultation process. A second newsletter will be prepared and distributed prior to the exhibition of the SEE.

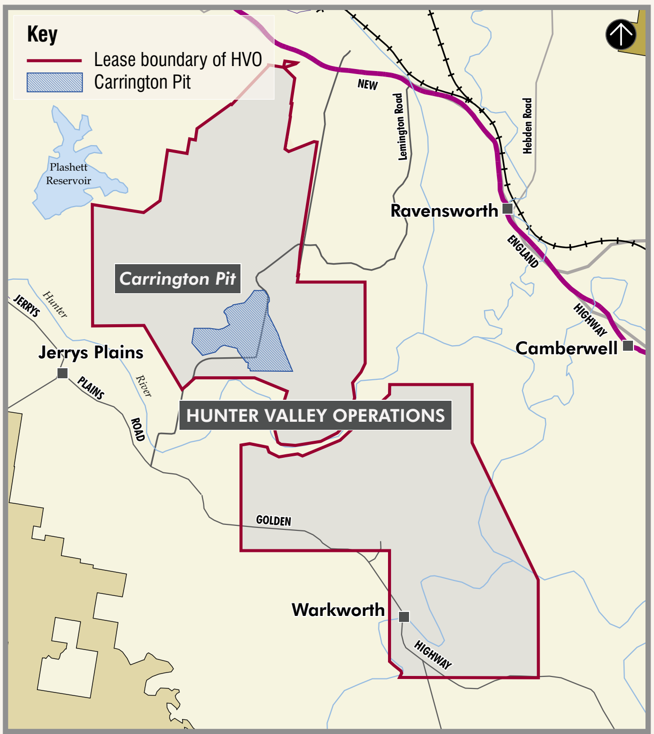

Figure 1 | *Location of Carrington Pit and HVO*

Location

HVO is located to the north west of Singleton, approximately half way between Singleton and Muswellbrook. The operations are bisected by the Hunter River, Figure 1.

Carrington pit forms part of HVO north of the Hunter River and the proposed extension areas are located to the south and east of the existing operation, Figure 2.

Overview of Proposal

Two extension areas are proposed for the Carrington pit: an eastern extension and a southern extension. The eastern extension area will be located in an area that was previously disturbed for mining; while the southern extension area will be located on grazing land located between the existing Carrington mining operation and the Hunter River.

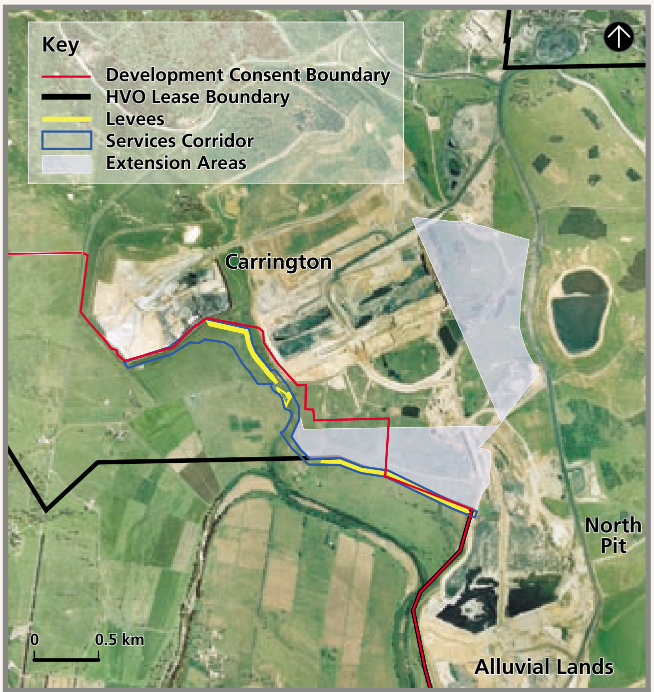

Figure 2 | *Proposed Extension of Carrington Pit*

CARRINGTON EXTENDED

Hunter Valley Operations

COAL & ALLIED

A Rio Tinto Group Company

An additional strip of land will also be incorporated into the development for use as a service corridor. This service corridor will extend around the southern boundary of the existing operation and proposed southern extension area and will be used for services such as pipelines, cables and access etc. Three levees will be constructed to prevent interaction between the Hunter River and the mine during floods.

The same mining techniques and fleet of mining equipment are proposed to be used and there will be no increase in the approved rate of production which is 10 Million tonne per annum (Mtpa) Run of Mine (ROM) coal. The proposed extension is planned to extend the life of the pit by 4 years.

Planning Framework

The proposed Carrington extension will require development consent under the provisions of the Singleton Local Environmental Plan, 1996. However, as the proposal will be a modification to an existing consent provided by the Minister for Infrastructure, Planning and Natural Resources, the Minister will be the consent authority.

The proposed extension is a change to the West Pit Extension and Minor Modifications consent and a Statement of Environmental Effects (SEE) needs to be prepared in accordance with Section 96(2) of the ***(EP&A Act, 1979)***.

Potential Environmental Issues

As part of the SEE process, a number of specialist studies will be undertaken to assess the following:

- Potential noise and vibration impacts associated with the proposed extension of Carrington pit combined with operations within HVO north of the Hunter River;
- Potential impacts on air quality associated with the proposed extension combined with operations within HVO north of the Hunter River;
- Potential impacts to flora and fauna in the proposed extension areas;
- Potential impacts to surface and groundwater regimes;
- Potential impacts to Aboriginal and European heritage items within the proposed extension area;
- Potential visual impacts due to the extension,
- Potential socio-economic impacts, and
- Potential impacts that the proposed extension may have on traffic using local roads.

Community Consultation

The SEE will be placed on exhibition after finalisation. During this time, any individual or group will have the opportunity to make a formal submission to the Minister on the proposal.

A second newsletter will be prepared and distributed prior to exhibition of the SEE to inform the community of any changes to the project, environmental outcomes of the assessment, the location of the SEE when on exhibition and the means to provide a submission to the Minister.

Carrington Pit Extension SEE Team

A specialist team has been selected to prepare the SEE for the Carrington extension. The Coal & Allied contact is:

- Daniel Eason - Project Co-ordinator

ERM environmental consultants are conducting detailed environmental studies and preparation of the SEE. The ERM team members include:

- David Snashall - Project Director
- Dr Lynette Coleman - Project Manager

Further Information

Should you have any queries regarding the proposed extensions and the preparation of the SEE please contact:

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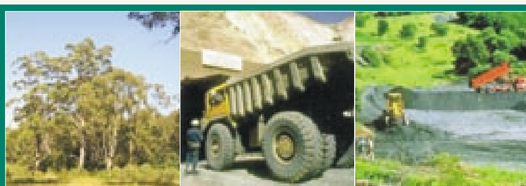
Phone: 6570 0093
Email: Daniel.Eason@rtca.riotinto.com.au

newsletter



Annex C

Hydraulic Assessment Of Levees

HYDRAULIC ANALYSIS
HUNTER RIVER AND FLOODPLAIN
FOR
CARRINGTON MINE EXTENSION

August 2005

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Job No: CD174 File:/docs/reports/HunterRiver.doc	Date: 04 August 2005 Rev No: 2.0	Principal: BWL Reviewer: BWL

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APPENDIX A

1 INTRODUCTION

1.1 Background

This report is an assessment of the effects on flooding in the Hunter River of proposed levees associated with the extension of the Carrington Mine. Peak water surface levels for the 100 year average recurrence interval (ARI) flood, as well as a larger flood event, are also provided to assist the designers with setting the crest levels of the various levees. The Carrington Mine is located on the northern floodplain immediately upstream of the Hunter Valley No. 1 North Mine.

Previous hydraulic investigations were undertaken by Lyall & Macoun Consulting Engineers (LMCE, 1990 and 1992a) for the extension of the Hunter Valley No. 1 Mine. These investigations involved the development of a one-dimensional hydraulic model based on the HEC-2 water surface profile modelling software (U.S. Army Corps of Engineers, 1982). This model was calibrated using data recorded for the February 1955 flood and was then used in initial planning studies to investigate the effects of various levee proposals on flow patterns and water surface levels.

Further project planning for the Hunter Valley No. 1 Mine resulted in the emergence of issues that could not be addressed by the HEC-2 model. These issues were related to the design of the levee and included definition of water velocities along the face of the levee and the effects of two-dimensional (in plan) characteristics of the flow pattern. This affected estimates of water levels and thus of the required levee height. Two-dimensional numerical modelling was undertaken using finite elements to address these issues. The FESWMS hydraulic modelling package was used for this purpose. Results of the modelling were presented in a report by LMCE (1992b).

Additional one- and two-dimensional (FESWMS) analyses were undertaken shortly after the above work was completed and the results were presented in an Addendum (LMCE, 1992c). The analyses assessed the effects of discharges with a magnitude larger than the 100 year ARI flood for the chosen levee option, which was denoted Levee 5. A discharge of 12,500 m^3/s, which was estimated to have a return period of 1 in 185 years was selected for this purpose. Hydraulic analysis showed that this discharge would result in peak water levels around 1 m higher than the 100 year ARI flood, which at the time was estimated to have a peak discharge of 9,600 m^3/s.

A levee following the alignment of Levee 5 was subsequently constructed and, together with the existing Cheshunt levees on the southern floodplain, represents present day conditions on the floodplain.

1.2 Approach to Present Analysis

The FESWMS model was not available for the present Carrington Mine project. Given the availability of the results of the previous FESWMS analysis, the present project does not warrant the implementation of new detailed two-dimensional modelling. Accordingly, it was decided to carry out the present analysis by interpretation of the FESWMS hydraulic modelling carried out in the previous investigations, supplemented by new one-dimensional analysis using the HEC-RAS modelling software. (HEC-RAS is a development of the HEC-2 software used in the previous analyses).

The HEC-RAS model was used to provide the comparison between present day and post-Carrington Mine levee conditions presented in Appendix A and the results of both modelling approaches were interpreted to provide recommended levee crest levels in Section 4 of the report.

1.3 Proposed Levee Alignments

The analyses described below are based on the construction of three levees on the northern floodplain to enable the extension of the Carrington Mine to proceed. They are shown on **Figure 3.2** which shows the layout of the HEC-RAS model used in the hydraulic analyses and are denoted:

- **The South Levee** is the most downstream levee and extends in an east-west direction over 1.2 km and is located about 500 m from the main channel of the Hunter River.

- **The Archaeology Levee** is the most upstream levee and follows an S-shaped route bounded by the two existing levees for the Carrington Mine. It is to be situated 800 m to the north of a sharp bend in the river as it turns from a northerly to easterly course. This levee is denoted the "Arch Levee" in **Figure 3.2.**

- **The Gully Levee** is a minor levee to be located near the eastern abutment of the Arch Levee.

Subsequent to the hydraulic analysis, advice was received that the Archaeology Levee would not form part of the project. Any potential constriction on flows resulting from this levee would not now occur. Consequently, the very minor modelled increases in peak flood levels resulting from the project will in fact be even less than presented in the following results.

1.4 Review of Survey Data

A recent topographic survey of the river channel and northern floodplain at 2 m contours was supplied by Coal and Allied for the purposes of refining the hydraulic model.

A comparison of cross sections taken at the same locations as those incorporated in the existing (1992) hydraulic model showed that, whilst there was good agreement between the two sets of data within the extent of the river channel, the new survey gave natural surface levels on the floodplain which were on the average about 1 m lower than the levels in the cross sections of the hydraulic model.

The survey used to construct the HEC-2 and FESWMS hydraulic models was supplied by Coal and Allied in 1992 and comprised 1:2000 scale plans with 1 m contour spacing over the downstream portion of the area of interest and 1:4000 scale plans with a 2 m contour spacing further upstream. In addition, the main river channel together with portions of the adjacent floodplain, were surveyed at six locations.

If the cross sections in the existing hydraulic model were to be replaced by sections based on the new survey, then it is likely that computed flood levels would have been considerably lower than those presented in the previous studies.

Further, it is likely that if the new survey data were used for the present Carrington Mine study, then recommended crest levels of the proposed levees would be lower than would have been the case using the existing model data to define crest levels. Consequently, if the natural surface levels defined by the new data were actually on the low side, the proposed levees may have a lesser hydrologic standard than the desired design standard and may be overtopped by the design flood event.

Following discussions with Coal and Allied, it was agreed to base the investigation on the cross sections incorporated in the existing model and to adjust the natural surface levels in any interpolated cross sections so as to be consistent with those comprising the existing model.

This approach would allow the comparison of present day and post-Carrington Mine levee flooding conditions to be carried out and would also provide safe estimates of flood levels for setting the crest levels of the new levees.

2 FLOOD FREQUENCY ANALYSIS

In 1985, Snowy Mountains Engineering Corporation was engaged by Coal and Allied Operations Pty Ltd to carry out a hydrologic investigation to define flood levels, frequencies and flow durations along the reach of the Hunter River adjacent to the Hunter Valley No. 1 Mine (SMEC, 1985). The No. 1 Mine is located downstream of the Carrington Mine along a 5 km section of river extending from 40 km to 45 km upstream of Singleton. The investigation comprised frequency analysis to define peak discharges for a range of frequencies between 10 and 500 years ARI.

In the SMEC, 1985 study, analyses were carried out using the Singleton and Liddell gauging station data. At the Liddell station, which is situated near the township of Jerrys Plains a short distance upstream of the Carrington Mine, the record commenced in 1971. The flood record at Liddell was correlated with the record at the long term gauging station at Singleton for which records are available back to 1898.

From information contained in the SMEC study report, the recorded peak discharge at Singleton for the February 1955 flood was 12,500 m^3/s and the best estimate of the corresponding peak at the Liddell gauging station was 11,000 m^3/s. From the results of SMEC's frequency analysis the 100 year ARI discharge at Liddell was estimated as 9,600 m^3/s, increasing to 19,000 m^3/s for the 500 year ARI event.

Later, Lyall and Macoun Consulting Engineers undertook a hydraulic investigation of the new bridge on MR213 over the Hunter River at Bowmans Crossing (LMCE, 1996). The crossing is located about 8 km north-west of Jerrys Plains. This investigation also used the Liddell and Singleton gauging station data to define the flood frequency relationship, but was based on an additional 10 years of flood data compared with the SMEC study.

Various annual and partial duration series analyses were carried out. Peak flows were assessed for floods ranging between 50 and 500 years ARI. The peak flows adopted in the LMCE, 1996 study are presented in **Table 2.1**.

As the Carrington Mine is located a short distance downstream of Jerrys Plains and there is no significant tributary runoff entering the Hunter River between the two locations, the flows given in **Table 2.1** may be used in the present study to define peak flood flows.

TABLE 2.1
PEAK DISCHARGES
HUNTER RIVER AT JERRYS PLAINS

Frequency (years ARI)	Discharge (m^3/s)
5	1,500
10	2,600
20	4,000
50	7,300
100	10,000

3 IMPACTS OF PROPOSED LEVEES ON FLOODING PATTERNS

3.1 Adjustments to HEC-2 Model

The HEC-2 model set up during the planning stages of the Hunter Valley No. 1 Mine levee consisted of thirty-four cross sections (the locations of Sections 1 to 22 are shown on **Figure 3.1**). The most downstream cross section, C.S. 1 was located approximately 2 km downstream from the eastern boundary of the Hunter Valley No. 1 Mine site and a short distance upstream of the confluence of Bayswater Creek with the Hunter River. The most upstream cross section, C.S. 34, was approximately 8.7 km upstream as measured along the valley middle thread from the western boundary of the No. 1 Mine site and was close to the downstream part of the township of Jerrys Plains. The total length covered by the model was 14.4 km.

The cross sectional geometry was taken from available topographic maps supplemented by ground survey of the river channel at several locations. For the area up to C.S. 19, the available mapping was at a scale of 1:2000 with 1 m contour intervals, but upstream of this cross section the mapping was at a scale of 1:4000 with 2 m contour intervals. The main river channel cross section plus parts of the adjacent floodplain were surveyed at six locations between C.S. 18 and C.S. 28 and interpolated as necessary to suit cross sections used in the model.

In the HEC-2 modelling approach, it is assumed that the water surface is level across any cross section and this required that the cross sections be properly aligned to the direction of flow. The sections in the model were generally inclined normal to streamlines that were estimated by inspection of the river alignment and floodplain topography.

In recent years HEC-2 has been superseded by the HEC-RAS modelling system, which was used for the present study. The layout of the HEC-2 model was reviewed, some adjustments were made to the orientation of the sections in the model and some additional sections inserted in the vicinity of the Carrington Mine to better represent the modelling of flow patterns at the proposed levees.

The layout of the adjusted (HEC-RAS) model in the Carrington Mine area is shown on **Figure 3.2.**

3.2 Use of the FESWMS Two Dimensional Model in the Present Study

As mentioned in **Section 1.1**, hydraulic analysis for the design of the Hunter Valley No. 1 Mine levee (Levee 5) had been undertaken in the previous investigations using two-dimensional finite elements. The FESWMS model extended over 5.7 km from C.S. 7 to C.S. 20, which includes the proposed location of the South Levee but stops short of the proposed Archaeology Levee. The FESWMS model would have had to be extended several kilometres upstream to allow evaluation of the impacts of the Archaeology Levee, but in any case was not available for the present investigation. Accordingly, as discussed later, evaluation of the impacts on flooding patterns of the three proposed Carrington Mine levees has been undertaken using HEC-RAS.

However, the FESWMS results provide insight into the required crest levels of the South Levee and also provide starting water surface levels at the downstream end of a truncated HEC-RAS model, which was used in **Section 3.3** to continue the hydraulic analysis upstream into the area in which the other Carrington Mine levees will be located.

FESWMS model results for the 100 year ARI flood incorporating Levee 5 are presented in **Figures 3.3** and **3.4**. The approximate location of the South Levee is shown on these diagrams, although it is to be noted that the levee was not included in the model for which these results apply, as this analysis was carried out in the LMCE 1992 studies.

Figure 3.3 shows velocity vectors in the main river channel and floodplain. Flow velocity is proportional to the length of the arrows. The small flow velocity vectors in the embayment in which the South Levee will be located confirms the fact that the levee would be outside the effective flow area and will be situated in a backwater. Consequently it would be expected that the levee would not have a significant effect on flow patterns.

Although it is to be located upstream of the extent of floodplain modelled by FESWMS the Archaeology Levee is similarly to be located in an embayment away from the main flow paths. It is expected that this levee also would not have a significant impact on local flooding patterns. This is confirmed in the HEC-RAS modelling described later in **Section 3.3.**

From the water surface contours shown in **Figure 3.4**, there is a comparatively large flood slope along the extent of the Hunter Valley No. 1 Mine due to the constriction imposed by Levee 5 and the natural constriction on flows at C.S. 16. Upstream of that location and extending into the two embayments in which the proposed levees will be located, the flood slope is quite flat at about 0.4 to 0.5 m per km.

3.3 HEC-RAS Model Results

A truncated version of the HEC-RAS model was used to model the Carrington Mine levees. The model had a downstream boundary at C.S. 16 and for analysing the 100 year ARI and 1 in 185 year floods used starting water surface elevations obtained from the results of the FESWMS two-dimensional modelling.

The truncated model extended from C.S. 16 to C.S. 34. Additional cross sections were inserted to provide greater definition in the vicinity of the Carrington Mine site.

Two-dimensional modelling had only been carried out for the 100 year ARI and the 1 in 185 year floods. No starting water levels were available for the smaller flood events. For those events, starting water levels at C.S. 16 were derived by assuming that uniform flow conditions prevailed with an energy slope equal to 0.5 m per km.

Water surface profiles for floods between 5 and 185 year ARI are shown on **Figure 3.5.** Water surface levels at several cross sections which intersect the levees are shown on **Figures 3.6** and **3.7** and details of water levels, flow distributions and velocities under present day and post-levee conditions are presented in **Appendix A.**

For the HEC-RAS analyses, the full extent of the cross sections were assumed to be effective for the conveyance of flow, even though FWSWMS had shown that the ridge on the northern side of the river at C.S. 20 shielded the downstream area in which the South Levee would be located from the flow and that as a consequence, that area was largely ineffective for the conveyance of flow. A similar situation would be expected to occur upstream in the vicinity of the Archaeology Levee due to the shielding effects of a promontory at C.S. 27.

From inspection of **Figures 3.6** and **3.7**, the levees would only be called upon to protect the mine area for floods around the 20 year ARI magnitude and larger, as lesser events would be contained within the confines of the channel and the lower floodplain. Even with all of the cross section effective for flow for larger flood events, the levees would not result in a significant obstruction to flow on the northern floodplain.

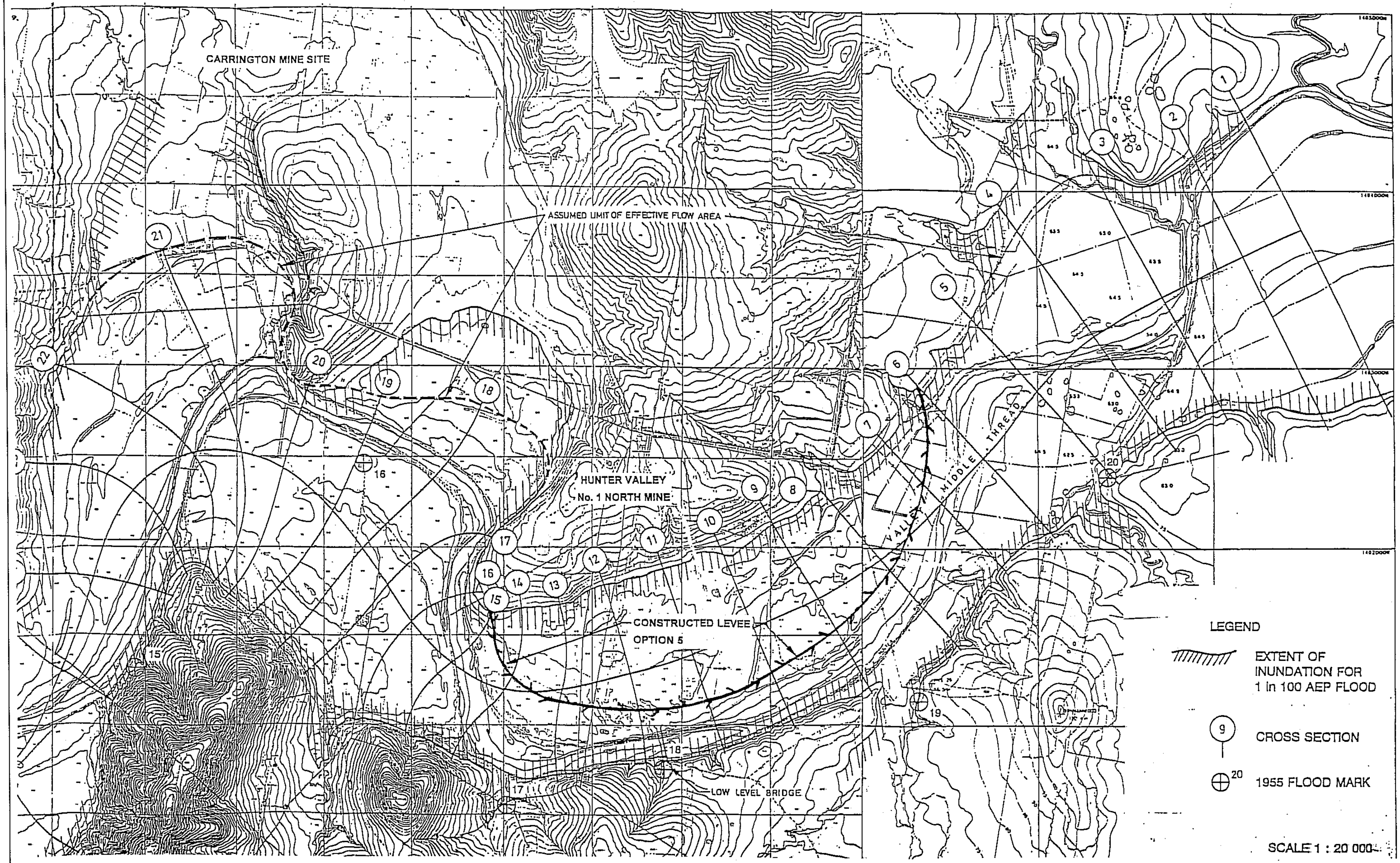
The modelled increases in water surface levels, changes in flow velocity and distribution on flow over the floodplain are shown in **Appendix A**.

3.4 Summary of Impacts of Proposed Levees

As the proposed levees are outside the main passage of flow, their main impact would be a localised re-direction of flows from the northern floodplain towards the channel. This would be accompanied by small increases in velocity, which would not have a significant effect on the morphology of the river channel. The modelled increases in flood level would reach a maximum of 60 mm at model C.S. 20, immediately upstream of the South Levee, but at most locations the modelled change in flood level is smaller and probably within the accuracy of the hydraulic model. Coal and Allied has advised that there are no developments bordering the river in the vicinity of the Carrington Mine which would be adversely affected.

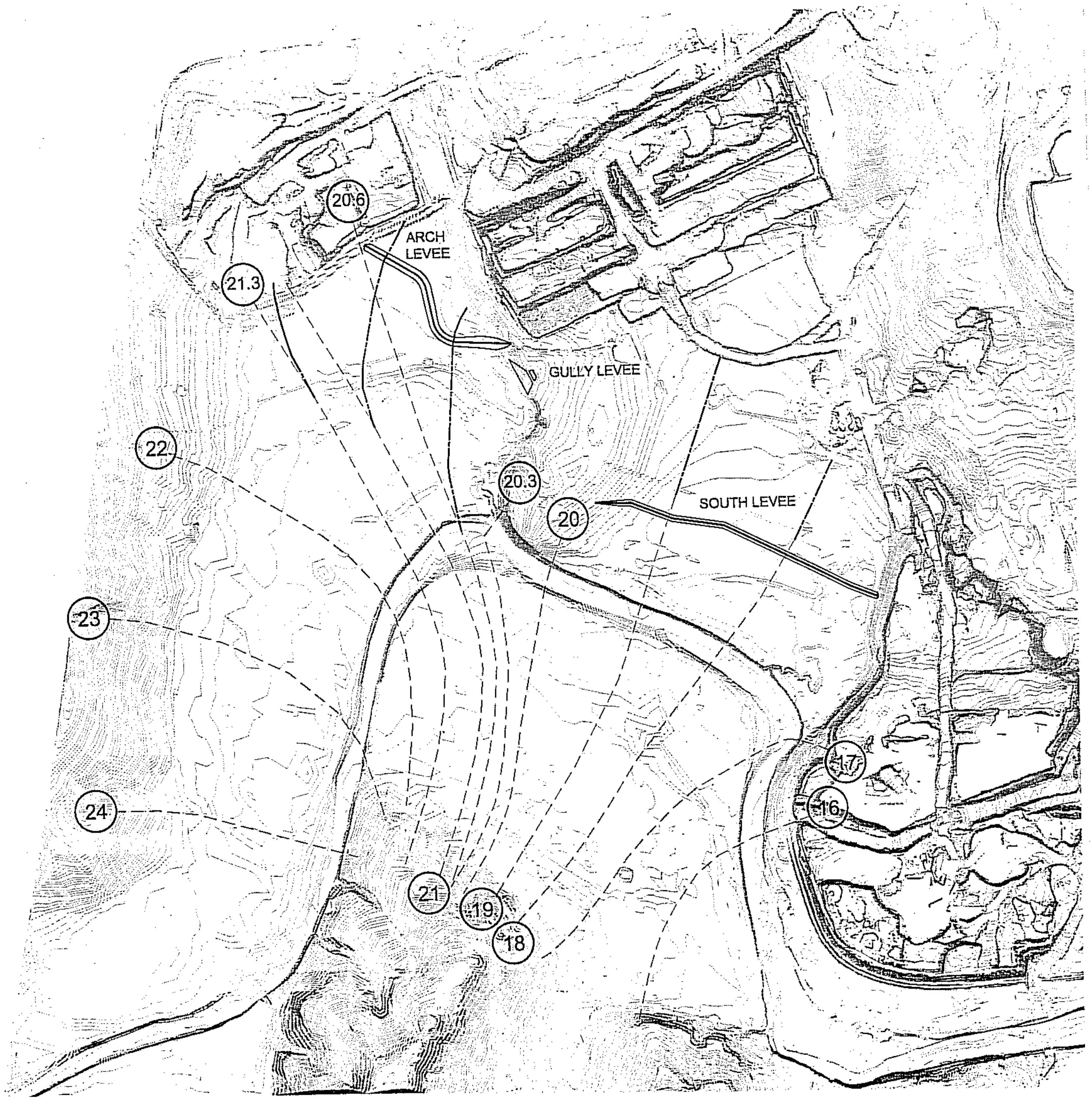
The modelled flow velocities on the northern floodplain near the levees would range between 0.3 and 1 m/s. Bearing in mind the previous discussion regarding the FESWMS results, these modelled velocities are likely to be on the high side, compared with velocities which would actually be experienced along the faces of the levees during major flooding.

For major flood events up to the magnitude of their chosen hydrologic standard (see **Section 4**), the levees would result in a small displacement of floodplain storage. However, the effects would be localised and are too small to be measured by hydraulic modelling.



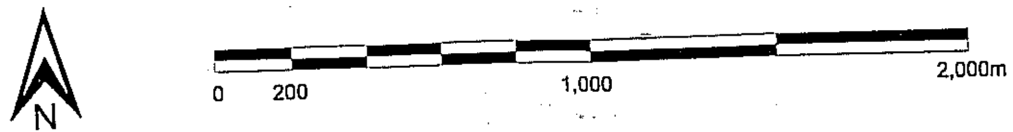
Taken from LMCE, 1992 (a)

CARRINGTON MINE EXTENSION
HYDRAULIC ANALYSIS OF HUNTER RIVER
Figure 3.1
HEC-2 MODEL LAYOUT



20 HEC_2 MODEL CROSS SECTION (LMCE, 1992)

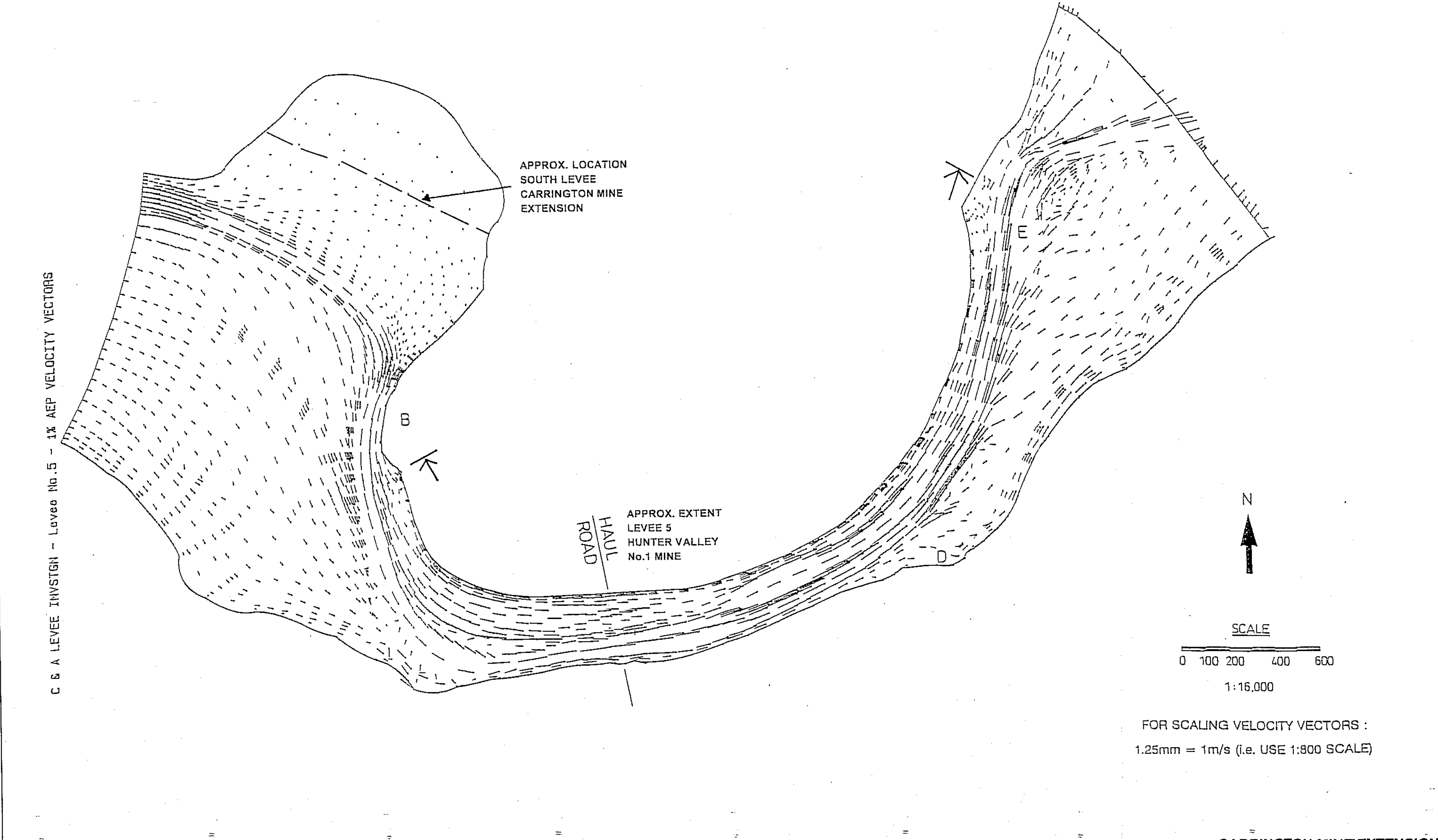
ADJUSTMENTS TO MODEL CROSS SECTION FOR PRESENT INVESTIGATION



CARRINGTON MINE EXTENSION
HYDRAULIC ANALYSIS OF HUNTER RIVER

Figure 3.2

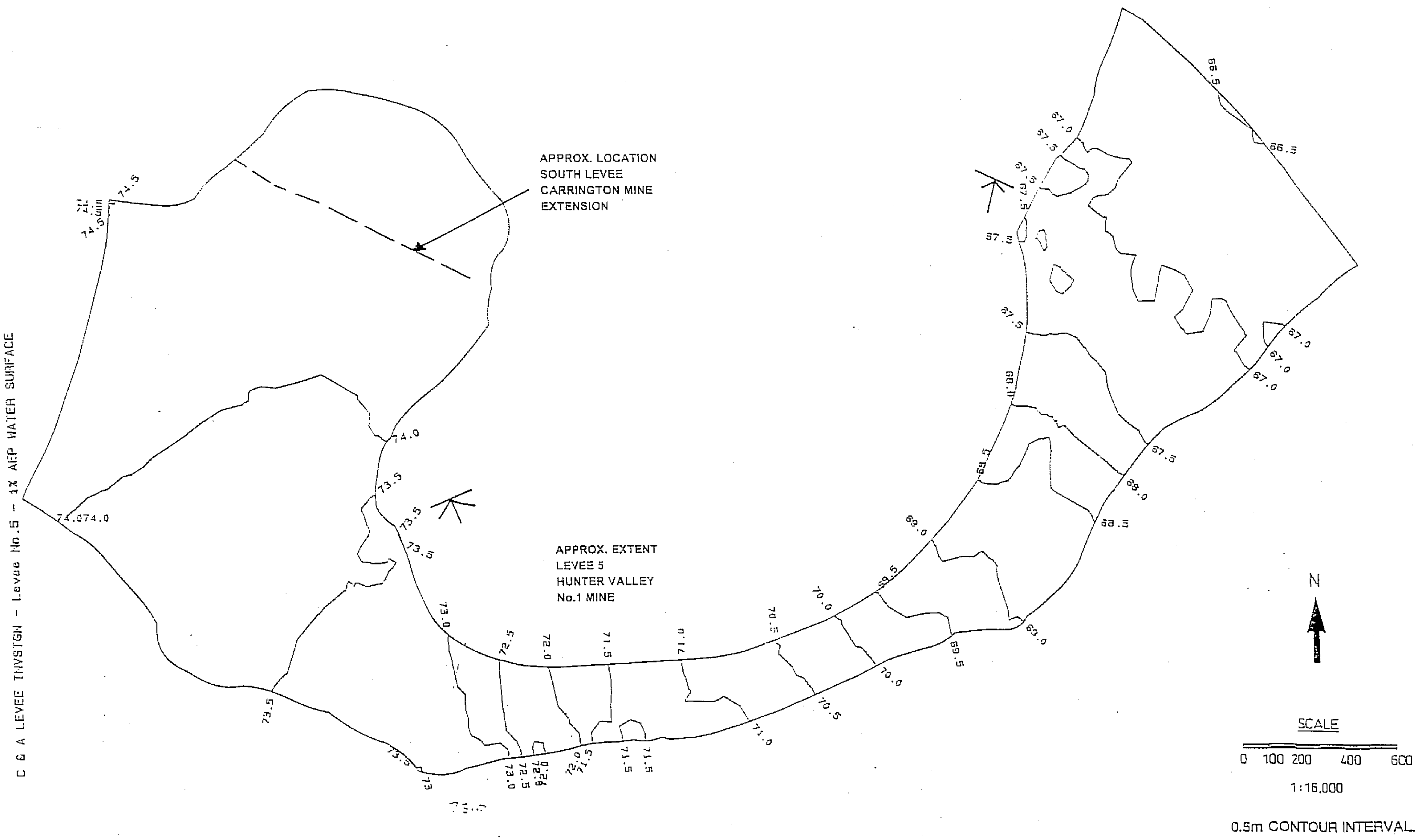
HEC RAS MODEL LAYOUT IN VICINITY OF LEVEE SYSTEM



Taken from LMCE 1992 (b)

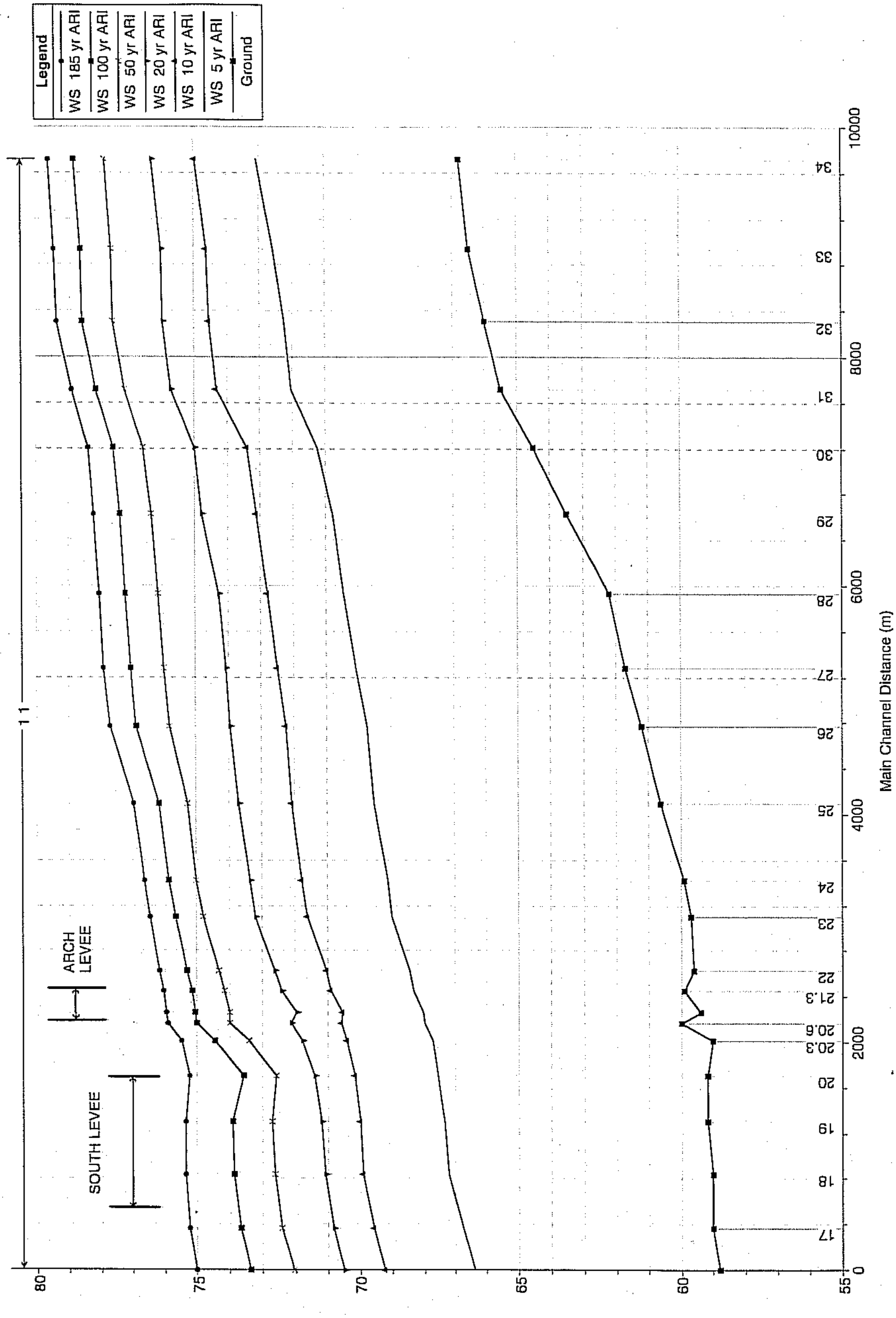
CARRINGTON MINE EXTENSION
HYDRAULIC ANALYSIS OF HUNTER RIVER

Figure 3.3
LEVEE 5 - 100 YEAR ARI VELOCITY VECTORS



Taken from LMCE, 1992 (b)

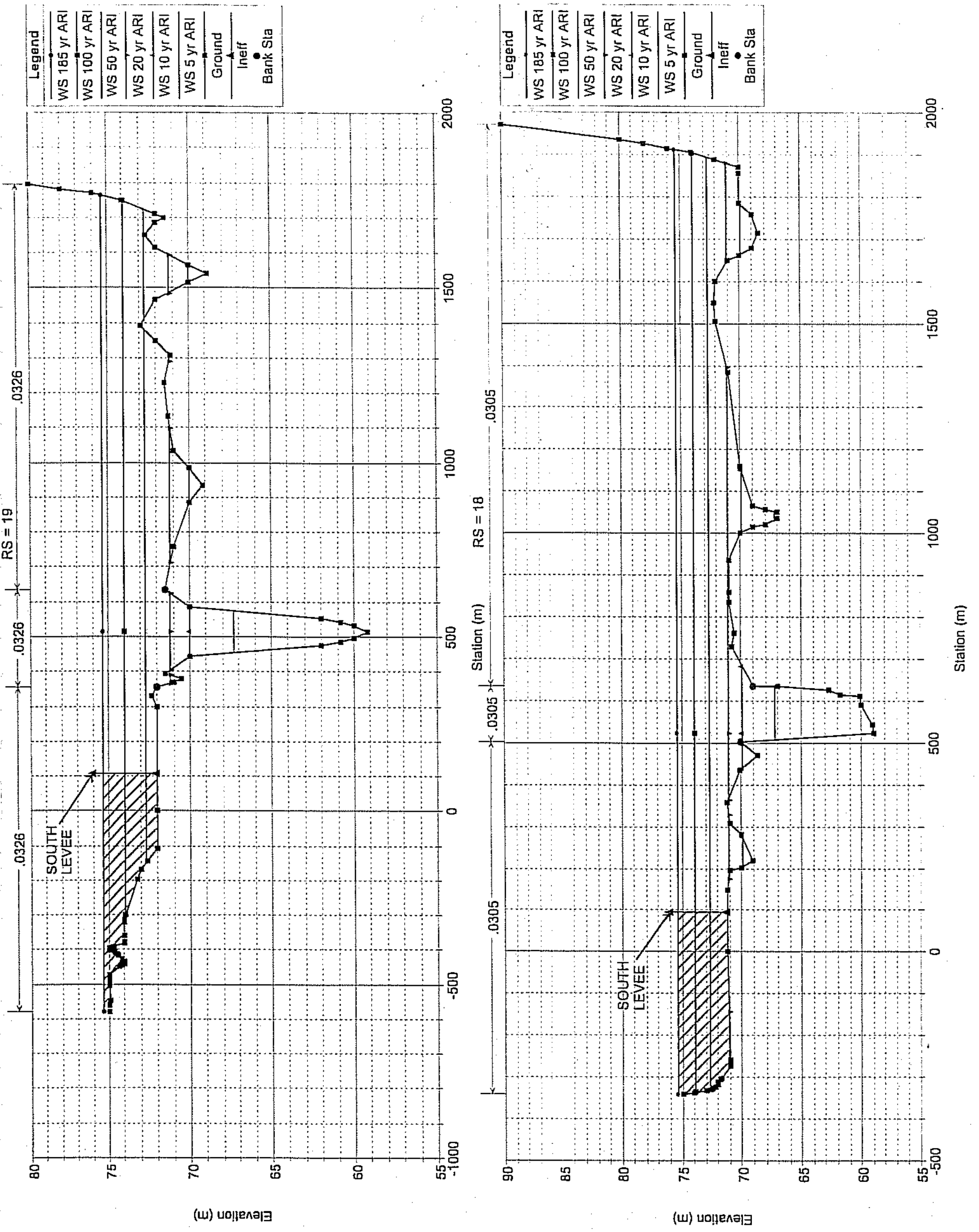
CARRINGTON MINE EXTENSION:
HYDRAULIC ANALYSIS OF HUNTER RIVER
Figure 3.4
LEVEE 5 - 100 YEAR ARI WATER SURFACE CONTOURS



CARRINGTON MINE EXTENSION
HYDRAULIC ANALYSIS OF HUNTER RIVER

Figure 3.5

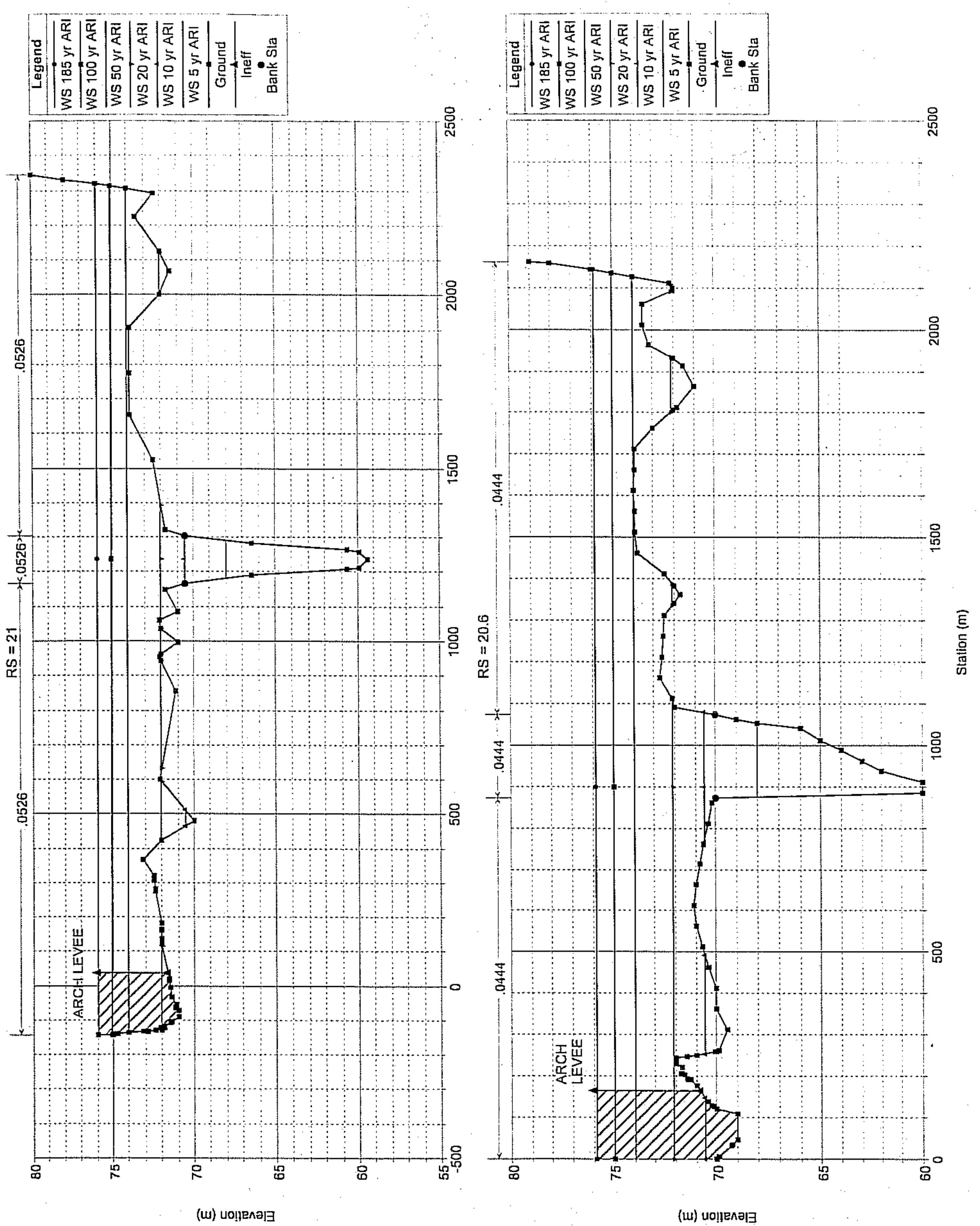
HEC-RAS MODEL WATER SURFACE PROFILES



CARRINGTON MINE EXTENSION
HYDRAULIC ANALYSIS OF HUNTER RIVER

Figure 3.6

HEC-RAS MODEL CROSS SECTIONS
AT SOUTH LEVEE



CARRINGTON MINE EXTENSION
HYDRAULIC ANALYSIS OF HUNTER RIVER

Figure 3.7

HEC-RAS MODEL CROSS SECTIONS
AT ARCH LEVEE

4 CREST LEVELS OF PROPOSED LEVEES

4.1 Considerations for Setting Crest Levels

Selection of the crest levels of the levees depend on factors such as the economic consequences of their being overtopped by floods greater than the hydrologic standard adopted and safety considerations. There is a well developed and tested flood warning system in the Hunter Valley which should provide sufficient warning time for the evacuation of plant and personnel. Provided that operation of the mine is integrated with the warning system, safety considerations should not be the major determinant in the setting of levee crests.

It is understood that the minimum design standard envisaged for the levees will be 100 years ARI. Such a standard would yield a 1 per cent chance of the levee being overtopped in any one year over its design life. It is understood that the operational life of the South Levee will be 6 years (2006 to 2012) and 3 years for the other levees (2006 to 2009). The chances of overtopping over their operational lives would be 6 per cent and 3 per cent respectively.

The economic assessment of the impacts of overtopping is outside the scope of the present investigation. However, to assist the designers with setting the levee standard, hydraulic analysis was undertaken of a flood larger than the 100 year ARI event. For this purpose, a discharge of 12,500 m^3/s was modelled. This discharge had been modelled by FESWMS in the 1992 investigations and consequently, starting water levels were available for use as the downstream boundary condition of the HEC-RAS model. It was estimated to have a return period of 1 in 185 years.

4.2 Design Flood and Crest Levels

Table 4.1 shows the estimated peak water levels at the proposed levees and crest levels applicable to the two alternative design return periods. The South Levee lies within the extent of the FESWMS model and consequently, results from that model have been adopted in lieu of the one-dimensional approach incorporated in HEC-RAS. The Archaeology Levee is upstream of the area modelled by FESWMS and therefore the HEC-RAS results have been used for that levee.

When setting crest levels of protective levees, it is usual practice to provide a "freeboard" allowance to the design flood levels to allow for factors such uncertainties in the estimation of design flow and the accuracy of the converting of flows to flood levels, as well as local effects on flooding patterns and wave action. Whilst freeboard allowances of 300 to 500 mm are common practice, there are no definitive guidelines. Each case should be decided on its merits bearing in mind the risk of the levee being overtopped, and the consequences of levee being overtopped by a sufficient depth to result in failure by scour.

For the present case a freeboard of 1 metre is recommended. This freeboard is similar to the value adopted in the design of Levee 5.

TABLE 4.1
RECOMMENDED CREST LEVELS OF PROPOSED LEVEES

	100 year ARI Hydrologic Standard		185 year ARI Hydrologic Standard	
	Flood Level m AHD	Crest Level m AHD	Flood Level m AHD	Crest Level m AHD
South Levee				
upstream end	74.5	75.5	75.5	76.5
downstream end	74.0	75.0	75.3	76.3
Gully Levee	75.0	76.0	76.0	77.0
Archaeology Levee				
upstream end	75.2	76.2	76.2	77.2
downstream end	75.0	76.0	76.0	77.0

Note: 1 metre of freeboard adopted for levee crest.

5 REFERENCES

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LMCE (1992a), ***"Hunter Valley No. 1 Mine, Possible Extension into Hunter River Floodplain, Additional Hydraulic Studies"***. Report prepared by Lyall & Macoun Consulting Engineers for C&A Operations Pty Limited, January.

LMCE (1992b), ***"Hunter Valley No. 1 Mine, Possible Extension into Hunter River Floodplain, 2-Dimensional Hydraulic Modelling of Levee Arrangements"***. Report prepared by Lyall & Macoun Consulting Engineers for C&A Operations Pty Limited, January.

LMCE (1992c), ***"Hunter Valley No. 1 Mine, Possible Extension into Hunter River Floodplain, 2-Dimensional Hydraulic Modelling of Levee Arrangements – ADDENDUM – Additional 2-Dimensional Modelling"***. Report prepared by Lyall & Macoun Consulting Engineers for C&A Operations Pty Limited, September.

LMCE (1996), ***"Hydraulic Investigation of New Bridge on MR213 at Bowmans Crossing"***. Report prepared by Lyall & Macoun Consulting Engineers for RTA.

Snowy Mountains Engineering Corporation (1987), ***"Flood Study for Hunter Valley No. 1 Mine"***. Report prepared for Coal and Allied Operations Pty Ltd.

APPENDIX A

PRESENT DAY AND POST-LEVEE

FLOOD LEVELS AND FLOODING PATTERNS

CARRINGTON MINE EXTENSION
COMPARISON OF SHORT HEC-RAS MODEL RESULTS
DOWNSTREAM STARTING SLOPE = 0.0005

				PRE-LEVEE CONDITIONS - FULL EXTENT OF CROSS SECTION AVAILABLE FRO FLOW							POST-LEVEE CONDITIONS - FULL EXTENT OF CROSS SECTION AVAILABLE FRO FLOW							DIFFERENCE						
Reach	River Sta	Profile	Q Total (m3/s)	W.S. Elev (m)	Q Left (m3/s)	Q Channel (m3/s)	Q Right (m3/s)	Vel Left (m/s)	Vel Chnl (m/s)	Vel Right (m/s)	W.S. Elev (m)	Q Left (m3/s)	Q Channel (m3/s)	Q Right (m3/s)	Vel Left (m/s)	Vel Chnl (m/s)	Vel Right (m/s)	W.S. Elev (m)	Q Left (m3/s)	Q Channel (m3/s)	Q Right (m3/s)	Vel Left (m/s)	Vel Chnl (m/s)	Vel Right (m/s)
1	34	5 yr ARI	1500	73.1		1500			2.18		73.1		1500			2.18		0	0	0	0	0	0	0
1	34	10 yr ARI	2600	74.96		2600			2.31		74.96		2600			2.31		0	0	0	0	0	0	0
1	34	20 yr ARI	4000	76.3	0.08	3939.32	60.6	0.24	2.66	0.51	76.3	0.08	3939.26	60.66	0.24	2.66	0.51	0	0	-0.06	0.06	0	0	0
1	34	50 yr ARI	7300	77.84	11.45	6228.35	1060.2	0.85	3.33	1.03	77.84	11.46	6227.52	1061.01	0.85	3.32	1.03	0	0.01	-0.83	0.81	0	-0.01	0
1	34	100 yr ARI	10000	78.79	34.9	7341.39	2623.71	1.19	3.46	1.31	78.79	34.92	7339.92	2625.16	1.19	3.46	1.31	0	0.02	-1.47	1.45	0	0	0
1	34	185 yr ARI	12500	79.58	60.37	8027.63	4412	1.36	3.44	1.54	79.59	60.42	8024.66	4414.93	1.36	3.44	1.54	0.01	0.05	-2.97	2.93	0	0	0
1	33	5 yr ARI	1500	72.57		1500			1.93		72.57		1500			1.93		0	0	0	0	0	0	0
1	33	10 yr ARI	2600	74.63		2564.23	35.77		2.02	0.42	74.63		2564.29	35.71		2.02	0.42	0	0	0.06	-0.06	0	0	0
1	33	20 yr ARI	4000	76.01	0	3668.15	331.86	0.01	2.28	0.68	76.01	0	3668.2	331.8	0.01	2.28	0.68	0	0	0.05	-0.06	0	0	0
1	33	50 yr ARI	7300	77.6	4.41	5365.94	1929.65	0.57	2.68	1.01	77.6	4.41	5364.81	1930.77	0.57	2.68	1.01	0	0	-1.13	1.12	0	0	0
1	33	100 yr ARI	10000	78.59	15.37	6256.62	3728.02	0.77	2.78	1.24	78.59	15.38	6255.26	3729.35	0.77	2.78	1.24	0	0.01	-1.36	1.33	0	0	0
1	33	185 yr ARI	12500	79.4	30.11	6923.42	5546.47	0.9	2.83	1.41	79.4	30.15	6920.82	5549.03	0.9	2.83	1.41	0	0.04	-2.6	2.56	0	0	0
1	32	5 yr ARI	1500	72.26		1500			1.54		72.26		1500			1.54		0	0	0	0	0	0	0
1	32	10 yr ARI	2600	74.54		2569.73	30.27		1.36	0.29	74.54		2569.79	30.21		1.36	0.29	0	0	0.06	-0.06	0	0	0
1	32	20 yr ARI	4000	75.96		3642.09	357.91		1.46	0.51	75.96		3641.94	358.06		1.46	0.51	0	0	-0.15	0.15	0	0	0
1	32	50 yr ARI	7300	77.56	4.6	5648.56	1646.84	0.4	1.77	0.85	77.56	4.61	5647.8	1647.59	0.4	1.77	0.85	0	0.01	-0.76	0.75	0	0	0
1	32	100 yr ARI	10000	78.53	17.09	7066	2916.91	0.57	1.95	1.08	78.53	17.11	7065.17	2917.72	0.57	1.95	1.08	0	0.02	-0.83	0.81	0	0	0
1	32	185 yr ARI	12500	79.32	35.37	8289.2	4175.42	0.69	2.09	1.25	79.33	35.43	8287.5	4177.07	0.69	2.09	1.25	0.01	0.06	-1.7	1.65	0	0	0
1	31	5 yr ARI	1500	72.02		1500			1.6		72.02		1500			1.6		0	0	0	0	0	0	0
1	31	10 yr ARI	2600	74.35	0.1	2566.53	33.37	0.16	1.77	0.32	74.35	0.1	2566.61	33.3	0.16	1.77	0.32	0	0	0.08	-0.07	0	0	0
1	31	20 yr ARI	4000	75.74	7.39	3642.56	350.05	0.49	2.06	0.65	75.74	7.39	3642.39	350.22	0.49	2.06	0.65	0	0	-0.17	0.17	0	0	0
1	31	50 yr ARI	7300	77.21	45.51	5852.45	1402.04	0.92	2.77	1.12	77.21	45.55	5851.43	1403.02	0.92	2.77	1.12	0	0.04	-1.02	0.98	0	0	0
1	31	100 yr ARI	10000	78.11	91.77	7319.69	2588.54	1.16	3.15	1.49	78.11	91.83	7318.51	2589.66	1.16	3.15	1.49	0	0.06	-1.18	1.12	0	0	0
1	31	185 yr ARI	12500	78.86	147.45	8556.37	3796.18	1.38	3.42	1.77	78.86	147.6	8553.83	3798.58	1.38	3.42	1.77	0	0.15	-2.54	2.4	0	0	0
1	30	5 yr ARI	1500	71.27		1500			3.38		71.27		1500			3.38		0	0	0	0	0	0	0
1	30	10 yr ARI	2600	73.42		2534.74	65.26		4.02	0.68	73.42		2535.01	64.99		4.02	0.66	0	0	0.27	-0.27	0	0	0
1	30	20 yr ARI	4000	75.03	10.26	3121.29	868.45	0.65	3.99	1.26	75.03	10.29	3120.45	869.26	0.65	3.99	1.26	0	0.03	-0.84	0.81	0	0	0
1	30	50 yr ARI	7300	76.59	119.68	4122.47	3057.85	1.19	4.43	1.86	76.6	119.97	4119.27	3060.76	1.19	4.42	1.86	0.01	0.29	-3.2	2.91	0	-0.01	0
1	30	100 yr ARI	10000	77.57	270.02	4685.61	5044.38	1.44	4.58	2.22	77.57	270.34	4683.21	5046.45	1.44	4.57	2.22	0	0.32	-2.4	2.07	0	-0.01	0
1	30	185 yr ARI	12500	78.37	451.43	5148.98	6899.59	1.62	4.68	2.47	78.37	452.21	5144.81	6902.97	1.62	4.68	2.47	0	0.78	-4.17	3.38	0	0	0
1	29	5 yr ARI	1500	70.79		1500			2.75		70.79		1500			2.75		0	0	0	0	0	0	0
1	29	10 yr ARI	2600	73.13	3.24	2354.14	242.62	0.38	2.99	0.9	73.13	3.21	2354.59	242.2	0.38	3	0.9	0	-0.03	0.45	-0.42	0	0.01	0
1	29	20 yr ARI	4000	74.8	170.7	2915.31	913.99	0.61	3.03	1.16	74.8	171.08	2914.39	914.52	0.61	3.03	1.16	0	0.38	-0.92	0.53	0	0	0
1	29	50 yr ARI	7300	76.36	1177.41	3808.12	2314.48	1.12	3.38	1.62	76.36	1180.02	3804.35	2315.64	1.12	3.38	1.62	0	2.61	-3.77	1.16	0	0	0
1	29	100 yr ARI	10000	77.36	2267.8	4306.31	3425.9	1.43	3.5	1.85	77.36	2269.77	4303.65	3426.57	1.42	3.5	1.85	0	1.97	-2.66	0.67	-0.01	0	0
1	29	185 yr ARI	12500	78.18	3336.93	4723.9	4439.17	1.64	3.59	2.02	78.18	3340.3	4719.61	4440.09	1.64	3.58	2.02	0	3.37	-4.29	0.92	0	-0.01	0
1	28	5 yr ARI	1500	70.46		1500			2.33		70.46		1500			2.33		0	0	0	0	0	0	0
1	28	10 yr ARI	2600	72.81		2600			2.69		72.81		2600			2.69		0	0	0	0	0	0	0
1	28	20 yr ARI	4000	74.28	130.75	3841.11	28.14	0.43	3.24	0.34	74.29	132.2	3839.11	28.69	0.43	3.24	0.35	0.01	1.45	-2	0.55	0	0	0.01
1	28	50 yr ARI	7300	76.13	2113.4	4461.88	724.72	1.15	3.06	1.09	76.13	2117.97	4455.57	726.47	1.15	3.05	1.09	0	4.57	-6.31	1.75	0	-0.01	0
1	28	100 yr ARI	10000	77.18	3762.02	4906.44	1331.54	1.38	3.03	1.31	77.18	3764.73	4902.64	1332.63	1.38	3.03	1.31	0	2.71	-3.8	1.09	0	0	0
1	28	185 yr ARI	12500	78.03	5287.8	5310.29	1901.91	1.54	3.05	1.46	78.04	5291.84	5304.52	1903.64	1.53	3.04	1.46	0.01	4.04	-5.77	1.73	-0.01	-0.01	0
1	27	5 yr ARI	1500	70.08		1500			2.14		70.08		1500			2.14		0	0	0	0	0	0	0
1	27	10 yr ARI	2600	72.49	15.68	2584.32		0.32	2.4		72.49	15.5	2584.5		0.32	2.4		0	-0.18	0.18	0	0	0	0
1	27	20 yr ARI	4000	74.08	468.58	3381.79	149.63	0.73	2.51	0.47	74.09	470.4	3378.8	150.79	0.73	2.51	0.47	0.01	1.82	-2.99	1.16	0	0	0
1	27	50 yr ARI	7300	75.96	1851.88	4133.44	1314.69	1.15	2.48	0.87	75.97	1854.08	4128	1317.92	1.15	2.48	0.87	0.01	2.2	-5.44	3.23	0	0	0
1	27	100 yr ARI	10000	77.03	2808.75	4677.98	2513.27	1.28	2.54	1.08	77.03	2809.66	4674.48	2515.87	1.28	2.53	1.08	0	0.91	-3.5	2.6	0	-0.01	0
1	27	185 yr ARI	12500	77.89	3690.65	5142.37	3666.98	1.37	2.59	1.22	77.89	3692.01	5136.96	3671.03	1.37	2.58	1.22	0	1.36	-5.41	4.05	0	-0.01	0
1	26	5 yr ARI	1500	69.74		1500			1.95		69.74		1500			1.95		0	0	0	0	0	0	0
1	26	10 yr ARI	2600	72.26	0.39	2490.34	109.27	0.19	2.05	0.37	72.26	0.38	2491.52	108.1	0.19	2.05	0.37	0	-0.01	1.18	-1.17	0	0	0
1	26	20 yr ARI	4000	73.98	34.48	2857.83	1107.69	0.44	1.85	0.75	73.98	34.64	2855.6	1109.76	0.44	1.85	0.75	0	0.16	-2.23	2.07	0	0	0
1	26	50 yr ARI	7300	75.81	204.5	3979.41	3116.09	0.53	2.1	1.13	75.82	205.82	3975.31	3118.87	0.53	2.09	1.12	0.01	1.32	-4.1	2.78	0	-0.01	-0.01
1	26	100 yr ARI	10000	76.85	548.46	4761.63	4689.91	0.74	2.27	1.33	76.86	549.75	4758.75	4691.5	0.74	2.27	1.33	0.01	1.29	-2.88	1.59	0	0	0
1	26	185 yr ARI	12500	77.7	944.53	5414.71	6140.76	0.89	2.4	1.48	77.71	946.97	5410.02	6143.01	0.89	2.39	1.48	0.01	2.44	-4.69	2.25	0	-0.01	0
1	25	5 yr ARI	1500	69.52	0.64	1499.36		0.3	1.54		69.52	0.64	1499.36		0.3	1.54		0	0	0	0	0	0	0
1	25	10 yr ARI	2600	72.08	18.28	2571.2	10.51	0.53	1.79	0.45	72.08	18.22	2571.32	10.45	0.54	1.79	0.45	0	-0.06	0.12	-0.06	0.01	0	0
1	25	20 yr ARI	4000	73.7	165.23	3778.26	56.52	0.6	2.18	0.86	73.7	165.89	3777.47	56.64	0.6	2.18	0.86	0	0.66	-0.79	0.12	0	0	0
1	25	50 yr ARI	7300	75.27	771.44	6361.52	167.05	0.95	3.16	1.48	75.28	775.55	6357.09	167.36	0.95	3.15	1.48	0.01	4.11	-4.43	0.31	0	-0.01	0
1	25	100 yr ARI	10000	76.15	1601.88	8135.24	262.88	1.28	3.74	1.86	76.16	1607.27	8129.63	263.09	1.28	3.73	1.86	0.01	5.39	-5.61	0.21	0	-0.01	0
1	25	185 yr ARI	12500	76.92	2665.14	9481.78	353.08	1.59	4.09	2.1	76.93	2675.29	9471.28	353.44	1.59	4.09	2.1	0.01	10.15	-10.5	0.36	0	0	0
1	24	5 yr ARI	1500	69.13	42.25	1447.59	10.16	0.69	2.3	0.86	69.13	42.25	1447.59	10.16	0.69	2.3	0.86	0	0	0	0	0	0	0
1	24	10 yr ARI	2600	71.79	399.45	2152.99	47.56	1.08	2.44	0.98	71.79	398.84	2153.67	47.49	1.08	2.44	0.98	0	-0.61	0.68	-0.07	0	0	0
1	24	20 yr ARI	4000	73.39	918.3	2971.63	110.07	0.93	2.86	1.26	73.4	921.15	2968.69	110.16	0.93	2.86	1.26	0.01	2.85	-2.94	0.09	0	0	0
1	24	50 yr ARI	7300	74.99	2811.96	4259.3	228.74	1.51	3.58	1.69	75	2819.15	4251.95	228.9	1.51	3.57	1.68	0.01	7.19	-7.35	0.16	0	-0.01	-0.01
1	24	100 yr ARI	10000	75.84	4466.49	5205.88	327.63	1.91	4.09	1.98	75.85	4472.27	5199.96	327.78	1.91	4.08	1.98	0.01	5.78	-5.92	0.15	0	-0.01	0

5084.72	5989.52	425.76	2.2	4.46	2.2	76.59	6093.87	5980.04	426.1	2.2	4.44	2.2	0.01	9.15	-9.48	0.34	0	-0.02	0
	1500			2.2		68.98		1500			2.2		0	0	0	0	0	0	0
19.01	2572.42	8.57	0.48	2.45	0.57	71.62	18.83	2572.67	8.5	0.48	2.45	0.57	0	-0.18	0.25	-0.07	0	0	0
371.76	3558.73	69.51	0.7	2.77	0.78	73.23	374.38	3555.74	69.88	0.7	2.77	0.78	0.01	2.62	-2.99	0.37	0	0	0
1865.65	5154.58	279.77	1.18	3.41	1.26	74.8	1878.31	5140.56	281.13	1.18	3.4	1.26	0.01	12.66	-14.02	1.36	0	-0.01	0
3405.29	6120.49	474.22	1.51	3.74	1.54	75.66	3414.64	6110.14	475.22	1.51	3.73	1.54	0.01	9.35	-10.35	1	0	-0.01	0
5012.22	6819.67	668.11	1.75	3.9	1.71	76.43	5027.98	6802.43	669.59	1.74	3.89	1.71	0.02	15.76	-17.24	1.48	-0.01	-0.01	0
	1500			2.46		68.45		1500			2.46		0	0	0	0	0	0	0
34.96	2557.86	7.18	0.66	2.94	0.36	71.02	34.6	2558.41	6.99	0.66	2.94	0.36	-0.01	-0.36	0.55	-0.19	0	0	0
295.74	3480.57	223.69	0.77	3.25	0.86	72.65	300.03	3473.68	226.29	0.77	3.24	0.86	0.01	4.29	-6.89	2.6	0	-0.01	0
1836.9	4527.94	935.16	1.22	3.5	1.03	74.35	1857.56	4490.01	952.43	1.21	3.46	1.03	0.03	20.66	-37.93	17.27	-0.01	-0.04	0
3269.34	4785.08	1945.58	1.44	3.37	1.29	75.31	3278.56	4767.27	1954.17	1.43	3.35	1.29	0.02	9.22	-17.81	8.59	-0.01	-0.02	0
4594.3	4989.83	2915.88	1.56	3.26	1.44	76.15	4605.48	4967.97	2926.55	1.55	3.24	1.43	0.02	11.18	-21.86	10.67	-0.01	-0.02	-0.01
	1500			1.78		68.34		1500			1.78		0	0	0	0	0	0	0
	2600			2.15		70.91		2600			2.16		0	0	0	0	0	0.01	0
117.46	3803.37	79.17	0.37	2.59	0.5	72.43	124.16	3794.56	81.28	0.37	2.57	0.5	0.01	6.7	-8.81	2.11	0	-0.02	0
1971.33	4518.8	809.87	0.88	2.53	0.69	74.18	1996.15	4474.02	829.83	0.87	2.5	0.69	0.03	24.82	-44.78	19.96	-0.01	-0.03	0
3477.15	4737.41	1785.44	1.03	2.41	0.88	75.16	3487.51	4717.31	1795.19	1.03	2.39	0.88	0.02	10.36	-20.1	9.75	0	-0.02	0
4855.6	4913.14	2731.25	1.11	2.31	0.99	76.03	4867.28	4889.49	2743.24	1.11	2.3	0.99	0.02	11.68	-23.65	11.99	0	-0.01	0
	1500			2.32		68.02		1500			2.32		0	0	0	0	0	0	0
3.84	2596.16	0	0.31	2.7	0.05	70.53	3.7	2596.3	0	0.31	2.71	0.05	-0.01	-0.14	0.14	0	0	0.01	0
305.34	3672.9	21.76	0.58	3.16	0.34	71.98	251.77	3727.6	20.63	0.6	3.22	0.34	-0.01	-53.57	54.7	-1.13	0.02	0.06	0
2907.29	3682.53	710.18	0.95	2.56	0.6	74	2613.92	3940.57	745.52	1.01	2.74	0.64	-0.02	-293.37	258.04	35.34	0.06	0.18	0.04
4577.21	3683.32	1739.47	1.04	2.33	0.78	75.05	4187.86	3956	1856.13	1.11	2.5	0.84	-0.01	-389.35	272.68	116.66	0.07	0.17	0.06
5040.86	3733.28	2725.87	1.09	2.19	0.88	75.95	5565.21	4006.41	2928.38	1.16	2.35	0.94	0.01	-475.65	273.13	202.51	0.07	0.16	0.06
	1500			1.76		68		1500			1.76		0	0	0	0	0	0	0
156.08	2443.5	0.43	0.46	1.8	0.23	70.58	56.31	2543.3	0.39	0.35	1.89	0.23	-0.02	-99.77	99.8	-0.04	-0.11	0.09	0
986.03	2970.96	43.02	0.65	1.76	0.32	72.12	703.81	3253.14	43.05	0.65	1.96	0.34	-0.04	-282.22	282.16	0.03	0	0.2	0.02
2939.6	3781.88	578.52	0.94	1.82	0.45	73.99	2451.56	4220.32	628.12	1.02	2.08	0.5	-0.03	-488.04	438.44	49.6	0.08	0.26	0.05
4230.35	4247.93	1521.73	1.06	1.86	0.65	75.01	3610.49	4716.79	1672.72	1.15	2.11	0.72	-0.02	-619.86	468.86	150.99	0.09	0.25	0.07
5374.04	4602.32	2523.64	1.13	1.86	0.77	75.9	4638.07	5070.88	2791.05	1.23	2.1	0.85	-0.01	-735.97	468.56	267.41	0.1	0.24	0.08
	1500			2.25		67.75		1500			2.25		0	0	0	0	0	0	0
	2600			2.25		70.4		2600			2.25		0	0	0	0	0	0	0
	3981.95	18.05		2.76	0.4	71.78		3981.95	18.06		2.76	0.4	0	0	0	0.01	0	0	0
0.32	6408.39	891.29	0.48	3.54	0.99	73.44	0.33	6399.23	900.44	0.48	3.53	0.99	0.02	0.01	-9.16	9.15	0	-0.01	0
1.34	7608.15	2390.51	0.67	3.73	1.27	74.46	1.35	7597.52	2401.13	0.67	3.72	1.27	0.01	0.01	-10.63	10.62	0	-0.01	0
2.98	8021.66	4475.37	0.75	3.54	1.51	75.48	3.01	7993.16	4503.84	0.74	3.52	1.5	0.02	0.03	-28.5	28.47	-0.01	-0.02	-0.01
	1500			2.26		67.54		1500			2.26		0	0	0	0	0	0	0
	2600			2.51		70.17		2600			2.51		0	0	0	0	0	0	0
	3987.28	12.72		3.19	0.44	71.42		3987.27	12.73		3.19	0.44	0	0	-0.01	0.01	0	0	0
0.28	6907.35	392.37	0.53	4.75	0.97	72.57	0.31	6889.28	410.41	0.54	4.72	0.97	0.03	0.03	-18.07	18.04	0.01	-0.03	0
3.36	8410.27	1586.38	1	5.16	1.39	73.58	3.6	8342.9	1653.5	1	5.09	1.38	0.06	0.24	-67.37	67.12	0	-0.07	-0.01
15.45	7768.73	4715.82	1.11	4.02	1.63	75.23	15.68	7727.69	4756.63	1.11	3.99	1.63	0.03	0.23	-41.04	40.81	0	-0.03	0
	1500			2.22		67.35		1500			2.22		0	0	0	0	0	0	0
	2573.88	26.12		2.5	0.4	69.98		2573.88	26.12		2.5	0.4	0	0	0	0	0	0	0
	3636.42	363.58		2.9	0.87	71.19		3636.38	363.62		2.9	0.87	0	0	-0.04	0.04	0	0	0
221.23	4908.74	2170.03	0.68	2.95	1.26	72.7	115.34	4973.61	2211.05	0.7	2.99	1.27	0.01	-105.89	64.87	41.02	0.02	0.04	0.01
936.05	4990.85	4073.1	0.91	2.49	1.32	73.92	503.63	5232.19	4264.18	1.07	2.61	1.38	-0.01	-432.42	241.34	191.08	0.16	0.12	0.06
1882.17	4807.69	5810.13	0.85	2	1.23	75.37	957.09	5233.13	6309.78	1.16	2.17	1.34	-0.01	-925.08	425.44	499.65	0.31	0.17	0.11
	1499.23	0.77		1.8	0.18	67.24		1499.23	0.77		1.8	0.18	0	0	0	0	0	0	0
21.01	2437.21	141.78	0.33	2.06	0.48	69.91	21.01	2437.21	141.78	0.33	2.06	0.48	0	0	0	0	0	0	0

Annex D

Groundwater & Surface Water Assessment & Associated Peer Review

COAL & ALLIED
CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES
SEPTEMBER 2005

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EXECUTIVE SUMMARY

Groundwater and surface water management studies have been conducted in respect of proposed extensions to mining at Carrington. The studies have included a review of findings provided in the Carrington Environmental Impact Statement (1999) and subsequent reports. Groundwater related studies have included aquifer numerical model re-design and calibration, computer simulations of pit development including recovery of water levels-pressures post mining. Surface water related studies have included an assessment of changes to the runoff regime and a review of mine water management systems.

Previous groundwater studies identified two saline aquifer systems. These included moderate to high hydraulic conductivity aquifer materials contained within an ancient alluvial palaeo channel, and relatively low conductivity aquifers contained within the underlying coal measures. Installation of a large number of additional piezometers since mining commenced in 2001, has confirmed the initial hydrogeologic model adopted for the palaeo channel aquifer and facilitated improved mapping of the geometry and hydraulic properties of the channel. Routine monitoring of water levels and basic hydrochemical parameters has confirmed a generally saline groundwater system with little or no rainfall recharge in recent years.

Water levels within the alluvial aquifer have steadily declined in both the west and east alluvial channels as a result of mining and the prevailing drought conditions over the last three or four years. Numerical model re-calibration against these declining trends has resulted in a re-defined hydraulic conductivity distribution that reflects the presence of high conductivity braids probably associated with cleaner gravels, contained within a lower conductivity (more silty) matrix.

Computer simulation of mining operations to the currently approved extents, indicates groundwater levels within the alluvium would continue to decline. Seepage to the mine pit via the alluvium is predicted to stabilize at about 0.2ML/day assuming drought conditions prevail. This rate is predicted to rise to 0.3ML/day for proposed southward extensions to mining. While the existing hydraulic gradient is southward and saline seepage is currently migrating to the Hunter River, a reversal of this gradient is predicted by 2007 after which time, leakage from the Hunter River to the alluvium would commence. Leakage can be mitigated by installation of ‘cut off’ walls across the palaeo channel. Such walls would also inhibit long term leakage of leachate from the spoils emplaced within the mine void, southward into the undisturbed alluvium.

Simulations of cut off walls constructed in the east and west channels indicate a need to key the walls into the underlying consolidated coal measures strata to ensure contact with consolidated strata, and to construct the walls to an elevation of at least 65mAHD. Groundwater levels to the south of the walls would then rise slightly in response to isolation of mine dewatering and to rainfall recharge over time. A weak southward hydraulic gradient would be re-established south of the installed walls.

Simulation of mining operations to the proposed new mine extents south and east of the approved extents, indicates only small differences in water levels and pit seepage rates (when cut off walls are constructed), when compared to mining operations to the currently approved extents. Predicted river seepage and leakage rates are almost identical in the east channel while west channel conditions are unchanged.

Regional computer model simulations incorporating mine development at West Pit and North Pit demonstrate coal measures aquifers at Carrington will depressurise to a depth of about 70 metres over the mining period to at least 2011. The depressurisation regimes for both the approved and extended mining scenarios, do not differ significantly at the model scale. Pit seepage rates attributed to storage depletion within the coal measures, would rise to about 0.45ML/day at the completion of mining. Thus a total pit seepage rate of 0.65ML/day is predicted for the currently approved mining extents (alluvium plus coal measures), while

0.75ML/day is predicted for the proposed new extents. Leakage rates from the regional alluvial lands to the mine pit via the coal measures, are calculated to be less than 0.01ML/day for the approved and proposed extents respectively.

On cessation of mining, two scenarios have been identified for pit closure – an open water void above emplaced materials that would generate an evaporative sink over an elevation range of 40 to 45mAHD, or a filled reshaped pit without an open water void but with a depression designed to facilitate evapotranspiration at an elevation above 45mAHD. The latter would host high transpiration tree species with a significantly reduced tendency for evaporative concentration of salts when compared to open water conditions. Computer model simulations indicate groundwater levels within the mine pit (emplaced spoils) will be slow to recover with more than 100 years predicted for equilibration of the final void water level. The equilibrated level for an open water void is below the prevailing river level and results from a combination of processes including direct rainfall to the open void, rainfall infiltration-percolation through spoils within the pit void regional groundwater seepage from the underlying coal measures, and evaporative losses from the open water surface. Final design would be based on the most up to date research at the time of closure since each design offers a different outcome in respect of long term void water quality. Negligable seepage is predicted to occur from the palaeo channel alluvium through the cut off walls into the pit void.

Leachate generated by water-rock interactions within the final void would be contained within the void. Water quality is predicted to be in the range 4000 to 6000mg/l. Speciation is predicted to be dominated by bi-carbonate ions – Na>Mg>Ca and HCO_3>Cl>SO_4. This range of dissolved solids is similar to that currently prevailing within the palaeo channel. However the current water quality is dominated by primary salinity (NaCl).

Extended mining will temporarily remove catchment runoff from an area of about 60ha in the east channel. This runoff currently enters a local un-named drainage and either recharges the alluvium or flows into the Hunter River via a billabong. The runoff would be restored by 2014 following reshaping of spoils and the final void area. However the final void may also attract runoff from an area as large as 290ha resulting in long term loss (of runoff) to the river. For median conditions and typical catchment parameters this would equate to about 109ML/annum or 0.4% of the ten percentile regulated (low) flow in the river.

Review of the mine water management system indicates a small deficit during dry and drought periods due to the relatively low rates of seepage to the mine pit. This deficit is currently met through staging storage within the wider CNA water sharing system linking operations between West Pit, North Pit and South Pit. A surplus is expected to prevail during wet years. This surplus can also be managed through the available storage. There would be no significant change in pit water seepage or runoff entering Carrington Pit for the proposed extended mining scenario. Dam 9N which currently receives all pumped water from the mine pit, would be relocated to the south-east of its current position. The dam would continue to receive pit water. Sedimentation Dam 12N would be destroyed (as originally planned) without impact on the mine water system. Sedimentation Dam 13N would be enlarged following closure and a number of additional temporary sedimentation dams constructed to manage ruoff from the final landform.

Coal & Allied propose to maintain the existing environmental monitoring programme throughout the mine life and during any aftercare period. Monitoring would include routine measurement of groundwater pressures-levels and groundwater quality parameters in existing and new piezometers, and surface water pumpage, storage and water quality parameters in accordance with current schedules.

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1. INTRODUCTION

In May 1999, Coal & Allied (CNA) completed an Environmental Impact Statement addressing the development of Carrington Mine situated immediately to the west of Hunter Valley Operations North Pit. The new mine site provided for coal extraction down to and including the Bayswater seam with mining progressing in a southward direction for a distance of about 1.8 kilometres from the subcropping Bayswater seam. Approximately 290ha of alluvium and overburden were scheduled to be extracted over a period of more than 7 years with spoils being emplaced up dip of the mining face and subsequently re-shaped and re-habilitated.

Mackie Environmental Research (MER) prepared an issue paper examining the impacts on the groundwater and surface water regimes. That paper was referenced in the EIS (MER, 1999). Findings supported a dual aquifer system comprising permeable alluvium contained within an ancient palaeochannel, overlying relatively impermeable coal measures. Mining required pre stripping of the alluvium in such a manner as to induce slow gravity drainage of groundwater from the unconsolidated silts, sands and gravels. Groundwater seepage was predicted to occur at an increasing rate during early years of mining peaking at a little over 2ML/day after 2 years and declining during later years of mining to a rate of about 1.4ML/day.

Surface water and water management impacts were noted to be temporary and manageable with catchment runoff losses incurred during the term of mining. Restoration of such losses would follow completion of mining and rehabilitation.

Mining has progressed since July 2000 from the northern part of Carrington, in a southward direction as shown on Figure 1. CNA propose to extend the area approved for mining (see Figure 1) by about 60ha in a southward direction including part of the eastern palaeochannel and by about 80ha in an easterly direction within the coal measures. Accordingly, the change to predicted impacts on the groundwater, surface water and water management systems has been considered. Specifically, the 1999 alluvial aquifer groundwater model used to predict impacts of mining on the groundwater systems, has been updated and re-calibrated against measured impacts of mining to-date. This model has then been used to assess groundwater seepage management strategies and to predict future impacts of mining. In addition, a regional coal measures aquifer model has been modified in order to examine the magnitude of leakage to/from the Hunter River induced by deeper coal measures depressurisation. In respect of surface water runoff, the landform has also been amended, catchment impacts reviewed, and the change in contribution of rainfall/runoff to the mine water management system assessed.

This report provides a summary of the predicted change in groundwater and surface water impacts associated with the proposed extension to mining at Carrington.

2. GROUNDWATER HYDROLOGY

Groundwater systems in the Carrington area are best identified in terms of unconsolidated alluvial deposits contained with the ancient palaeochannel, and consolidated coal measures strata that host the palaeochannel and other alluvial deposits adjacent to the Hunter River.

2.1 Unconsolidated alluvial aquifers

Unconsolidated alluvial deposits are composed mostly of alluvial gravels silts and clays that overly the coal measures. These deposits are contained within an ancient meander or palaeochannel of the Hunter River (see Figure 1 for extents). This channel is now broadly defined in terms of the east channel where mining is proposed to be extended southward and eastward, and the west channel where mining is restricted to the northern area known as 'West Wing'. A bedrock high occurs between each channel in the centre of the meander.

The depositional environment within the channel was subjected to frequent flooding and as a result, gravels were deposited contiguously with silts and clays. This generated a variable but silt bound matrix of overbank sediments. Hill slope runoff and sheet wash from surrounding hardrock areas also contributed colluvial deposits in fans and braids.

Many exploration bores and groundwater piezometers have been installed within the palaeochannel prior to and during mining operations. More recent bores support findings from earlier bores and generally confirm the hydrogeological model adopted for the original EIS studies (MER, 1999). That is, alluvial deposits attain thicknesses of the order of 15 to 20 metres. The deepest 5 to 12 metres comprises fine to coarse gravels and cobbles contained within a silty-clayey matrix. This zone is often overlain by 1 or 2 metres of clay which is in turn overlain by shallow sands, silts, clays and surficial loams. Occasional clean clay free sand and gravel braids are noted within the deep clayey gravel matrix. Although connectivity cannot be easily mapped, these zones provide leakage pathways for gravity drainage from the adjacent less permeable strata.

Figure 2 provides a plot showing the base of alluvium and the general geometry of the palaeochannel while Figure 3 provides a north-south vertical section showing the alluvium and the underlying coal measures.

2.1.1 Water table within the alluvium

The alluvium exhibits a saturated thickness ranging from less than 1 metre in northern parts of the channel and in pinch out areas, to more than 7 metres in southern central parts of the channel. The phreatic surface prior to mining was initially monitored at ten piezometer locations known as CGW1 through CGW10 together with a number of open exploration holes. Measurement of water levels on a semi continuous basis indicated minor recharge to the system for low to moderate rainfall periods. This low level of recharge was attributed to the presence of relatively impermeable surficial clays blanketing most of the area. Dry-drought conditions have prevailed since 2001.

Hydraulic gradients pre-mining were noted to support a weak flow from north to south towards the Hunter River (MER, 1999) as indicated by the potentiometric surface plotted on Figure 4.

Since 2000 there have been numerous drilling campaigns to install additional piezometers. Locations of these piezometers were determined through continual re-assessment of dewatering of the alluvium. In all, some 55 locations have been constructed throughout the area and monitoring of both the potentiometric surface and basic water quality parameters (pH and EC) has been maintained to the present time. Figure 4 provides a locality plan showing all piezometers (many have now been mined through) while Figure 5 shows the current potentiometric surface. Appendix A provides a history of monitoring at these locations. Reference to Figure 5 shows both northward and southward hydraulic gradients within the undisturbed areas of alluvium and reflecting flow to the mine pit and the river respectively. Clearly the east channel has been impacted to a greater degree than the west channel.

2.1.2 Hydraulic properties distribution within the alluvium

The hydraulic conductivity distribution within the palaeochannel aquifer has been assessed over a period of 5 years, initially on the basis of hydraulic testing at piezometer locations and subsequently using computer based numerical modelling to develop candidate areas of higher or lower conductivity in accordance with observed impacts of mining. The current distribution is indicated on Figure 6 and is the result of three significant model re-calibrations undertaken in 2002, 2004 and 2005.

The distribution suggests the presence of key drainage pathways within the palaeochannel pre mining. It is suspected however, that these pathways probably comprised a complex network of interconnected transmissive braids of small dimension, hosted within the more silty and clay bound matrix of gravels. The estimated conductivity range is from 1 to 95m/day. Drainable porosity of this system is moderate and reconciled at about 10% from numerical model calibrations.

2.1.3 Groundwater quality within the alluvium

Within the palaeochannel, groundwater salinity is brackish to saline with an electrical conductivity (EC) range typically from 7000 to 11000uS/cm. This poor quality has probably resulted from sustained upwards leakage of coal measures groundwaters into the basal sections of the alluvium. Since mining is now significantly advanced in the Bayswater seam, loss of pressure through direct seam seepage to the mine pit has undoubtedly reduced the rate of upwards leakage. This pressure loss is evident at a number of piezometers within the east and west channels eg. CGW44/A, CGW45/A, CGW47/A, CGW54/A in Appendix A.

Spatial variation in water quality is also reflected in EC measurements recorded at the numerous piezometers. Figure 7 provides a summary plot of average EC values at selected sites. This plot provides little evidence of improved quality groundwater within the east channel nearer the river although it is expected that immediately adjacent to and beneath the river, the salinity will fall rapidly. EC values in the west channel hint at some improvement although this may also be attributed to irrigation. River water salinity is typically 600 to 700uS/cm. pH of groundwater within the alluvium ranges from 6.5 to 7.5.

A number of ionically speciated water samples are summarised on a tri-linear speciation plot in Appendix A. This type of plot comprises two triangular fields representing cations and anions, and a central diamond field. Samples are commonly represented as percentage milli equivalents within the triangular fields where each apex represents 100% of the nominated ion. Plotted positions are then projected into a central diamond field, thereby allowing a generalised classing of groundwaters. Plotted positions of palaeochannel samples support a classing of waters where sodium chloride or primary salinity tends to dominate ie. Na>Mg>Ca and $Cl>HCO_3>SO_4$. This type of water is consistent with coal seam waters that have been monitored over many years throughout the Upper Hunter region. Exceptions are boreholes CGW7 and CGW48 where increased contribution form bicarbonates are noted. These samples may be influenced by irrigation waters.

2.2 Regional hardrock aquifers

The coal measures accessible by open pit mining at Carrington comprise hardrock strata within the Jerrys Plains Subgroup. Seams currently being mined include a number of Broonie seams and the underlying Bayswater seam which represents the floor of the mine pit. The Bayswater seam subcrops in the northern part of the palaeochannel (see Figures 2 and 3). The Archerfield sandstone underlies the Bayswater seam. This unit is regionally extensive and is known to be a moderate to high strength sandstone exhibiting very low hydraulic conductivity. Interburden strata largely comprise sandstones and siltstones with thin claystone-shale beds generally occurring adjacent to the seams. All strata dip gently to the south-east at 2 to 3 degrees.

Aquifers within the coal measures are largely identified with the coal seams and more specifically, those seams or zones within seams where cleating is relatively well developed. Where cleating is undeveloped, the seams may be regarded as aquitards.

Sandstones and siltstones (interburden between seams) may provide groundwater storage through intergranular porosity but the permeability of these strata is generally so low that they cannot be regarded as aquifers and are instead regarded as aquitards or aquicludes. They do however sometimes act as storage zones which can provide leakage to adjacent strata under certain circumstances.

Claystones and shales are regarded as aquicludes that effectively isolate and confine different strata. It is not uncommon to find coal seams that can provide an artesian flow (when penetrated by a borehole) through confinement above and below by claystone strata. Indeed, a flowing borehole sustained a surface spring in the northern area of the palaeochannel prior to commencement of mining. This site has now been mined through.

Jointing also provides an interconnecting network for transmission of groundwater within interburden in areas where bedding flexure occurs or areas where faulting is evident. Typically however, transmission tends to be only weakly enhanced since joints are often discontinuous and/or apertures are either very small or infilled by secondary minerals such as calcite or siderite (carbonates).

2.2.1 Regional phreatic surface

The regional water table surrounding Carrington Pit has been influenced by mining operations in that pit and at West Pit, North Pit and Cumnock underground. These operations have effectively depressurised the hardrock strata firstly through seam horizontal pressure losses, and subsequently through leakage from interburden strata to the coal seams. Regional structures like faults and dykes have also influenced the depressurisation process by either acting as conduits or as barriers that compartmentalise pressure losses. Hence the depressurisation is a complex three dimensional regime that is extremely difficult to map. Generally the shallower zone is of particular interest since this zone can host localised aquifers where useful bore yields can occasionally be found.

A regional shallow pressure – water table surface was generated in 2003 as part of the extensive West Pit EIS process using a combination of measured water levels and computer modelling (for areas lacking measured levels). That surface has been regenerated using a reduced rate of recharge and is provided as Figure 8.

2.2.2 Regional hydraulic properties of coal measures

Hydraulic conductivities have been measured on interburden from selected boreholes within the Carrington area and in adjacent areas over a number of years. Conductivities have also been determined at a number of locations for seams below the Bayswater seam (MER 2003) and the upper Broonie seams. A similar conductivity range is assumed to apply for the Bayswater seam.

Available data sets have been used to develop an understanding of the likely bulk conductivity of coal measures in the region. The following Table 1 provides a summary of typical conductivities while further details are provided in Appendix B.

Table 1: Coal measures typical hydraulic conductivity estimates

Strata	K (m/day)
coal seams	5.0E-03 to 5.0E-02
sandstones	3.0E-04 to 3.0E-06
siltstones	2.0E-05 to 2.0E-07
claystones and shales	1.0E-06 to 1.0E-08

K = horizontal permeability

2.2.3 Regional groundwater quality

Regional groundwater quality can be classed according to host lithology. Groundwaters within certain coal seams are known to be highly saline (sodium chloride) while groundwaters within interburden often exhibit a different type of salinity (sodium bicarbonate) depending upon the prevailing mineralogy.

Electrical conductivity ranges from about 3000 to more than 12000uS/cm throughout the region. However, mine water generated as a result of pit seepage, is commonly in the range 4500uS/cm to about 8000uS/cm depending upon prevailing climatic conditions. This range is consistent with that observed within the palaeochannel aquifer. The water type is predominantly Na>Mg>Ca and $Cl>HCO_3>SO_4$.

3. COMPUTER SIMULATION OF AQUIFER RESPONSES

Impact of Carrington pit development on the groundwater systems within the palaeochannel and the underlying hardrock regime, has been previously assessed using computer based aquifer modelling techniques (MER 1999, MER 2000b, MER 2003, MER 2004). Two models have been employed:

- a single layer model addressing the palaeochannel alluvium and the management of seepage and river leakage during mining. This model has also been used to predict the recovery of water levels post mining;
- a regional three layer model addressing the hardrock coal measures, cumulative impacts and the magnitude of leakage induced by depressurisation within the coal measures.

Previous models adopted the finite difference Modflow scheme for solving a set of differential equations known to govern groundwater flow (McDonald et al, 1988). This simulation method required dividing the overall area of interest into rectangular cells with the number of cells defined in the model grid being determined by the general juxtaposition of planned operations (pit and floor layouts), the Hunter River and the expected hydraulic gradients developed within the alluvium or the coal measures during the course of mining.

These previous models have been expanded within the current study and translated into the Modflow-Surfact code, a derivative of Modflow offering more robust handling of de-saturation and improved solution accuracy/efficiency based upon adaptive time stepping. Appendix C provides detail relating to model design, calibration and simulation procedures.

3.1 Palaeochannel aquifer simulations

Mining operations have been simulated using the palaeochannel single layer model. Seven variations of this model have been used to both re-calibrate and to consider impacts. Pit development has been represented by stripping of the alluvium in accordance with the mine plan. Key features of the model include:

- excavation of the initial box cuts (slots 1 and 2) below the water table in July 2000;
- simulated removal of alluvium in the eastern and western channels at 3 monthly intervals from the commencement of mining;
- excavation of dewatering slot 3 in the eastern channel in December 2003 (used for re-calibration);
- continuing removal of alluvium in the eastern channel to the southern most approved limit of mining;
- removal of additional alluvium to the proposed extension of mining;

- installation of a clay barrier wall to impede exchange of groundwaters between mining operations and the Hunter River;
- simulation of recovery of groundwater levels post mining.

3.1.1 Simulation of mining operations to the approved extents without a barrier

Figure 9 shows the simulated water table response for the progression of mining from commencement in January 2001 to January 2004. Figure 10 shows the simulated water table response for the progression of mining from January 2005 (current) to January 2008 when excavations in the eastern channel have reached the approved southern extents to mining. Plotted responses indicate removal of the water table in mined areas to the base of the alluvium (hatched areas) and decline in the remaining groundwater table situated between mining operations and the Hunter River.

Examination of the potentiometric contours indicates a southward flow/gradient to the Hunter River is sustained in the eastern channel until January 2007. At this time a reversal of hydraulic gradient is apparent and flow is predicted to occur in a northward direction from the river. This flow would be generated by leakage from the river. A similar reversal is predicted in the western channel after 2006. However both scenarios are inherently conservative since they assume that drought conditions prevail at all future times.

The (dry weather) pit seepage over the period of mining is shown on Figure 11. This estimate is the calculated daily flux to all mine pit cells within the model. An initial pit seepage of more than 2ML is noted, declining to a present seepage rate of about 0.3 ML/day which is predicted to decline to about 0.2ML/day at the end of mining. The relative constancy in the rate over the period from 2004 to 2022 is attributed to removal of a large part of the storage within the alluvium and only slight changes in the hydraulic grade between the river and the mining operations over the remaining time period.

Also shown on Figure 11 are the river seepage and leakage flux estimates. Seepage represents (saline) flows reporting to the river from those cells adjacent to the river that have a higher calculated head than the river. Leakage represents flows from the river to those cells adjacent to the river (and beyond) that have a lower calculated head than the river – a sustained rate of about 0.08ML/day is predicted by 2010. Both seepage and leakage can prevail in a river reach at the same time due to differences in river stage. For this reason both types of flux are represented on the same plot. Where the two responses cross over, seepage is exactly balanced by leakage for the considered reach. It is noted however that the decline in seepage includes a drought related response.

3.1.2 Simulation of mining operations to the proposed extents without a barrier

Figure 12 shows the simulated water table response for the progression of mining from January 2005 to January 2008 when excavations in the eastern channel have migrated to the proposed new southern extents to mining. As with the above noted scenario, plotted responses indicate removal of the water table in mined areas and decay of the remaining groundwater table between mining operations and the Hunter River.

Examination of the potentiometric contours indicates southward flow to the Hunter River is sustained until about January 2007. A reversal of hydraulic gradient is apparent in the eastern channel at this time with flow predicted to occur in a northward direction from the river. This flow would be generated by leakage from the river. As with the previous scenario, the reversal is clearly apparent by 2008.

Pit seepage over the period of mining is shown on Figure 13. This estimate is the calculated daily dry weather flux to all mine pit cells for the extended mining scenario. Comparison of this response to the response plotted on Figure 11 indicates only a slight increase in pit seepage.

Also shown on Figure 13 are the river seepage and leakage estimates. Comparison of these responses with those shown on Figure 11, indicates little change in seepage to the river but an increase in leakage from the river to a sustained rate of about 0.13ML/day by 2010.

3.1.3 Simulation of mining operations with a barrier

Figure 14 compares mining operations for both the approved and proposed extents to mining with a relatively impermeable barrier installed a short distance beyond the southward limits of mining in both the eastern and western channels. Such a barrier would be constructed to isolate mining operations and to effectively inhibit any measurable exchange of groundwaters between the mine pit and the alluvial lands to the south. The barrier could be constructed as:

- a slurry wall independent of mining operations. This option may be invoked via a shallow or deep slot initially excavated in the alluvium. A trench would then be excavated to the base of the alluvium and supported by pumping bentonite slurry into the trench. The slurry would mix with, or replace the excavated materials. Soilcrete jet grouting may also be used locally to seal particular sections;
- a non slurried dry laid wall.. This option would utilise selected clay materials excavated from the alluvial lands and emplaced within a slot cut in advance of mining or within a benched area southward of the final highwall location(s).

The barrier would need a crest elevation above 65mAHD in order to isolate potential saturation zones.

Predicted water tables are shown for 2010-2011. Comparison of responses indicates a relatively flat water table southward of the barrier while north of the barrier, the pit is dewatered. A steep hydraulic gradient prevails across the barrier in both cases. The relatively flat water table south of the barrier results from minimal recharge to the aquifer system which has been adopted on the assumption that drought conditions will prevail into the future. This scenario is therefore considered to be conservative. Modelling of the recovery of water levels in the final void adopts an average rainfall recharge rate that results in an elevated water table with partial restoration of flow back to the river (see Section 4 below).

Figure 15 compares river leakage-seepage rates for both scenarios – negligible differences are noted.

3.2 Regional model simulations

As noted above a regional model has been adapted from modelling conducted for the West Pit EIS (MER, 2003). This model is regionally extensive and includes operations on the north side of the Hunter river – Carrington, West Pit and North Pit. The model has been used to both generate an estimate of cumulative pressure losses within the coal measures strata, and an estimate of leakage from the alluvial lands adjacent to the Hunter River, to Carrington pit via the coal measures. Details of the model are provided in Appendix C.

Model simulations commence in January 1980 (North Pit and West Pit) with mining being simulated at all operations by introducing the progressive deepening of pit floors in a piecewise manner that is generally consistent with historical operations. The model has been calibrated crudely against historical (average) seepages to the mine pits which were often based on anecdotal observations. Carrington pit has been represented from the initial box cut in 2000, to completion of mining at the earliest feasible time in January 2011.

Figure 16 provides a plot of the calculated drawdown in the shallow hardrock piezometric surface in 1980 together with calculated (cumulative) drawdowns for 2004, 2007 and 2010. Reference to this plot shows an expanding cone of depression around each mine pit.

Estimated long term seepage/leakage from the Hunter River alluvium to the mine pit, is provided on Figure 17. This estimate has been generated by conducting model simulations with the alluvium isolated from mining operations through the construction of a cut off wall.

Figure 17 indicates leakage and seepage do not change measurably over the period from 2000 to 2024. This negligible change is attributed to the very low vertical hydraulic conductivity of the coal measures strata and the presence of a significant buffer zone between the pit high walls and the river. This buffer zone is more than 400m in the east channel and more than 1100m in the west channel.

Pit seepage derived from dewatering of storage within the coal measures peaks at about 0.45ML/day at the completion of mining. It does not include provision for any increased localised storage that may be encountered in the vicinity of faults or dykes or in the potentially weathered shallow coal measures immediately beneath the alluvium. Total seepage on completion of mining (coal measures plus alluvium) is estimated at about 0.75ML/day declining thereafter as pressures equilibrate.

4. FINAL VOID

Mining operations at Carrington are expected to be completed by about 2011 at the earliest. At this time pit reshaping will be undertaken and water levels in the final void will begin to recover. The recovery process will involve a resaturation of waste rock spoils. Water for this resaturation will derive from rainfall infiltrating through rehabilitated areas, direct rainfall to any open void area, and a small component of seepage from the coal measures. The latter will be governed largely by the prevailing coal measures pressures which will in turn be governed by future regional mining operations.

4.1 Simulation of recovery of water levels within the pit void

Recovery of water levels within the pit shell containing emplaced spoils, has been simulated using a modified palaeochannel aquifer model with extents expanded to include the proposed pit shell shown on Figure 18. The base of the model has been interpolated to the pit floor while the initial water table has been adjusted to similar elevations. Closure design has not been finalised at the present time but two scenarios are feasible as described below and shown in sectional form on Figure 19:

- an open water void located within the area outlined on Figure 18. The pit shell outside the void would be filled above ground level and reshaped while within the void area it would only be backfilled to a nominal elevation of about 40mAHD (18 to 20m below river level) or lower, after reshaping. This scenario ensures an evaporative sink would develop when levels rise above 40mAHD, providing that sufficient water surface area is generated within the shaped void for evaporative losses to balance overall void influxes. An evaporative sink would result in the maintenance of an hydraulic grade towards the open void. However the void would also act as an evaporative concentrator leading to some increase in dissolved salts (depending upon mineralogy and mobility of salts).
- A pit shell with no open water condition – spoils within the open void would be emplaced to an elevation above 40mAHD. Instead of an open water condition being permitted to develop, extensive tree planting would be undertaken within the shaped void. Species with high transpiration rates would be adopted in order to maintain the void water level below ground level. The advantage of this approach is a lower rate of evaporative concentration of salts. However there is a very long time frame before water levels would recover to the design elevation during which time, tree species would need to be maintained-regenerated.

In order to generate estimates of the rate of recovery of water levels within the pit shell, rainfall recharge has been applied at the rates described in Table 2. A conservative spoils infiltration rate of 20% of average annual rainfall has been adopted for design purposes but the expected rate is about 10%. The open water rate is a net loss based on an annual average rainfall of 640mm/year (Jerrys Plains) and an annual effective rate factored to 80% of potential evaporation (open water condition), of 1458mm/year. Net losses will increase from first saturation at the base of the shaped void where the open water area is effectively zero, to a rate where the water surface area provides losses equivalent to void influxes.

Within the pit area, the hydraulic properties of specific model cells have been changed to reflect the increased permeability and porosity of emplaced spoils. Assigned hydraulic properties of spoils include a conductivity of 1 m/day and a specific yield (drainable porosity) of 20% for spoils.

Table 2: Summary of recharge rates applied to recovery model

Area	Recharge (mm/year)	% of annual average rainfall
undisturbed alluvium	14	2.2
rehabilitated spoils (maximum rate)	130	20
Rehabilitated spoils (expected rate)	60	9.5
open water void	-818	-

A long term steady state level of about 45 to 50mAHD and a shaped void basin of the order of 72ha with a minimum water surface area of about 60ha has been conservatively calculated. The period of time required to achieve this is in excess of 100 years at the expected rainfall recharge rate through spoils materials. The steady state level is below the Hunter River which has an elevation of 58 to 60mAHD within the Carrington reach. Since the river and adjacent alluvium will be isolated from the void by cut off walls, no measurable exchange of groundwaters would take place. Leakage through the barriers is calculated to be less than 5 litre per day per metre of wall length.

The approximate geometry of the recovered water table within the pit shell is shown on Figure 20. Water levels reflect an hydraulic grade from the northern and western areas of the palaeochannel, towards the proposed open water surface in the east. Steep gradients can be identified across the cut off walls while to the south of the walls the water levels reflect re-established southward gradients as a result of natural rainfall recharge in those areas.

4.2 Final void water quality

An estimate of the final void water quality was provided in supporting documentation for the Carrington EIS (MER 1999). The estimate was based on leachate trials conducted by Department of Mineral Resources Laboratory. Those trials were based on crushed samples (to minus 2mm dia.) of interburden sandstones, siltstones and claystones. The leached salts were subsequently estimated for an alternative grain size distribution based upon spoils fragmentation where individual boulders to +1m dia. were included. The mobilisable salt load was calculated to generate a spoils water quality of 4750mg/L (approx. 7300uS/cm EC) for a spoils emplaced density of 2.1t/m3. The load was noted to be similar to the range encountered at North Pit (Hunter Valley Mine) where spoils leachate was observed to fall in the range 3860 to 6000mg/L. Figure 21 provides a trilinear speciation plot showing speciation of Carrington (DMR) leachate trials – all samples are dominated by Na-Mg, HCO_3.

More recent leachate trials have been undertaken on interburden for surrounding pits (eg. North Pit, West Pit) over longer periods of 3 to 6 months. These trials (eg MER 2003) have been conducted on similar interburden samples and have generated similar estimates of leachate to that noted above.

In addition, geochemical modelling has been employed as a means of understanding likely long term void water quality in the nearby Alluvial Lands Pit where interburden and coarse rejects exhibiting similar mineralogy has been reposited (MER 2005a). Findings from that study noted the following:

- Rainwater interaction with rejects and spoils materials would involve both the dissolution of minerals, and ion exchange between the solute and mineral phases. Contributing minerals would include dolomite, halite and gypsum as sources for Ca, Mg, Na, K, HCO_3, Cl and SO_4 while exchanger clay minerals would include illite and smectite and to a lessor extent, kaolinite. Dolomitic cement is found in some interburden while halite tends to be associated with coal seams or roof and floor strata. The exchange process would lead to increased Na and reduced Ca and Mg in the solute;
- Simple mixing of rainwater, spoils and rejects (claystones and carbonaceous shales) leachates using representative, maximum and minimum water quality estimates generated from leachate trials, suggested a total dissolved solids (TDS) peak at about 11 years after commencement of filling of the void. A TDS range of 3600 to 4600 mg/L was found to prevail. TDS falls steadily thereafter by about 7% to 14% over a period of about 70 years due to increasing contributions of rainfall relative to coal measures groundwater seepage as the void filled. However the responses are probably sensitive to the projection of leachate trials from 3 months out to 80 and 100 years. TDS was predicted to be dominated initially by Cl concentrations to about 10 years providing coal seam seepage prevails, and subsequently by HCO_3 concentrations when rainwater percolation prevails;
- Mixing with geochemical reactions included in the process model, suggested the TDS could be 37% lower than if simple mixing is assumed. That is, precipitation and ion exchange would result in a peak TDS after 10 years of about 2900 mg/L. This is attributed to the loss of Na by exchange leading ultimately to an increase in Ca (from the exchanging material) and subsequent precipitation of calcium carbonate within the void. However the process depends on whether the exchange sites are initially occupied by Na or Ca (eg. smectite).

Since rainwater is expected to be the dominant process generating leachate within the void, HCO_3 concentrations are likely to dominate at Carrington.

5. SURFACE HYDROLOGY

Hydrological studies were included in MER 1999 to assess the impact of mining on the local drainage catchments. Studies included climate, catchment mapping and runoff simulation modelling. Long term yield of local catchments was estimated using a soil moisture accounting model addressing three catchments C1, C2 and C3 as shown on Figure 22. Median yields for these catchments are represented in Table 3 and are equivalent to about 6% of annual rainfall.

Table 3: Estimated catchment yields based on historical rainfall record

Catchment	Area (ha)	Median yield (ML/annum)
C1 – grassed with tree lined slopes	1177	445
C2 – grassed with occasional trees	398	150
C3 – grassed	391	146

Mining operations have affected catchments C1 and C3 to-date while catchment C2 has remained largely unaffected. Runoff generated in the northern areas of C1 is currently diverted into the drainage channels shown on Figure 23 and conveyed southward to the Hunter River. This drainage is planned to be relocated where it transgresses the mining area immediately east of West Wing pit so that the remaining block of coal between West Wing and the main Carrington Pit, can be mined.

Catchment C1 will be enlarged slightly following rehabilitation as shown on Figure 23. Catchment C2 will remain unchanged. Catchment C3 will be reduced by 186ha (48% loss) based on the original area identified in the EIS as part of this area is included in the final void area. C4 represents the catchment surrounding the final void (originally part of North Pit) with a maximum 290ha potentially contributing to the void. Isolation of this area represents a potential loss of runoff to the river based on median yields, of about 109ML/annum or about 0.4% of the ten percentile low (regulated) flow in the river. Final shaping may reduce this catchment area and increase the area of C3.

Catchment areas pre and post mining are summarised in the following Table 4 for both the currently approved mine extents and the proposed extents.

Table 4: Catchment areas pre and post mining

Catchment	Extents	Area pre mining (ha)	Area post mining (ha)	Percent change in area
C1	Approved	1177	1087	-7.6%
C2	Approved	398	398	0%
C3	Approved	391	481	+23% *
C1	Proposed	1177	1189	+1%
C2	Proposed	398	398	0%
C3	Proposed	391	205	-48%
C4	Proposed	0	290	To void

* final void area loss in C3 not included in 1999 EIS – assumed to be free draining void

6. MINE WATER MANAGEMENT

Mine water management includes the diversion, collection, storage and treatment of surface waters and groundwaters within the Carrington area. Water management details were extensively addressed in MER 1999 and provided for testing of the water management system using a dynamic catchment model exposing the system to various climatic periods extracted from the historical rainfall record. Original designs provided for the construction of a storage-discharge dam to the north of the mine pit within catchment C1. The water management system has been reviewed on a number of occasions since that time (eg. MER 2005b)

Operations since 2000 have not required the construction of a storage-discharge dam. Instead, sufficient storage has been available within North Pit water management system - Carrington mine water system is now an integral part of the North Pit system.

All mine water seepage to Carrington is pumped from the mine pit to Dam 9N, the location of which is shown on Figure 24, together with other mine water dams for the North Pit – West Pit - Carrington operations. Water can then be transferred from Dam 9N to North Pit, West Pit or South Pit if a surplus arises (see Figure 25 for North Pit water management schematic). Dam 9N will however be relocated to the east while a sedimentation dam known as Dam 12N will be destroyed. Dam 13N would be enlarged to manage runoff from the final landform. A number of temporary sedimentation dams would also be constructed within the final landform.

The system is balanced across all CNA pits to ensure water availability and maximum pit water re-use. To-date the mine pit has operated initially with a surplus during early years of development (2001-2002) and subsequently with a reducing surplus to a near balanced budget. Table 5 provides a simplified summary balance assuming a constantly disturbed mining area of some 200ha. MER 2005b provides comprehensive testing of the North Pit water management system. Findings confirm a generally balanced system for a wide range of operating constraints and climatic conditions providing staging storage remains available.

Surplus staging storage capacity in excess of 15000ML is available in the Alluvials Pit immediately to the east of Carrington should extreme wet weather conditions prevail.

The final landform drainage with temporary sedimentation dams, is shown on Figure 23 for an open water void condition.

Table 5: Simplified annual mine water balance

Water source	**10% wet year**	**50% wet year**	**90% wet year**
Rainfall in mm per annum	797	628	383
Yield as percentage of annual runoff	14%	9%	5%
Equivalent runoff from 200ha (ML)	223	143	80
Groundwater seepage (ML)	110	110	110
Make up water (ML)	0	0	10
Total annual balance	333	253	200
Water use			
Pumpage to HV North system (ML)	193	83	0
Haul road dust suppression (ML)	140	170	200
Total annual balance	333	253	200

Note that yields refer to disturbed catchments (lumped for estimation purposes)

No significant water management problems have arisen and none are foreseen for continued mining to the approved mine extents at Carrington. Since pit seepage and water usage are predicted to be about the same for the remaining period of mining for both the approved pit limits and the proposed extended pit limits, there will be minimal change to the water management system.

7. POTENTIAL IMPACTS ARISING FROM EXTENDED MINING

The inclusion of the areas of proposed extensions to mining has the potential to change impacts previously addressed in MER 1999. Areas of concern are summarised follows.

7.1 Loss of groundwater pressures or levels

Local and regional aquifer pressures and groundwater levels within both the palaeochannel alluvium and the coal measures will continue to decline. The hydraulic grade within the alluvium is currently towards the river but will reverse within a few years leading to the potential for increasing leakage from the Hunter River. Installation of a clay barrier or cut off wall would effectively mitigate such leakage via the alluvium. South of the cut off wall(s) a small southward hydraulic grade towards the river would be sustained by rainfall recharge.

The billabong area located in the south-eastern part of the east channel (see Figure 22) is unlikely to be affected by further declines in the water table since water levels in this area are already close to river bed levels as a result of mine and drought induced water table losses.

Within the deeper coal measures, the area affected by loss of pressure will expand to a distance of about 1 to 2 kilometres from the mine lease. More distant areas will be affected by 0.2 to 0.5 metres loss of water level (aquifer pressure) with an exponential increase in loss of pressure towards the pit. Areas immediately adjacent to the pit will lose more than 60 metres head of water when mining ceases.

Pit seepage from the alluvium is predicted to remain at the current or slightly higher rate of about 0.2 to 0.3ML/day for the remaining period of mining to the proposed new extents. Seepage from the underlying coal measures will derive mainly from storage within the Broonie and Bayswater seams and structurally disturbed areas. This seepage is predicted to increase to a maximum of 0.45ML/day giving a total rate (alluvium plus coal measures) of up to 0.75ML/day before evaporative losses from the seepage faces.

Depressurisation of the coal measures beneath the Hunter River alluvium is already evident as a result of mining at Carrington and in the Alluvial Lands pit to the east. Deep piezometers located near the Hunter River in the east channel exhibit depressurisation of the order of 2 to 5m. This depressurisation will continue as mining advances southwards and may induce leakage from the river at an estimated rate of less than 0.010ML/day.

Seepage-leakage rates arising from dewatering and depressurisation are currently estimated to be lower than predictions made in the EIS (MER, 1999) and do not measurably differ between the approved and proposed new mining extents. Seepage-leakage impacts of extending the mine limits are judged to be minimal.

7.2 Potential loss of groundwater yield at existing bore locations

Bores located within the alluvium north of the Hunter River and in proximity to Carrington operations, have been abandoned due to mining or in favour of improved quality water drawn directly from the Hunter River. There are a number of bores identified from the DIPNR database located south of the river within the alluvial lands. These are unlikely to be affected due to the relatively large mass of water contained within the alluvium, the rapid recharge capacity of the Hunter River, and the relatively low leakage rates predicted to occur from the alluvium to the coal measures. Yields at more distant locations will not be affected by the small relative change in coal measures depressurisation.

7.3 Potential change in groundwater quality

Water quality within the coal measures is generally saline and fails to meet quality guidelines for raw domestic waters (ANZECC, 2000) due to elevated primary salinity. The groundwater resource within the proposed extended areas (south and east of current operations) is considered to have limited beneficial use.

Dewatering-depressurisation of the alluvium and the coal measures is predicted to have minimal adverse impact on groundwater quality. Some leakage may occur from the Hunter River downwards into the alluvium or into the coal measures as water levels-pressures are reduced. The volume of leakage is predicted to be greater for the extended mining scenario when compared to current mining since operations will be closer to the river. However this leakage would be mitigated by construction of cut off walls in the east and west channels. Any leakage from the river to the alluvium would improve groundwater quality within the alluvium.

In respect of the coal measures, vertical leakage is predicted to be very small and dependent on fracturing and jointing at a local scale. As with the overlying alluvium, this leakage would displace currently saline waters with improved quality river water.

7.4 Loss of catchment runoff

Mining to the proposed southern and eastern limits will result in an additional 140ha of disturbed land. Current design provides for an open water void of 72ha and a surrounding shaped and rehabilitated spoils area of about 218ha that may also contribute runoff. Thus a maximum 290ha may capture and redirect runoff that would otherwise migrate southward towards the Hunter River. While loss of catchment relating to the approved extents to mining was broadly addressed in the EIS and a free draining open void proposed (MER 1999), the current design for extended mining provides for containment of leachate within the pit shell and void. Runoff from a maximum area of 290ha would not report to the river. This is equivalent to 109ML/annum or 0.4% of the ten percentile low (regulated) flow in the river.

A free draining void may be incorporated in the final pit closure design depending upon current and future research efforts.

7.5 Potential change in runoff water quality

Catchment runoff water quality is currently variable depending upon the time of sampling. Limited data indicates an average salinity of approximately 400 mg/L (615 uS/cm EC) could be expected. However it is also acknowledged that a first flush will show elevated salinity.

Runoff from rehabilitated spoils will initially exhibit elevated sediment load which will be contained within sediment Dam 12N. Once rehabilitation is established, long term change to surface water quality is unlikely. Monitoring of spoils runoff at North Pit operations indicates runoff quality will approach background levels within a few years following rehabilitation depending upon prevailing climate – dry or drought periods may extend the time for full rehabilitation.

7.6 Void water level recovery

Numerical modelling of recovery of water levels for an open void system supports an equilibrated recovery level between 45 and 55mAHD depending upon the final pit closure design. This level results from a small component of groundwater seepage to the void, rainfall infiltration through spoils, direct rainfall and runoff to an open void area and evaporation from that same area. The predicted equilibrated level would maintain a shallow hydraulic grade from installed cut off walls and northern areas of the palaeochannel, to the open void.

The river reach low flow water level varies from +60m in the west, to about 58m in the east where an unnamed drainage (draining the billabong area) enters the river. While predicted void water levels are lower than the prevailing river level, leakage from the river towards the void would not occur at a significant rate due to the proposed installation of cut off walls. Leachate generated from the emplaced spoils, would be contained within the void.

8. DIPNR LICENSING REQUIREMENTS

Licensing of certain aspects of the mining operations is required under Part 2 and Part 5 of the Water Act. The Water Management Act also has relevancy in respect of impacts on the Hunter River or adjacent connected alluvium.

8.1 Part 2 (Water Act) Licensing – surface water facilities

Part 2 of the Water Act relates to water rights and works.

In respect of current water management systems, the existing mine infrastructure will be used for all operations within the proposed extended area. However mine water Dam 9 will be relocated a short distance to the east of its current position. Current infrastructure relating to management of surface water runoff, erosion and sedimentation controls is either licensed or does not require licensing.

A permit would be required to undertake relalignment of the drainage channel between the West Wing and main Carrington Pit operations. In addition, a licence would be required for the construction of a flood protection levee immediately southward of the proposed extended mining area.. A further licence may be required for the proposed subterranean cut off walls.

Should water management plans change in the future, then applications should be made where appropriate.

8.2 Part 5 (Water Act) Licensing – groundwater seepage

Pit seepage is generally less than originally predicted in the EIS and is unlikely to increase measurably for the proposed extended mining area. Licensing relating to groundwater seepage to the mine pit has been required under Part 5 of the Water Act and may need to be amended.

8.3 Water Management Act (2000)

The Hunter River is now addressed under the Water Sharing Plan for the Hunter River Regulated Water Source. The river regime specifically includes both river water and groundwater resources contained within the underlying alluvium as defined by 'waterfront land'. This is taken to mean a strip of land that includes the highest bank above the river and possibly extending some 40 metres from that point.

Coal measures groundwaters are not included since they are contained within consolidated rock layers and generally have no beneficial use owing to their brackish or saline water quality and limited yield potential.

The palaeochannel aquifer beyond the area near the Hunter River is considered to fall outside the limitations imposed by waterfront land. Groundwaters contained within these unconsolidated deposits are also considered to have no beneficial use owing to the brackish to saline characterisation. These groundwaters currently migrate towards the river and undoubtedly contribute to river salt load.

Installation of cut off walls will mitigate exchange of groundwaters and may lead to improved water qualities. These same walls will inhibit leakage from the river water resource to the mine pit via the alluvium. The remaining element of predicted leakage is a small component that may enter the pit operations via downward leakage through the coal measures and lateral seepage along more transmissive zones like the coal seams. However this component is estimated to be small less than 0.01ML/day. This leakage will reduce to a negligible volume when pit void waters have recovered in the long term.

As such the impacts of Carrington operations on the water sharing plan are considered to be negligible

9. IMPACT ASSESSMENTS

The monitoring and verification of impacts is important for both the groundwater and surface water regimes. Assessment criteria set a series of benchmarks against which, impacts can be measured, alert protocols developed and mitigative actions initiated. While these criteria (and impacts) can be relatively easily established for surface waters, significant difficulties arise in respect of groundwater since subsurface groundwater flows in both a regional and local context, are difficult to quantify.

9.1 Groundwater monitoring

Impacts in respect of groundwater relate to two key areas:

- potential dewatering impacts on the Hunter River adjacent alluvium and depressurisation of the coal measures;
- changes to groundwater hydrochemistry induced by depressurisation.

Dewatering and depressurisation is calculated by regular measurement of prevailing groundwater levels in the alluvium and rock strata and comparing these levels with measurements prior to mining or to prior trends in data. CNA currently monitors groundwater levels at many piezometer locations within and around Carrington operations. Falling water levels/pressures have been measured at these locations. This dewatering and depressurisation is expected to continue in a predictable manner as mining progresses southward to the proposed new extension of mining. Groundwater impact assessment should therefore be based on the measured change in regional aquifer systems pressures, flows and hydrochemistry.

Monitoring should include:

- Bi monthly monitoring of water levels in all existing piezometers installed in the alluvium and in the underlying coal measures;
- Semi continuous (data logger) monitoring at selected piezometers in order to measure impacts of rainfall recharge and percolation.

The current schedule of groundwater quality monitoring should be maintained :

- Bi monthly monitoring of basic water quality parameters pH and EC in nominated existing piezometers;
- Six monthly measurement of total dissolved solids (TDS) and speciation of water samples in nominated existing piezometers.
- Graphical plotting of data and identification of trend lines and statistics including mean and standard deviation calculated quarterly. Comparison of trends with rainfall and any other identifiable processes that may influence such trends.

Impact analyses should include:

- Six monthly assessment of departures from identified monitoring or predicted data trends. If consecutive data over a period of 6 months (minimum of three consecutive readings) exhibit an increasing divergence in a negative impact sense from the previous data or from the established or predicted trend then such departures should initiate further action. This may include a need to conduct more intensive monitoring (including installation of additional piezometers) or to invoke impacts re-assessment and/or remedial actions if causality is attributed to mining operations and is assessed to be detrimental to the environment beyond impacts predicted in the EIS.
- Formal review of depressurisation and comparison of responses with aquifer model predictions annually. Expert review should be undertaken by a suitably qualified hydrogeologist if measured pit seepage and depressurisation exceeds predicted seepage and depressurisation.
- Annual reporting (including all water level and water quality data) to DIPNR in an agreed format.

9.2 Surface water monitoring

Operational impacts in respect of surface waters relate to two areas:

- Diversion of runoff from surrounding undisturbed catchments to minimise contributions to the mine water system;
- Capture and treatment of all runoff from disturbed areas to minimise impacts on natural drainage.

The topography is such that no diversion drains are required beyond those already approved. However it will be necessary to relocate mine water Dam 9N and sedimentation Dam 12N.

Design, construction and monitoring of the dams should ensure that:

- All new banks, channels and similar works constructed to convey runoff from rehabilitated areas above the dams do not cause damage to, or interfere with the stability or water quality of existing water courses.
- New banks, channels and similar works are to be maintained in a stable form to minimize scouring and erosion. Impacts of such works should be measured by monitoring of water quality parameters pH, EC and non filterable residue (NFR) at Dam 12N at monthly intervals during periods of sustained runoff, and comparing such measurements to measured water quality in the water course below the dam. If consecutive data measured at Dam 12N over a period of 6 months (minimum of three consecutive readings) exhibits an increasing divergence in a negative impact sense from the previous data or from the established or predicted trend then such departures should initiate a need to conduct more intensive monitoring or to invoke pumping the dam water back to the mine water system.
- Future dam design should provide for a minimum capacity based upon a 1 in 20 years ARI storm event and inlet/spillway structure designed to convey a 1 in 10 years ARI storm event and/or to meet design criteria prescribed in Managing Urban Storm water – Soils and Construction (NSW Dept. of Housing, 1988) for Type C or D basins and/or other design criteria considered appropriate to local conditions and micro climate influences.

Mine pit water monitoring should provide for:

- Fortnightly measurement of the volume of water pumped from the mine pit(s). Such measurement may be conducted using either flow meters, weirs, flumes, pump operational hours (combined with appropriate pump curves) or other suitable methods that result in an estimation error of less than 10%.
- Monthly monitoring of mine pit(s) water quality by measurement of pH and EC in the receiving dam(s).

In addition to the above and as part of overall water management procedures, the monitoring programme should be subject to review annually by CNA environmental services group and/or their appointed consultants.

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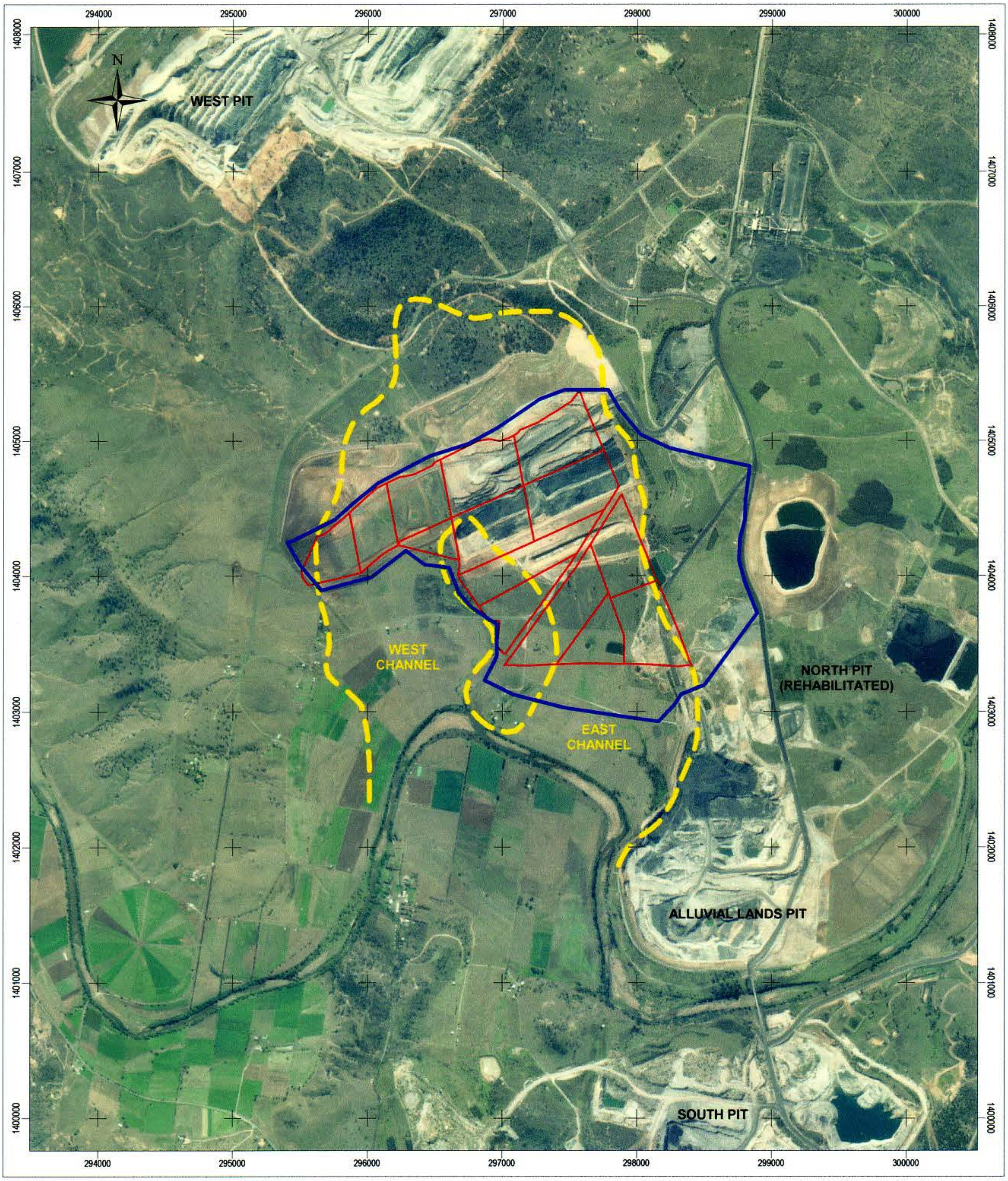
Pitman, W.V., 1973. A mathematical model for generating daily river flows from meteorological data in South Africa. HRU Report 2/76

IMPORTANT INFORMATION ABOUT YOUR HYDROLOGICAL REPORT.

Mackie Environmental Research has applied skills and standards appropriate to a Chartered Professional (AusIMM) in the preparation of your report, the content of which is governed by the scope of the study and the database utilised in generating outcomes.

In respect of the database, historical data is often sought from different sources including clients of MER, Government data repositories, public domain reports and various scientific and engineering journals. While these sources are generally acknowledged within the report, the overall accuracy of such data can vary. MER conducts certain checks and balances and employs advanced data processing techniques to establish broad data integrity where uncertainty is suspected. However the application of these techniques does not negate the possibility that errors may be carried through the analytical process. MER does not accept responsibility for such errors.

It is also important to note that in the earth sciences more so than most other sciences, conclusions are drawn from analyses that are based upon limited sampling and testing which can include drilling of exploration and test boreholes, flow monitoring, water quality sampling or many other types of data gathering. While conditions may be established at discrete locations, there is no guarantee that these conditions prevail over a wider area. Indeed it is not uncommon for some measured geo-hydrological properties to vary by orders of magnitude over relatively short distances. In order to utilize discrete data and render an opinion about the overall surface or subsurface conditions, it is necessary to apply certain statistical measures and other analytical tools that support scientific inference. Since these methods often require some simplification of the systems being studied, results should be viewed accordingly. Importantly, predictions made may exhibit increasing uncertainty with longer prediction intervals. Verification therefore becomes an important post analytical procedure and is strongly recommended by MER.



0 500 1000 1500 2000 2500 Metres

ISG co-ordinate system. Scale 1:20000

outline of proposed new extents (2005)

mine blocks for approved extents (1999 EIS)

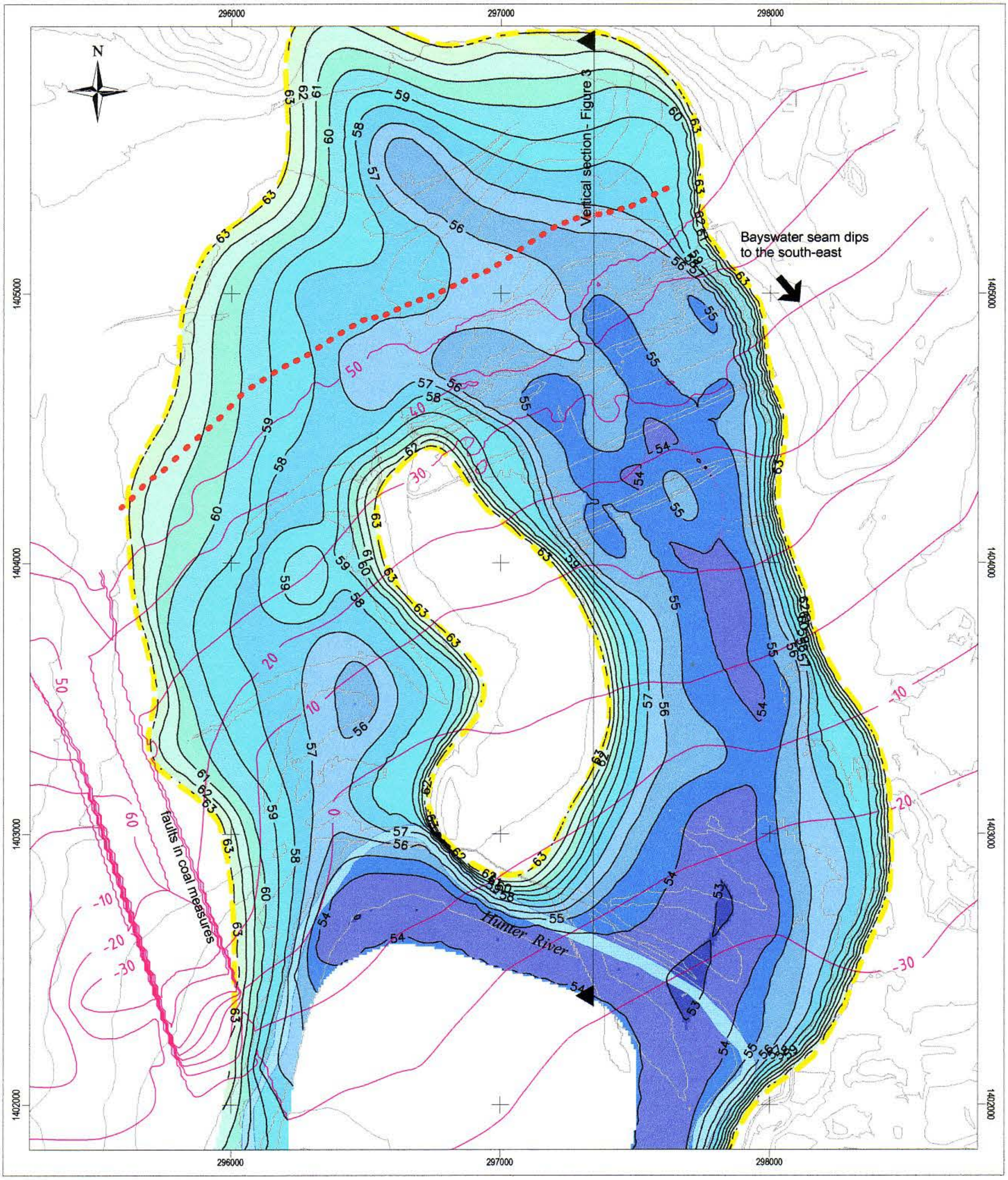
perimeter of alluvial palaeo channel

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Palaeo channel location and mining operations

Figure 1

Mackie Environmental Research



0 500 1000 1500 Metres

ISG co-ordinate system. Scale 1:20000

Elevation of gravel base (mAHD)

51 - 52	57 - 58
52 - 53	58 - 59
53 - 54	59 - 60
54 - 55	60 - 61
55 - 56	61 - 62
56 - 57	62 - 63

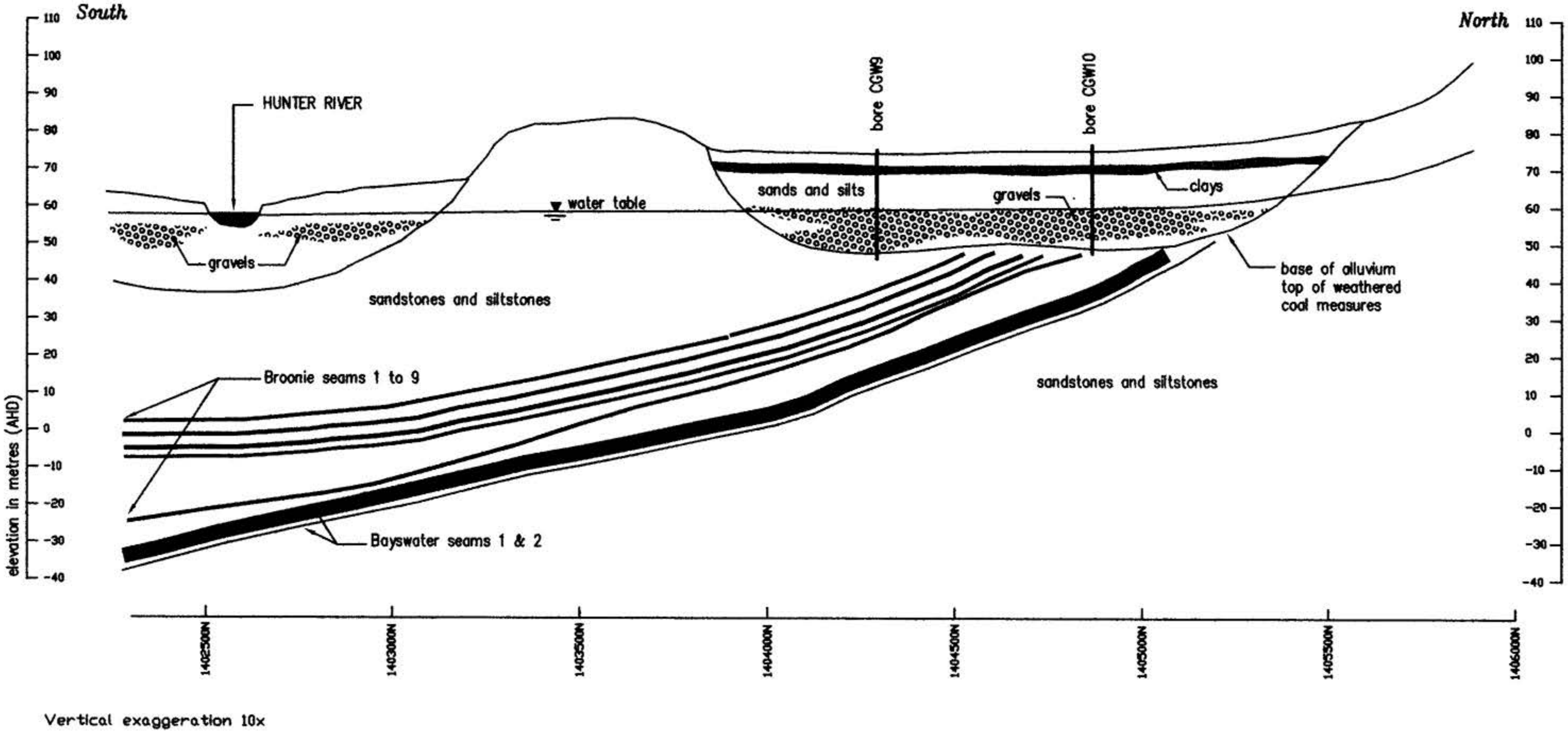
- Bayswater seam loxline
- base of gravel contours (mAHD)
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- floor of Bayswater seam (mAHD)
- Hunter River

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Re-interpolated base of alluvium - May 2005

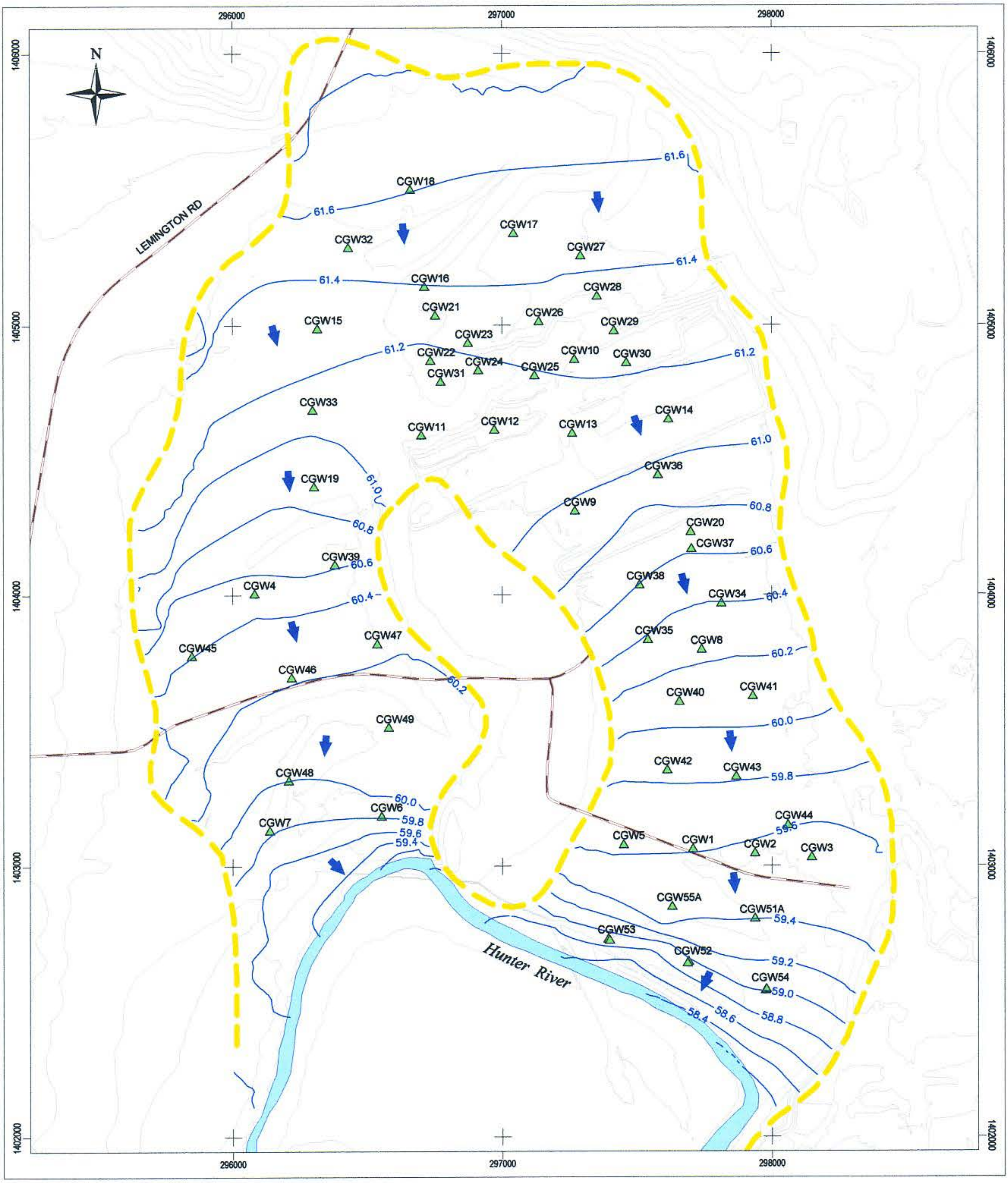
Figure 2

Mackie Environmental Research



SOUTH-NORTH HYDROGEOLOGICAL SECTION - PRE MINING

Figure 3



0 400 800 1200 1600 Metres

ISG co-ordinate system. Scale 1:20000

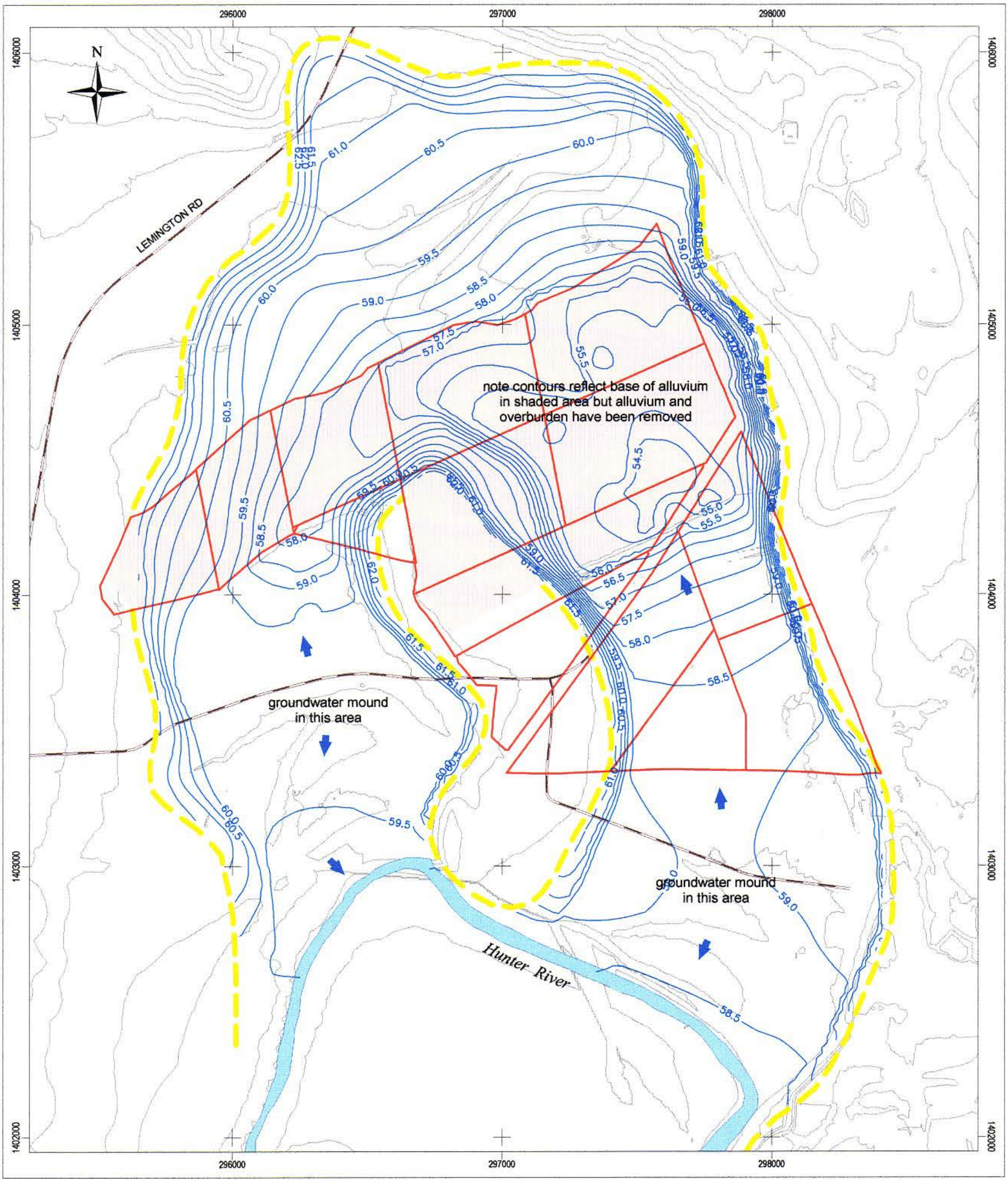
- piezometric surface (mAHD)
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- Hunter River

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Interpolated piezometric surface - pre mining (1999)

Mackie Environmental Research

Figure 4



0 500 1000 1500 Metres

ISG co-ordinate system. Scale 1:20000

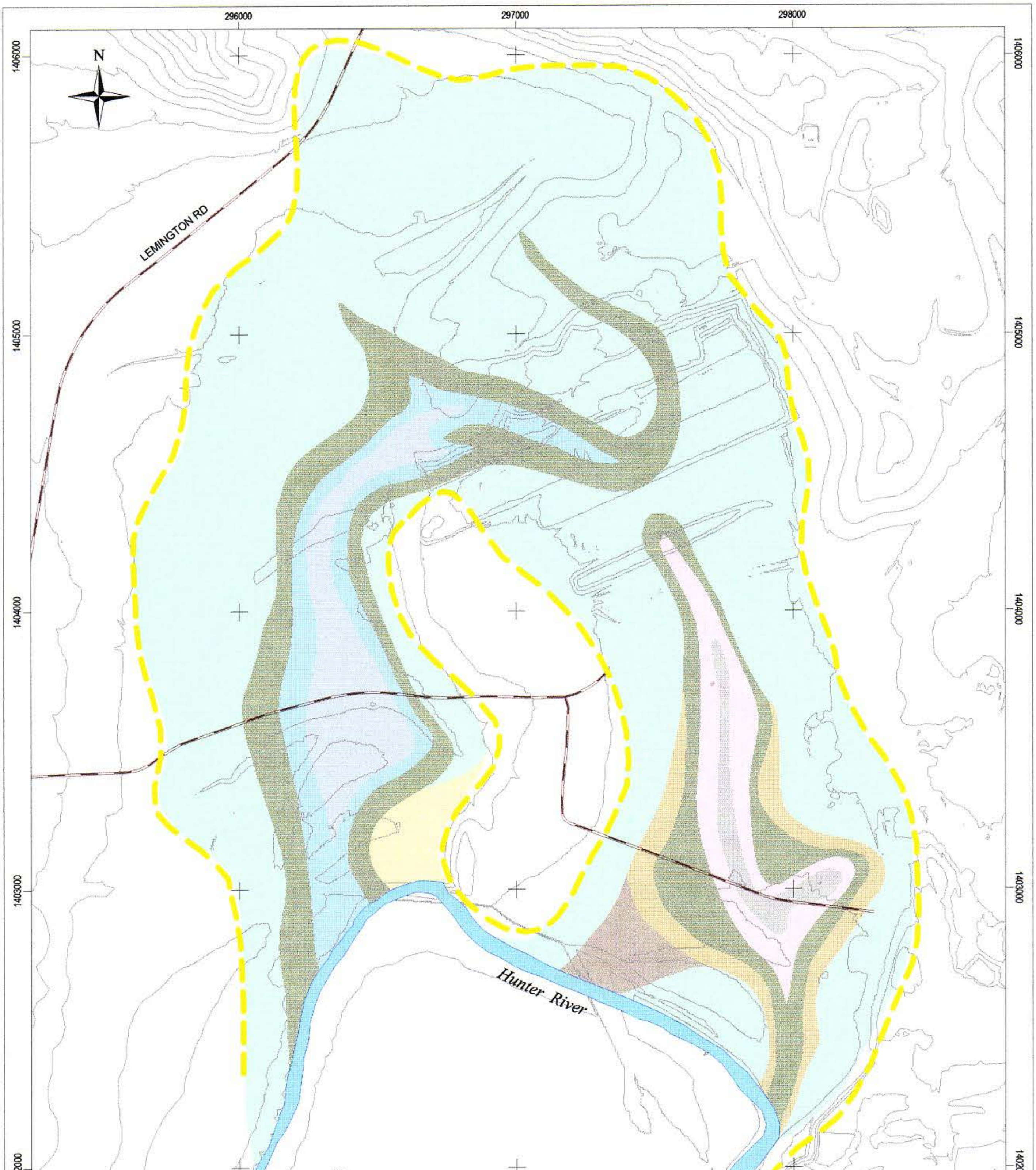
- piezometric surface (mAHD)
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- Hunter River

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Interpolated piezometric surface - current (2005)

Figure 5

Mackie Environmental Research



0 500 1000 1500 Metres

ISG co-ordinate system. Scale 1:20000

hydraulic conductivity (m/day)

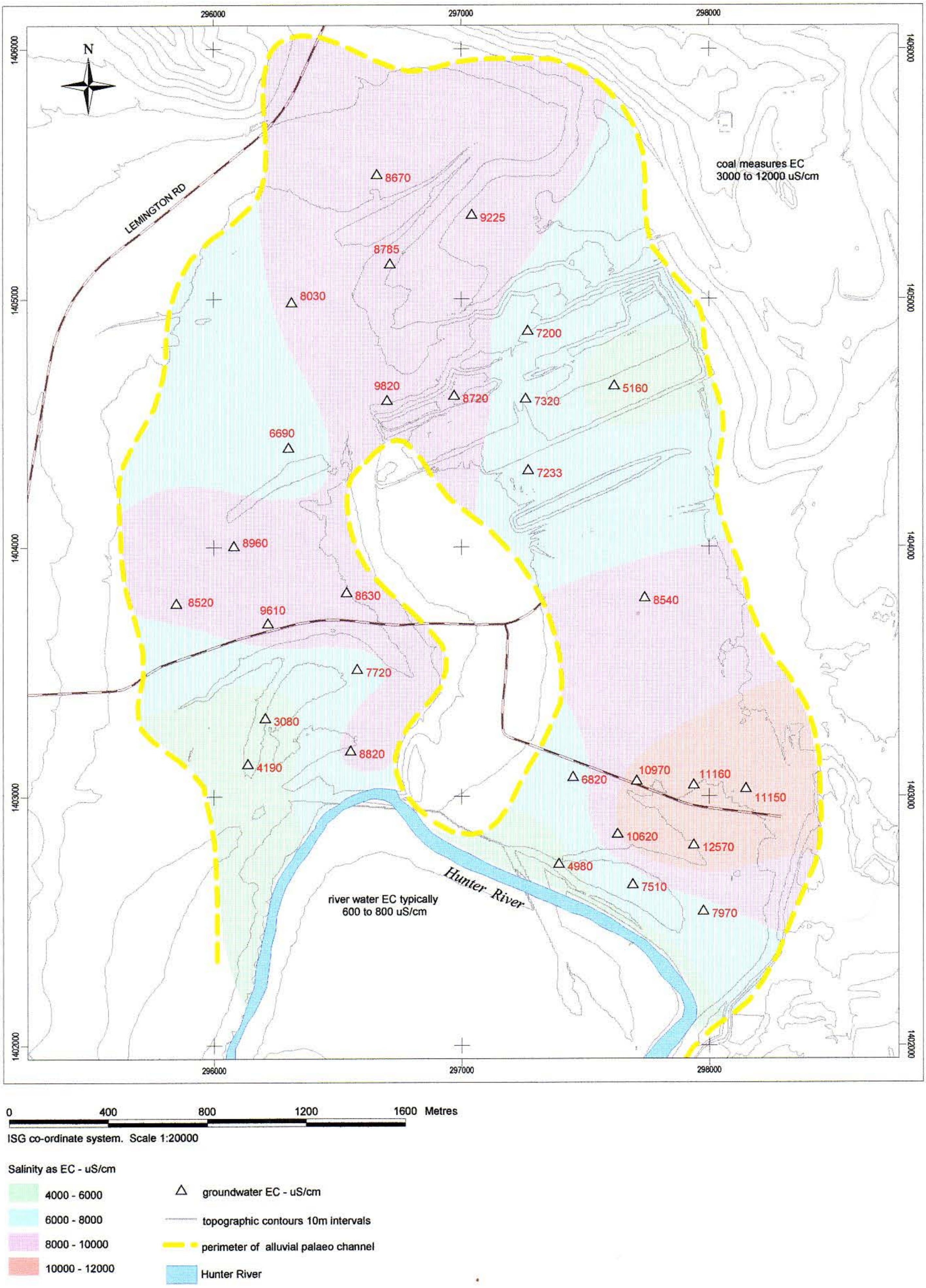
1	30	piezometric surface (mAHD)	
2	35	topographic contours 10m intervals	
7	60	perimeter of alluvial palaeo channel	
12	90	Hunter River	
20	95		

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Hydraulic conductivities derived from calibrated model

Mackie Environmental Research

Figure 6

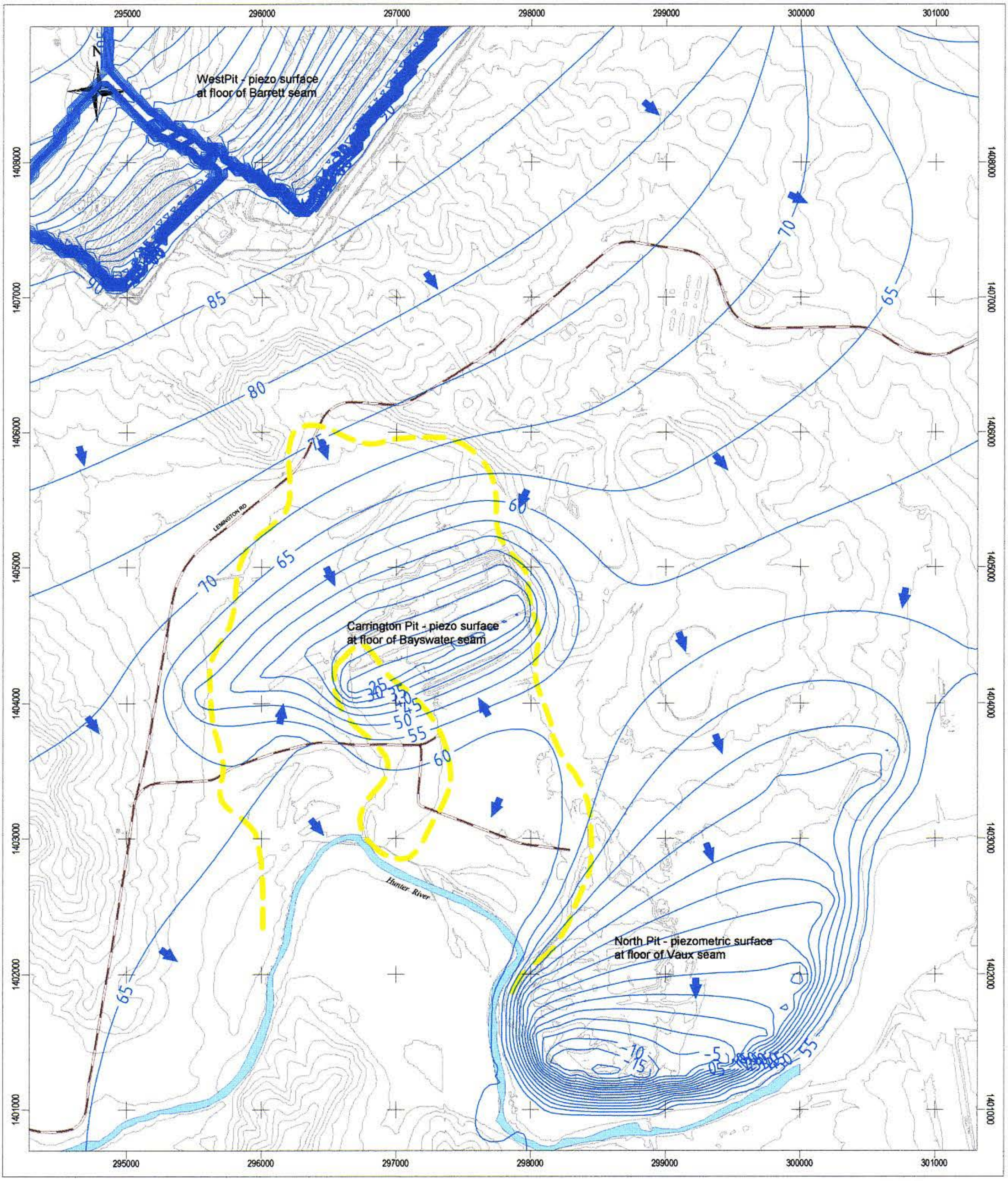


CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Generalised salinity distribution in alluvium - EC

Figure 7

Mackie Environmental Research



0 1000 2000 3000 Metres

ISG co-ordinate system. Scale 1:40000

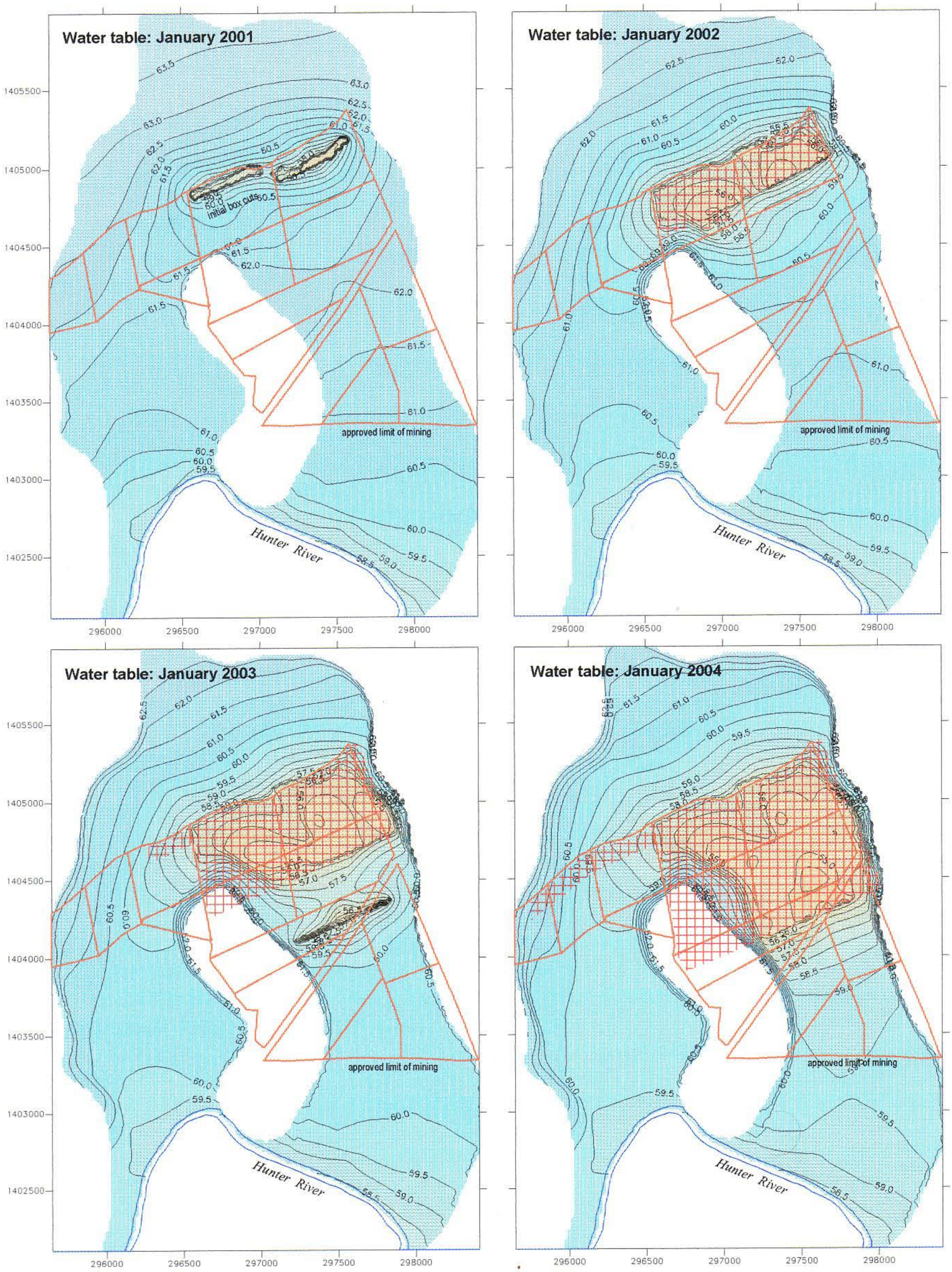
- piezometric surface (mAHD)
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- Hunter River

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Interpolated regional piezometric surface - current (2005)

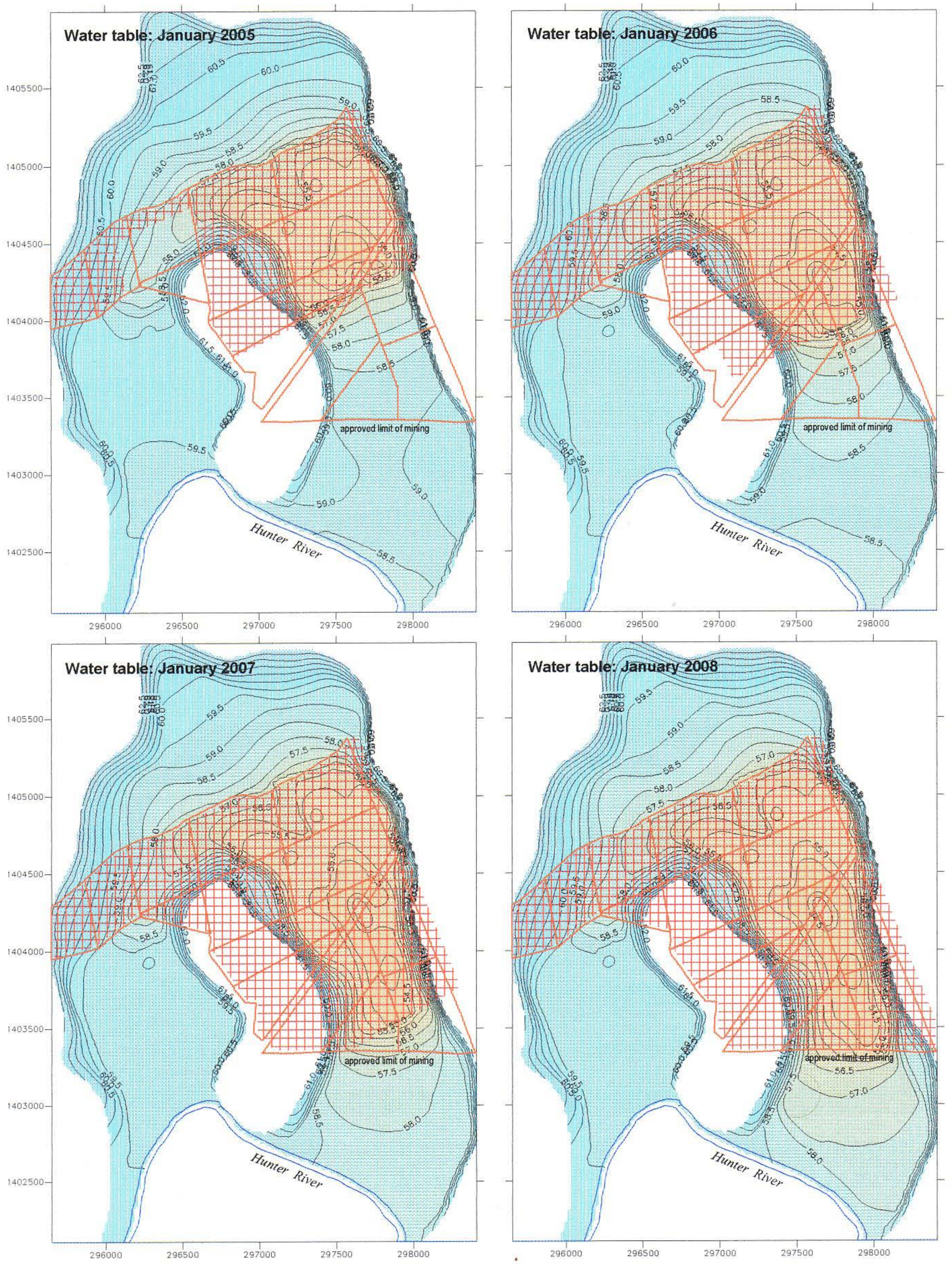
Figure 8

Mackie Environmental Research



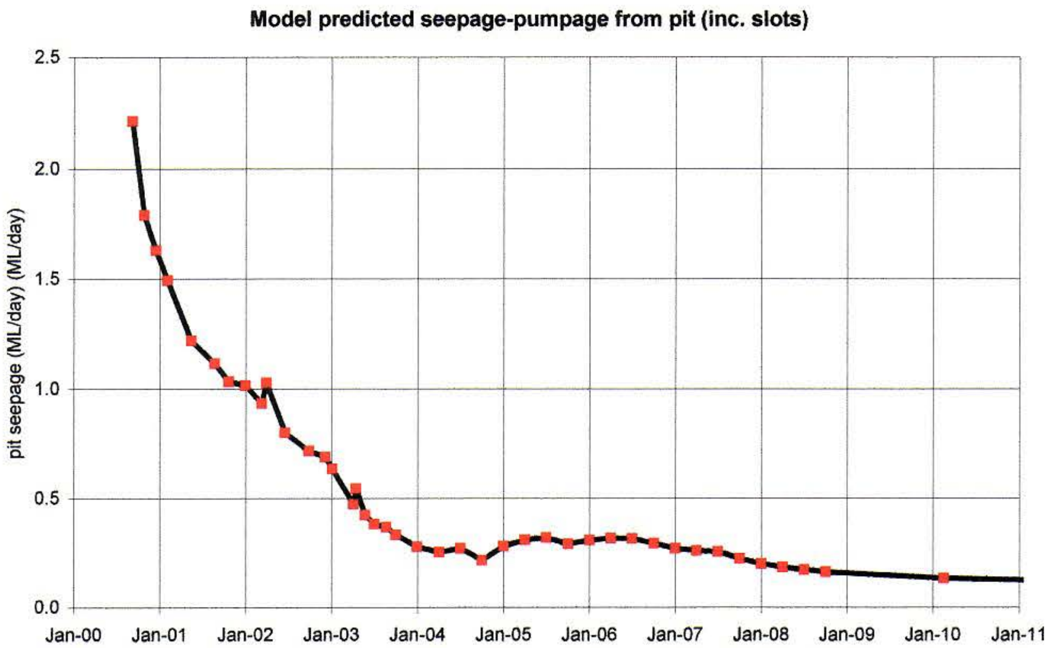
mined areas shown by shading

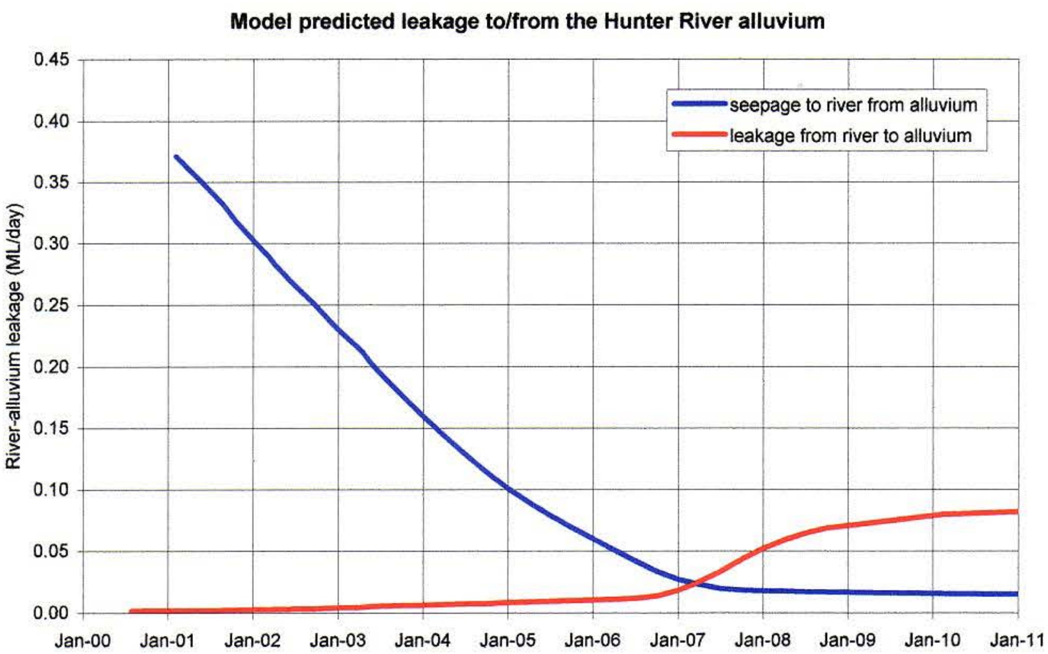
Water table decline over time
Approved mine limts - no barrier (2001 to 2004



mined areas shown by shading

Water table decline over time
Approved mine limts - no barrier (2005 to 2008)

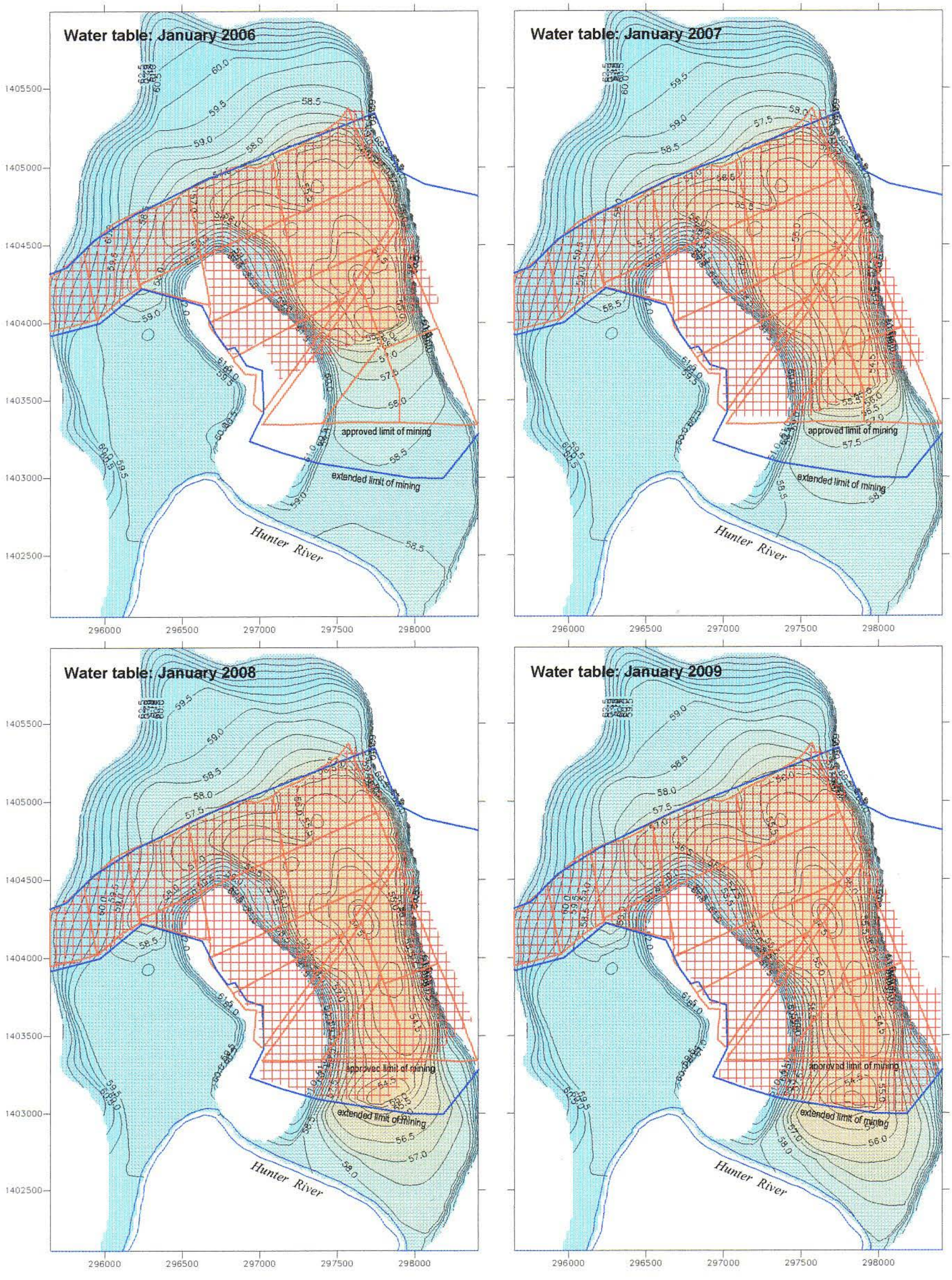




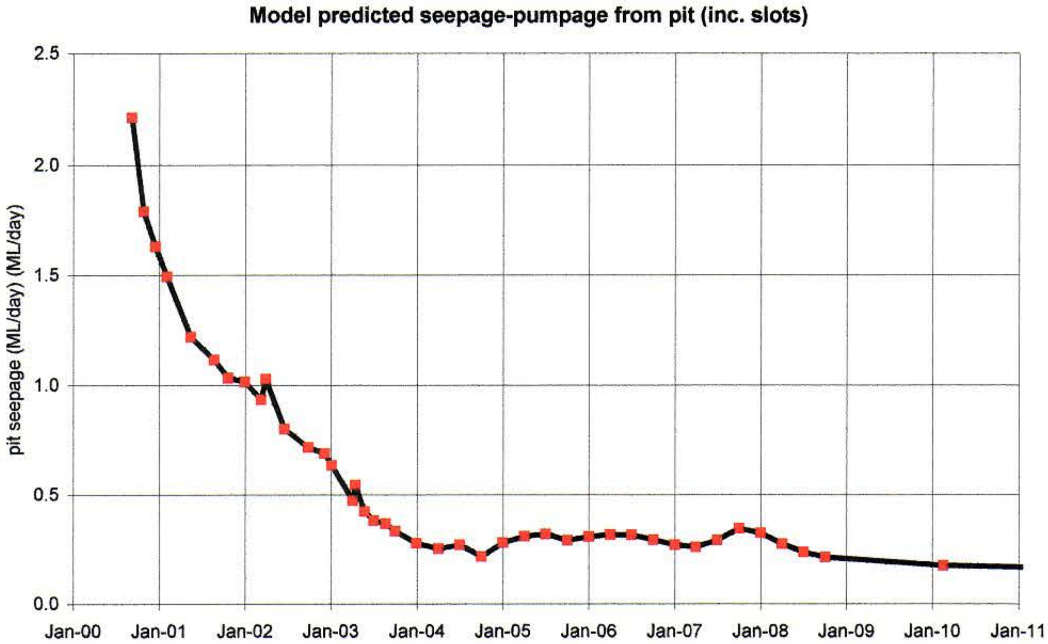
Note: decline in seepage to the river includes effects of drought

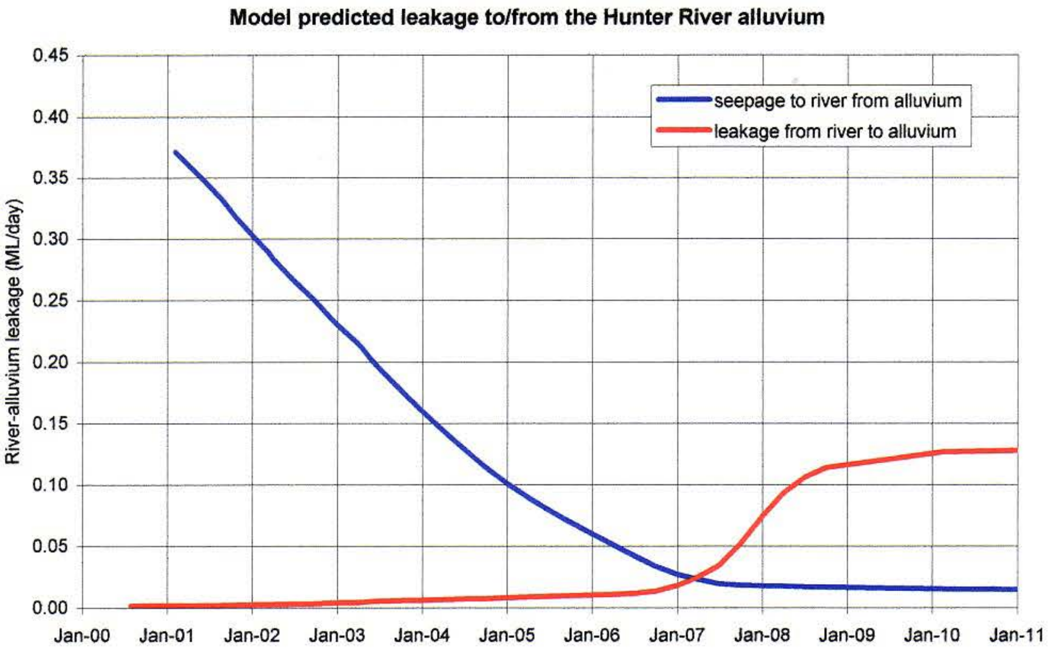
Model predicted pit seepage and river leakage to end of mining (approved area without barrier)

Figure 11



Water table decline over time
Extended mine limts - no barrier (2006 to 2009)





Note: decline in seepage to the river includes effects of drought

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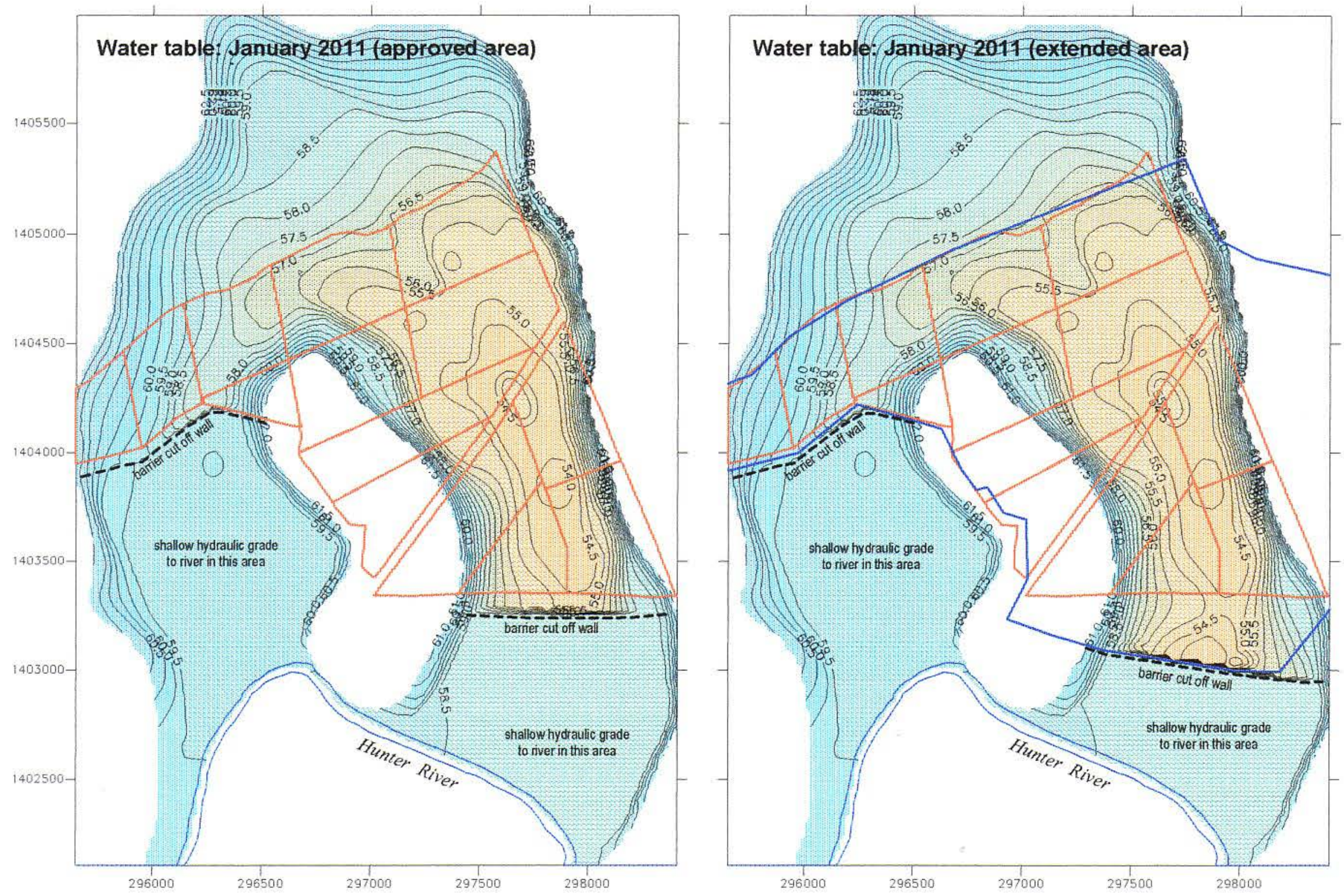
Model predicted pit seepage and river leakage to end of mining (extended area without barrier)

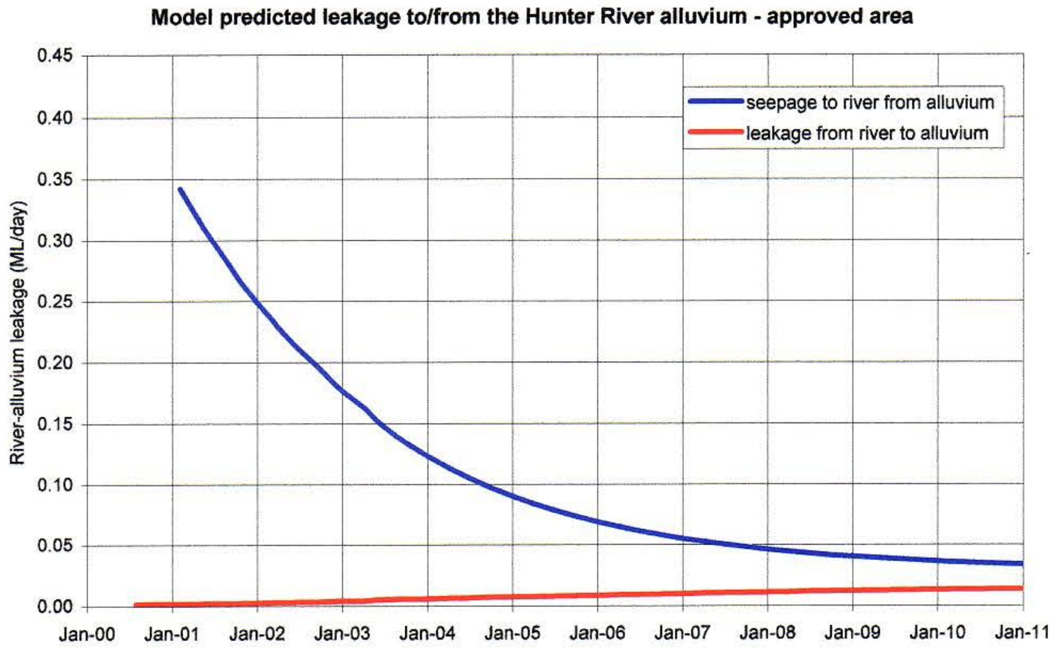
Figure 13

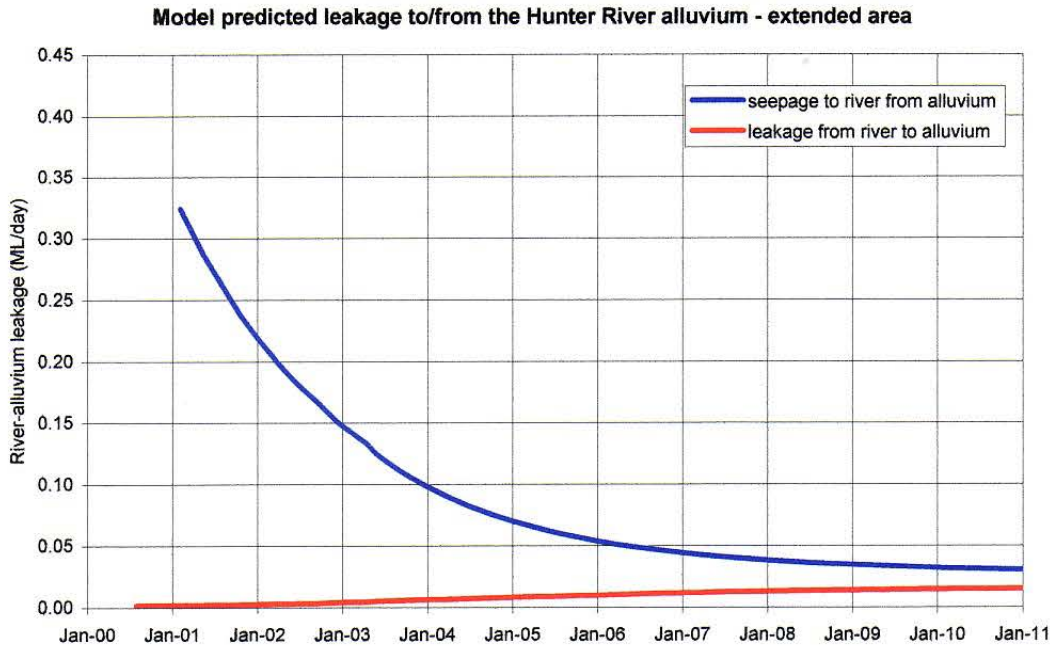


Note: mined areas not shown - contours in mined areas are set to base of alluvium

Comparison of water tables for approved and extended mine limts (barriers constructed)

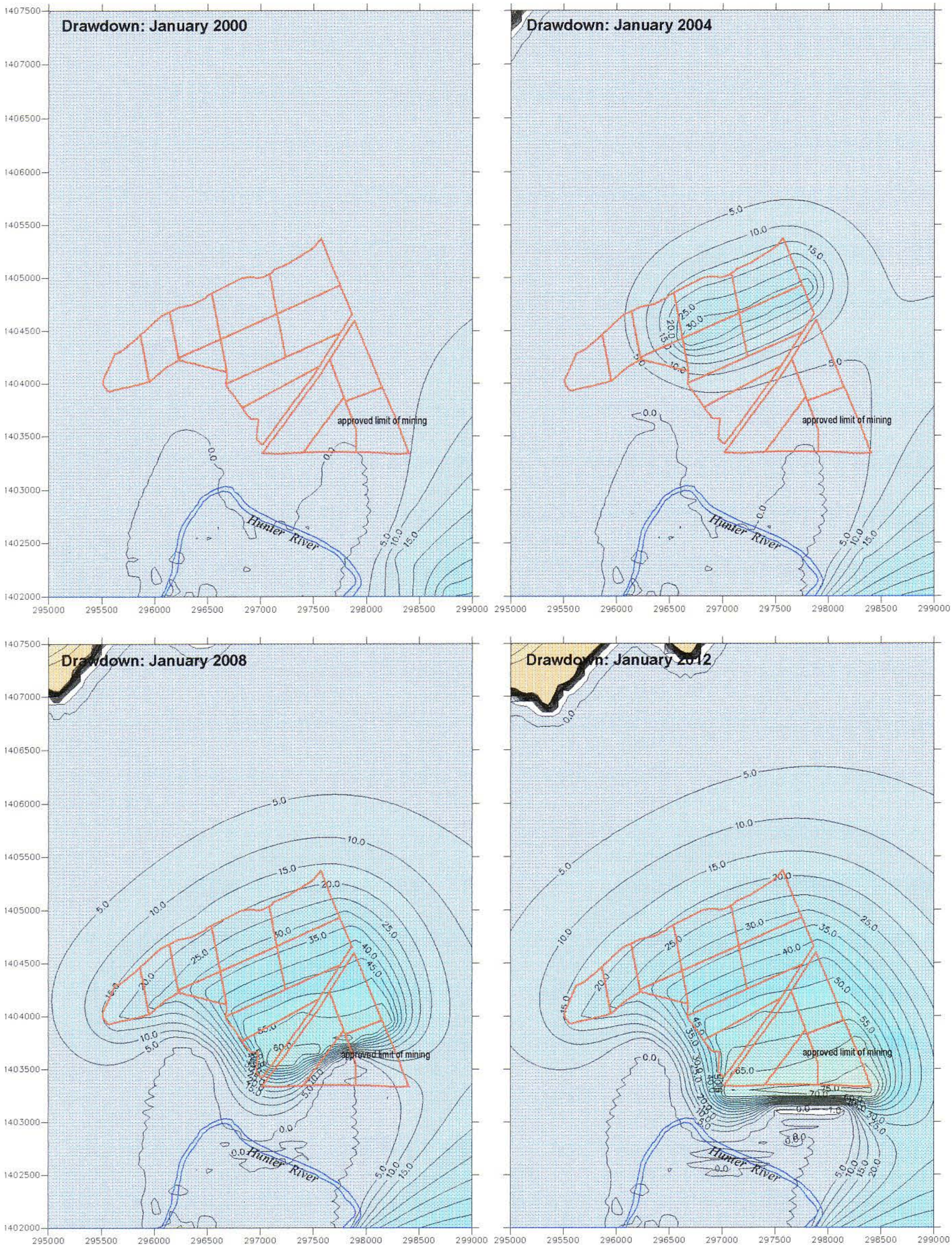
Figure 14





Comparison of leakage responses to/from the river for approved and extended area with barriers constructed

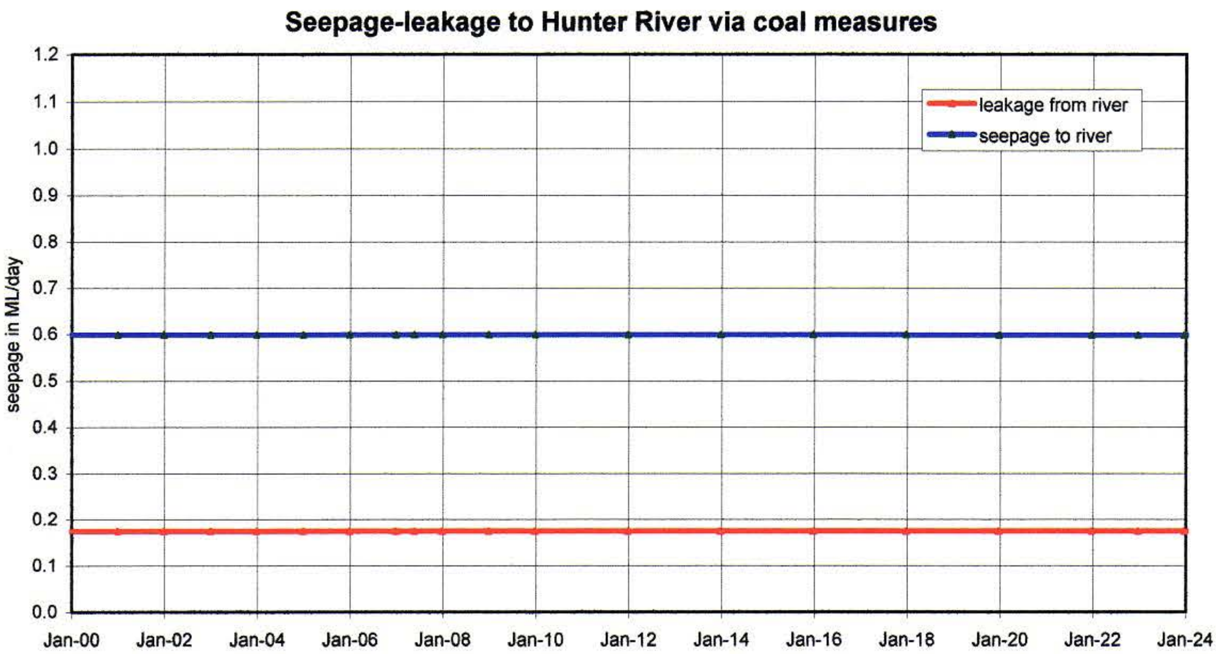
Figure 15

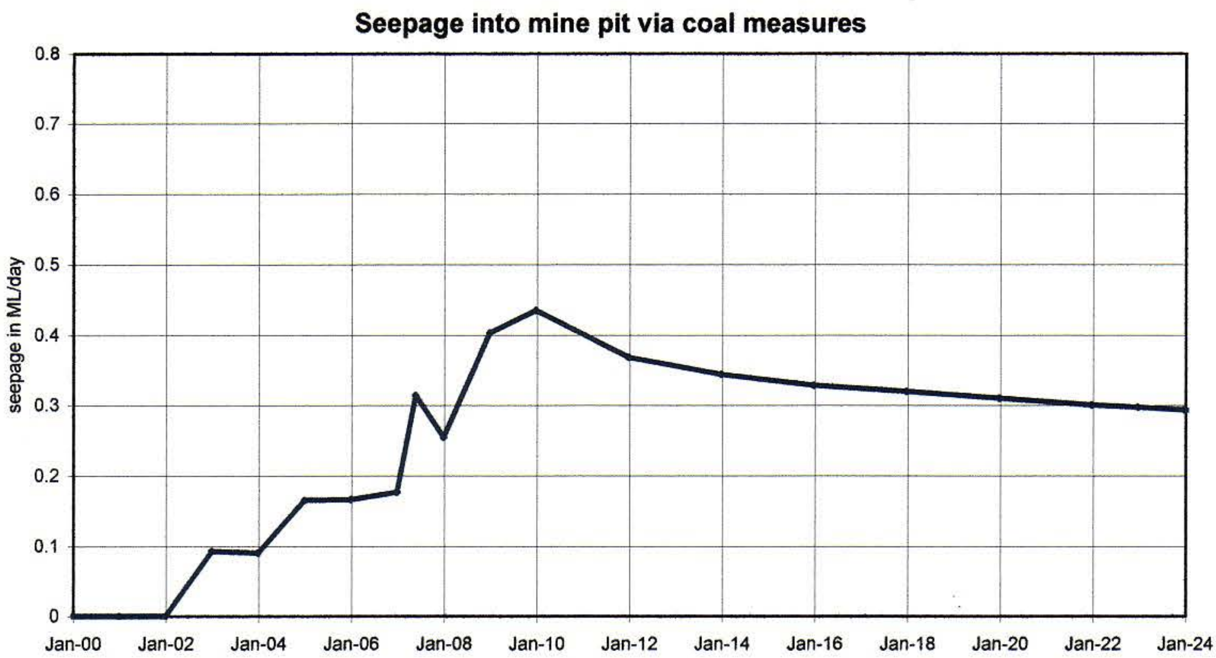


mined areas shown by shading

Drawdown in coal measures to completion of mining (2000 to 2012)

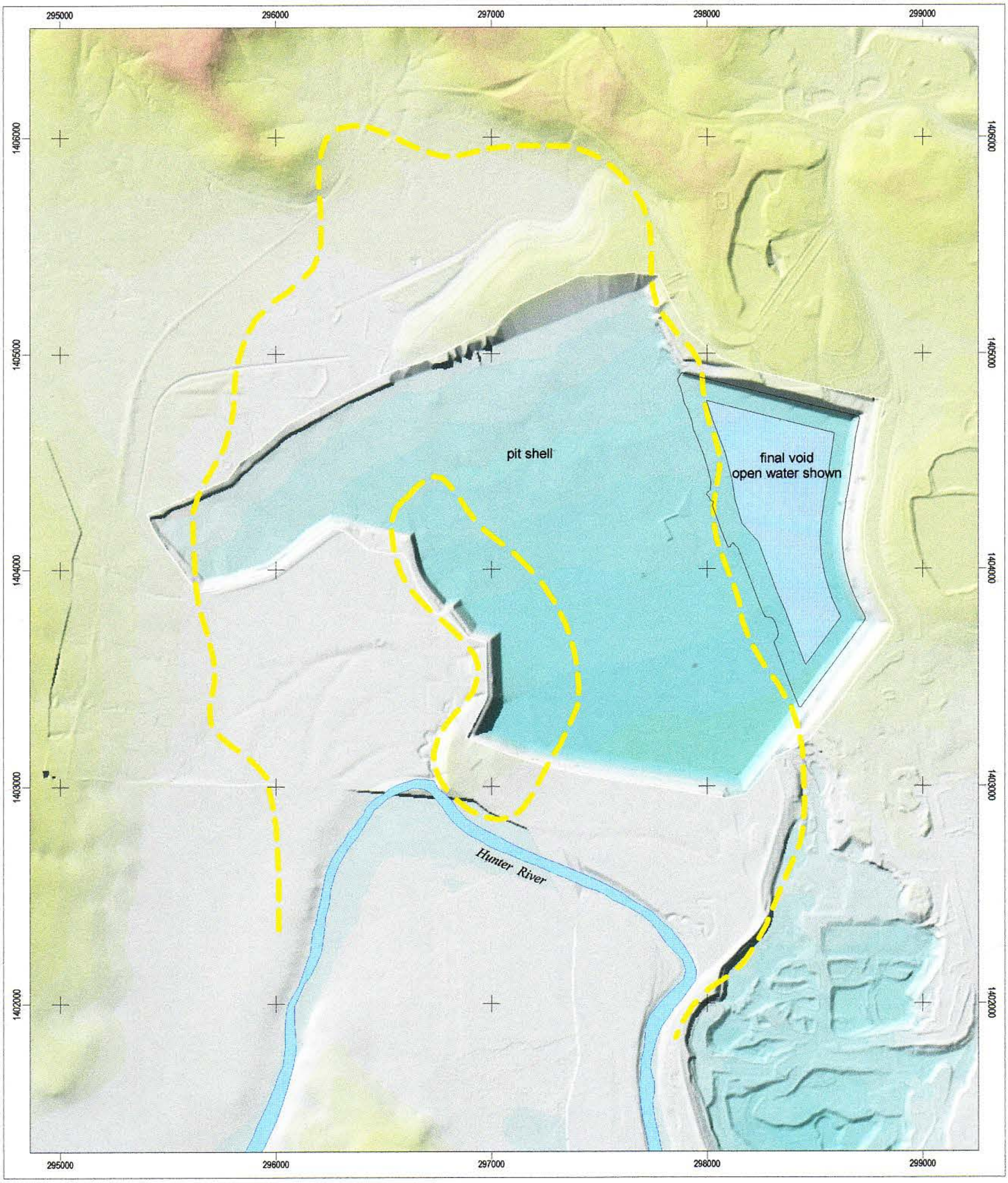
Figure 16





Pit seepage and river leakage estimates for hardrock pathway

Figure 17

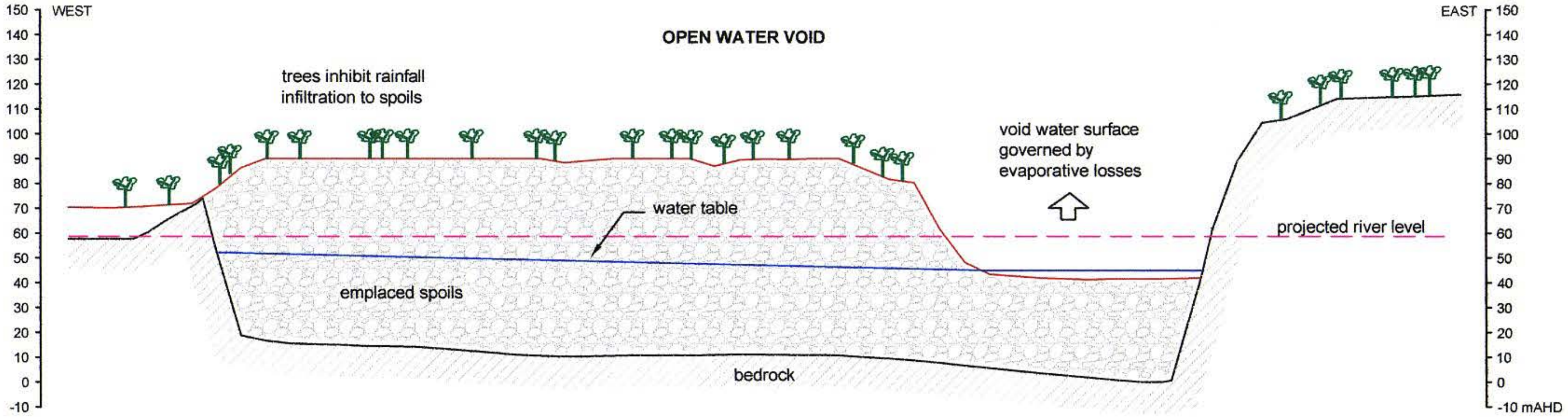


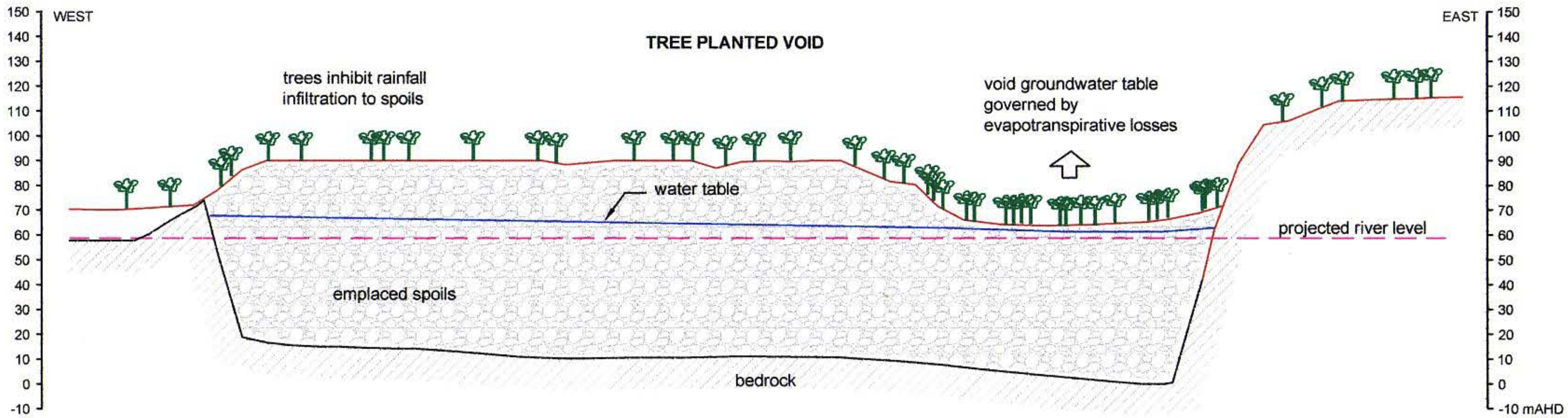
CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Final pit shell (filled with spoils) and open water void

Figure 18

Mackie Environmental Research



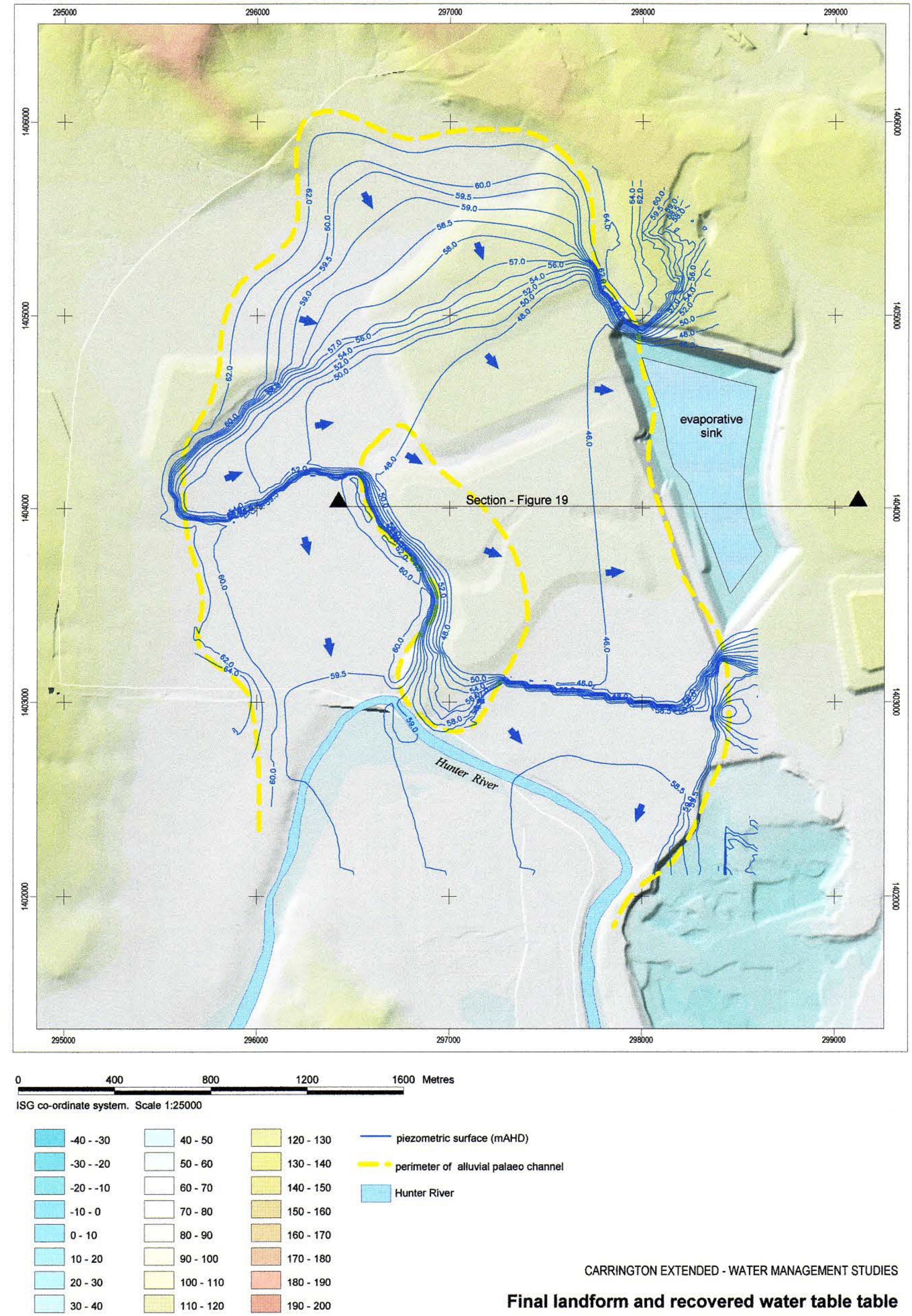


see Figure 19 for location of section

Options for final void closure

Figure 19

Mackie Environmental Research

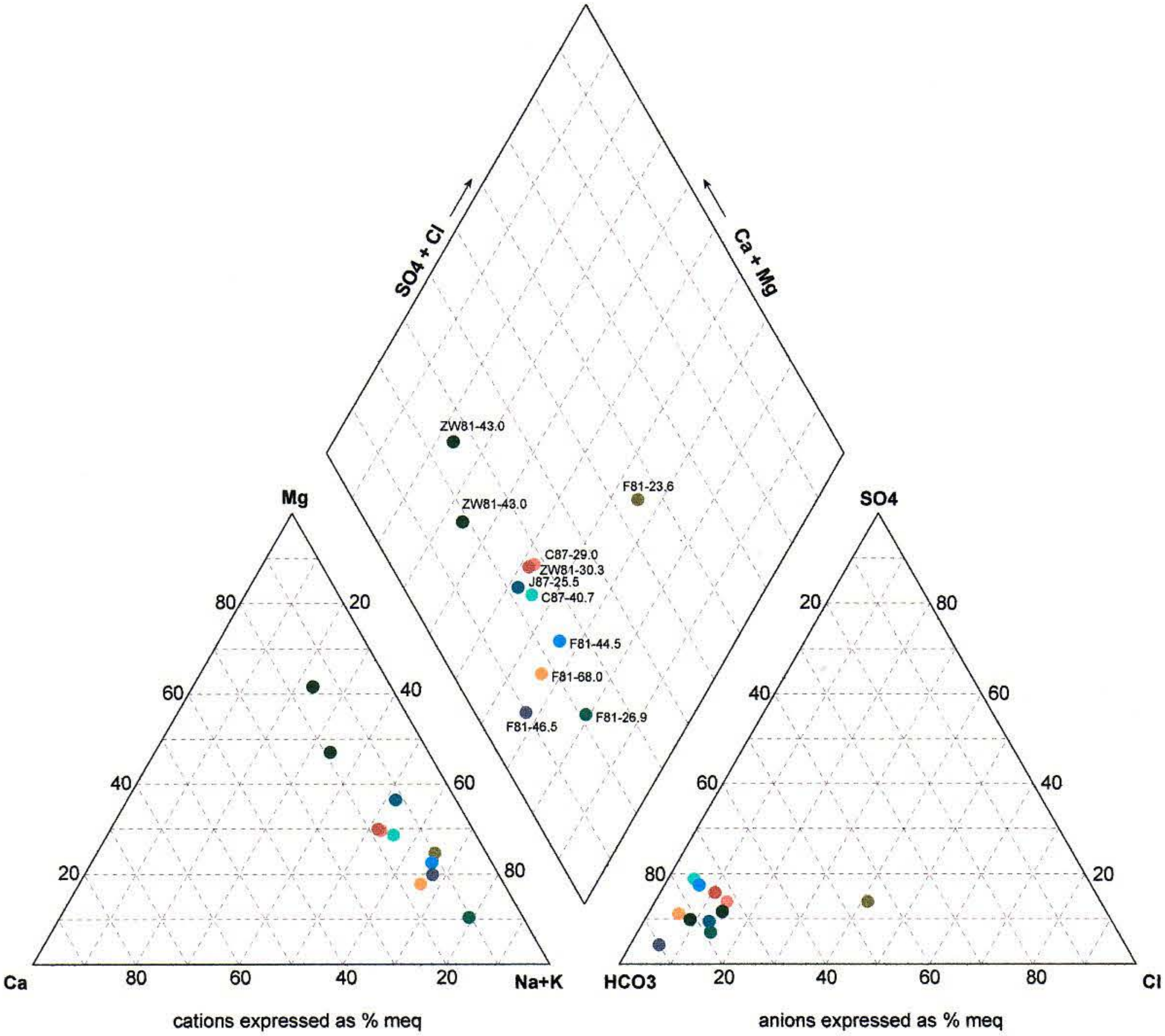


CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Final landform and recovered water table table

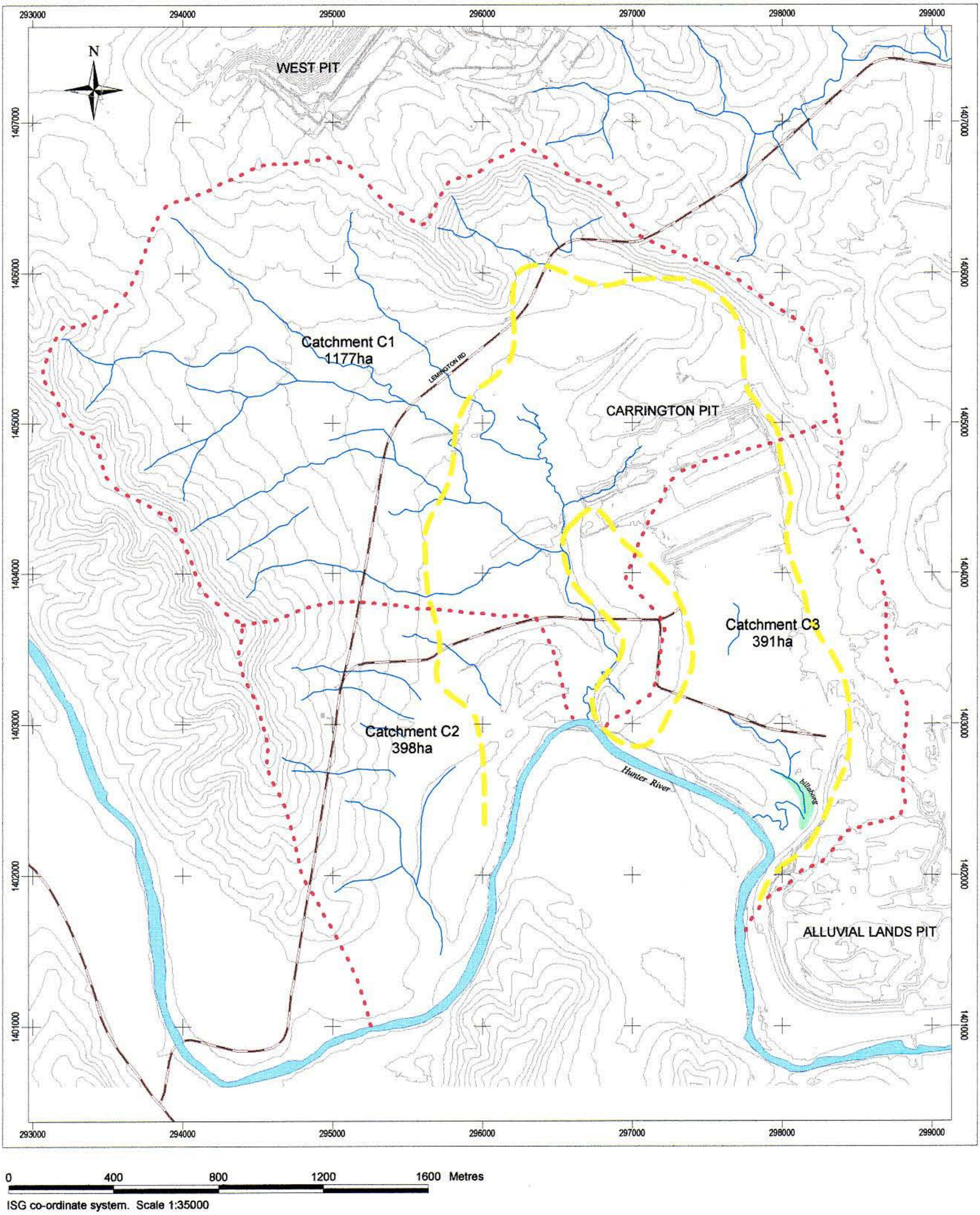
Figure 20

Mackie Environmental Research



Speciation of major ions for spoils leachates

Figure 21



ISG co-ordinate system. Scale 1:35000

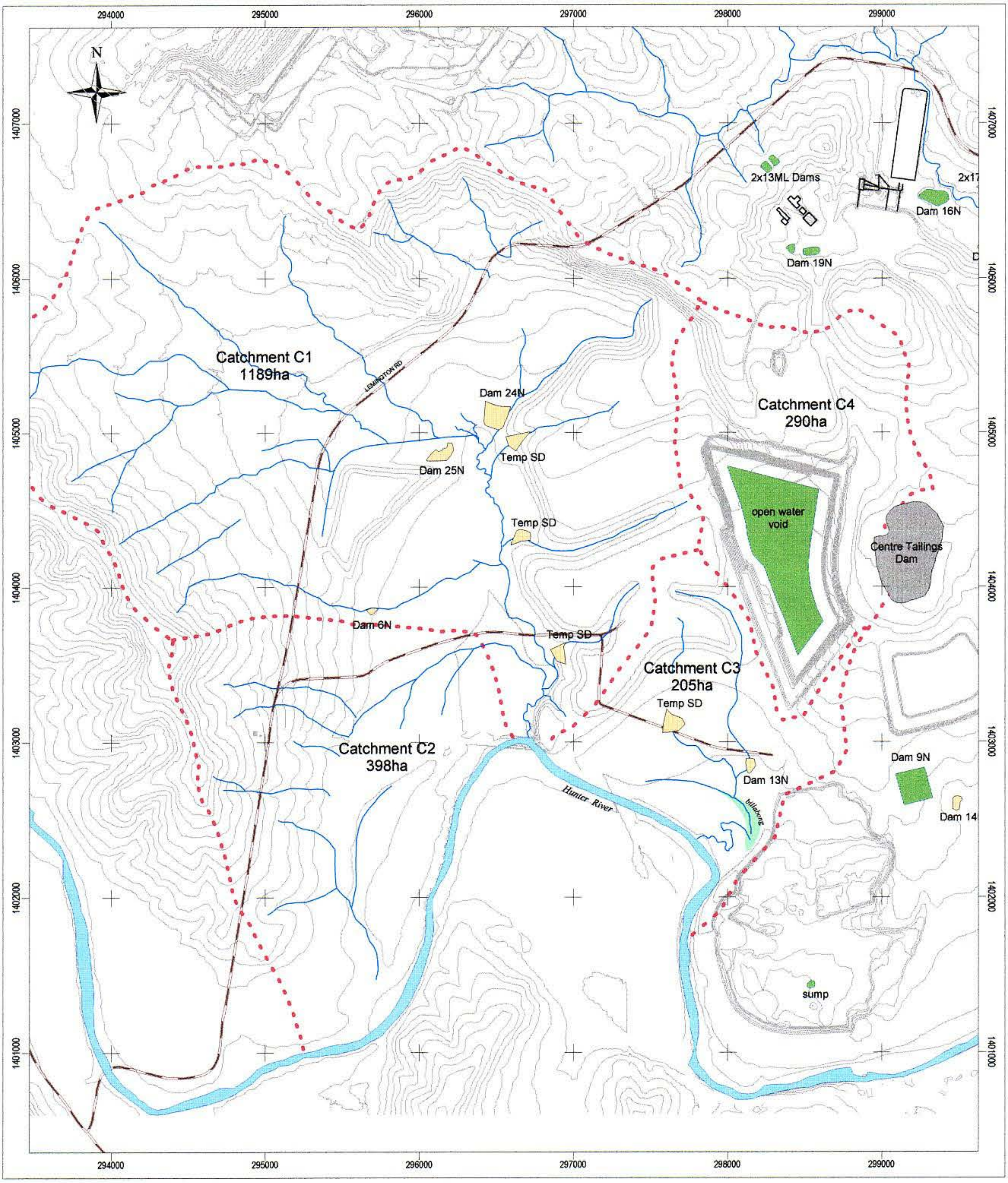
- catchment divide
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- Hunter River

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Regional catchments and drainage pre mining

Mackie Environmental Research

Figure 22



0 1000 2000 3000 Metres

ISG co-ordinate system. Scale 1:35000

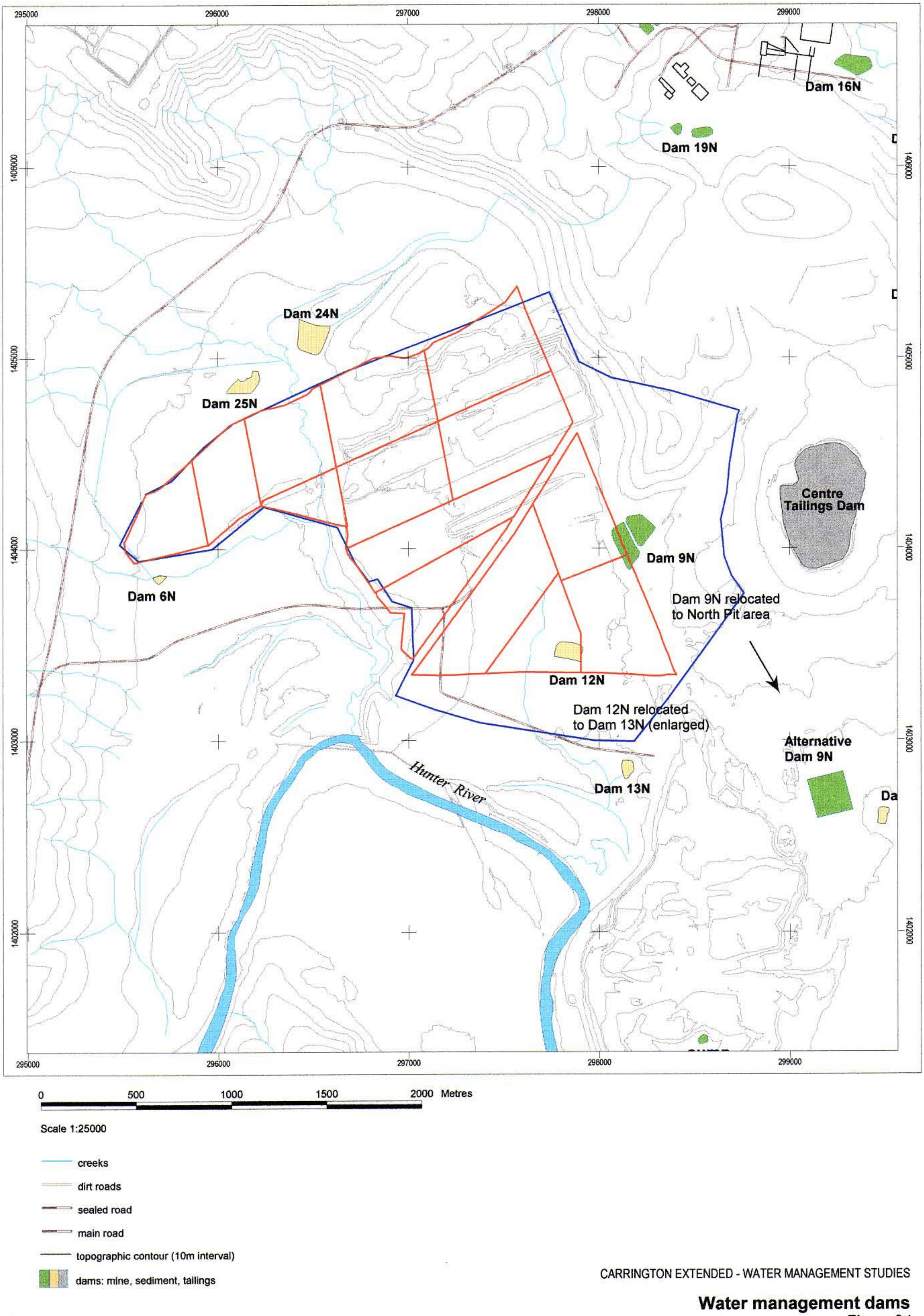
- catchment divide
- topographic contours 10m intervals
- Hunter River
- mine water dam
- sedimentation dam
- tailings dam

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Regional catchments and drainage post mining

Mackie Environmental Research

Figure 23

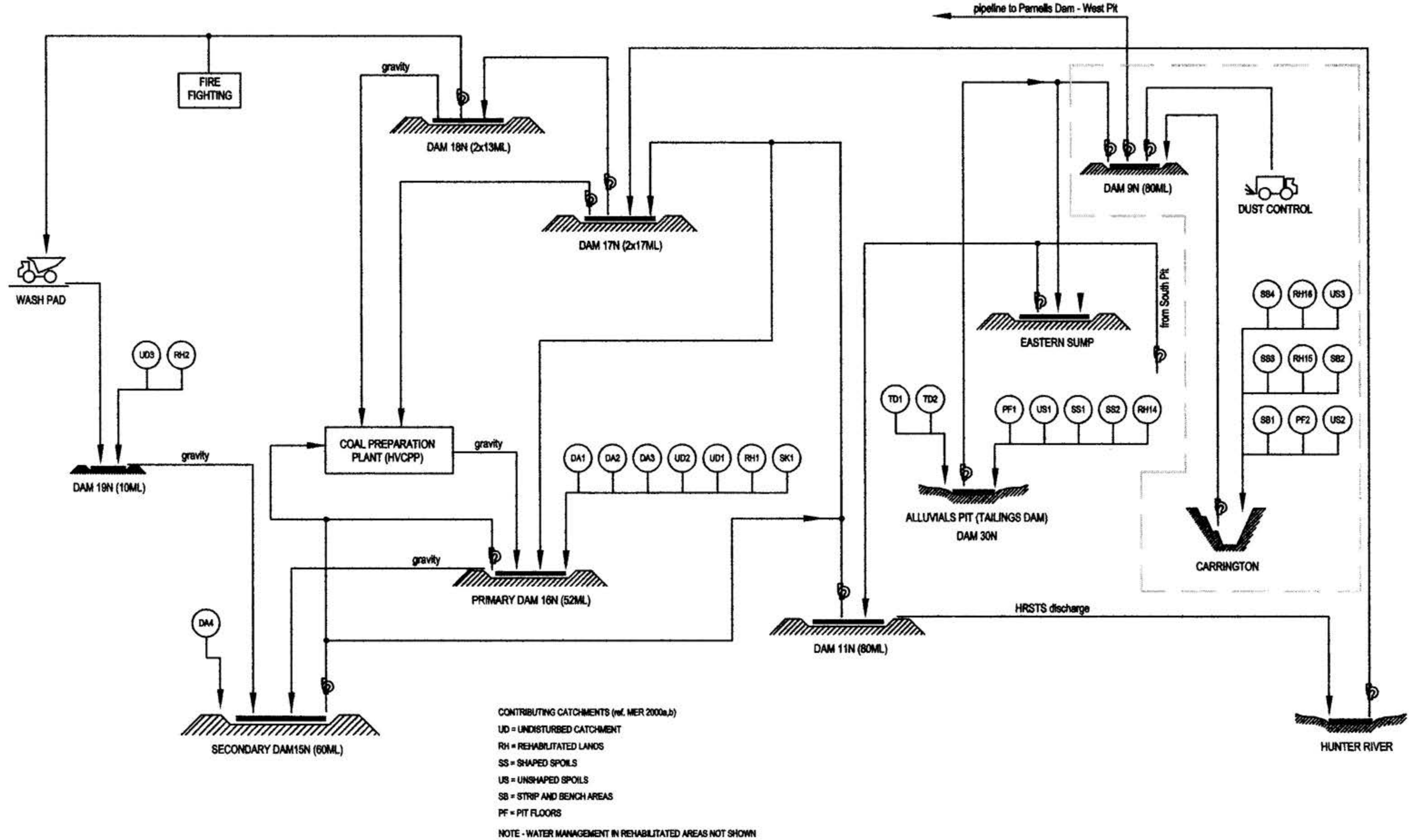


CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Water management dams

Figure 24

Mackie Environmental Research



NORTH PIT & CARRINGTON INTEGRATED MINE WATER SYSTEM - DEC. 2004

Figure 25

Mackie Environmental Research

APPENDIX A: PIEZOMETRIC MONITORING DATA

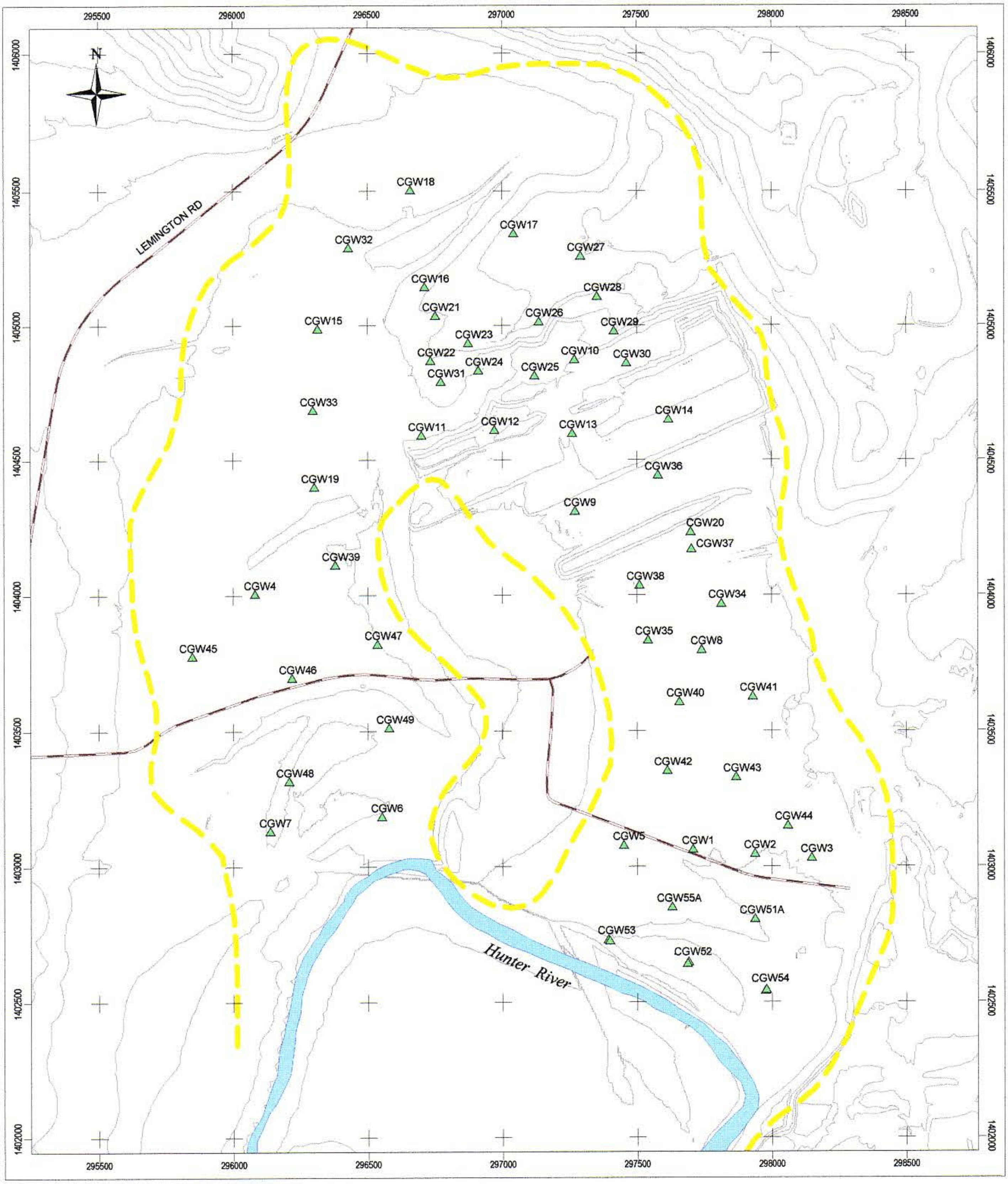
Groundwater levels and water qualities within the palaeochannel aquifer system, have been rigorously monitored since the commencement of mining operations. All measurements are undertaken by CNA appointed contractors – Ecowise Pty. Ltd.

Sampling has been undertaken at monthly, bi-monthly, quarterly and six monthly intervals. Measured parameters include groundwater depth/elevation, groundwater pH and EC, and full ionic speciation of selected water samples.

The following plots provide a concise summary of water levels and water quality data.

Table A1: Hydrochemical parameters for piezometers located in palaeochannel

Bore	Date	TDS	pH	EC	Ca	Mg	Na	K	CO3	HCO3	SO4	Cl
		mg/L		uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CGW1	Aug-04	6860	7.0	12000	93	290	2080	30	0	1415	625	3050
CGW3	Aug-04	7940	7.1	12500	120	410	1950	40	0	1610	700	3370
CGW39	Aug-04	4410	7.1	6900	126	229	980	8.8	0	976	195	1880
CGW43	Aug-04	5830	7.0	9900	91	265	1650	24	0	1098	650	2550
CGW47A	Aug-04	1760	7.2	3200	74	63	540	11.5	0	561	40	814
CGW48	Aug-04	1930	7.1	3500	120	139	430	3.2	0	1159	65	619
CGW6	Aug-04	2690	6.9	3700	160	144	400	7.6	0	744	85	867
CGW1	Sep-97	5710	7.23	9080	91	235	1680	16	0	1180	469	2380
CGW2	Sep-97	6360	7.34	8710	154	330	1810	25	0	1476	531	2740
CGW3	Sep-97	6100	7.19	8910	111	339	1830	31	0	1126	540	3030
CGW4	Sep-97	4980	7.39	8960	226	296	1270	15	0	739	304	2550
CGW6	Sep-97	3670	7.17	4190	205	210	843	7	0	797	238	1610
CGW7	Sep-97	1220	7.45	2200	92	82	275	5	0	754	65	332
CGW8	Sep-97	5340	7.16	8540	88	217	1670	21	0	1209	426	2310
CGW9	Sep-97	4600	6.95	7233	201	307	1040	11	0	1232	297	1890
CGW10	Sep-97	4070	6.99	7200	101	179	1250	18	0	1220	178	1780
CGW11	Nov-99	6460	7.28	9820	175	380	1750	10	0	1230	570	2780
CGW12	Nov-99	5720	7.29	8720	160	295	1600	7	0	1000	630	2380
CGW13	Nov-99	4800	7.26	7320	145	280	1350	10	0	1070	342	2060
CGW14	Nov-99	6020	7.11	9160	110	290	1800	29	0	1220	495	2560
CGW15	Nov-99	4980	7.29	8030	135	265	1400	13	0	970	348	2210
CGW16	Nov-99	5480	7.08	8785	140	290	1550	16	0	1070	525	2320
CGW17	Nov-99	5840	7.12	9225	150	340	1600	27	0	1140	585	2400
CGW18	Nov-99	5460	7.18	8670	140	300	1500	22	0	970	420	2410
CGW19	Nov-99	3840	7.11	6690	155	185	1120	9	0	990	228	1600



0 400 800 1200 1600 Metres

ISG co-ordinate system. Scale 1:20000

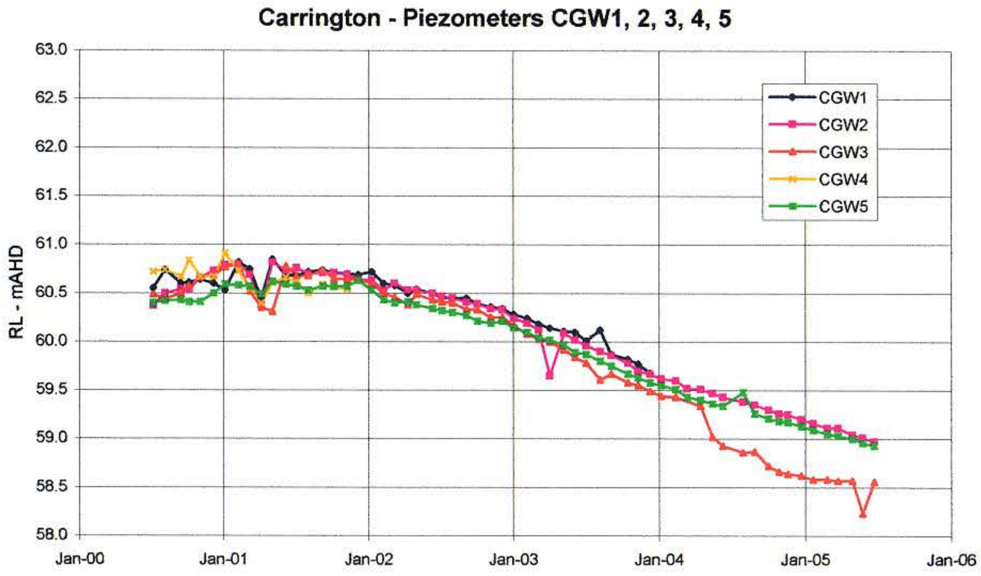
- piezometric surface (mAHD)
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- Hunter River

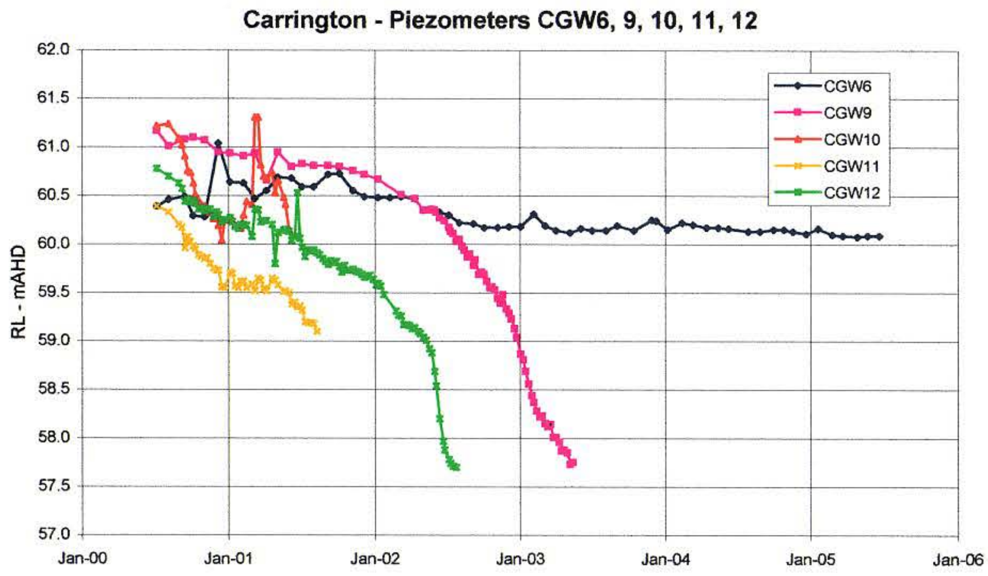
CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

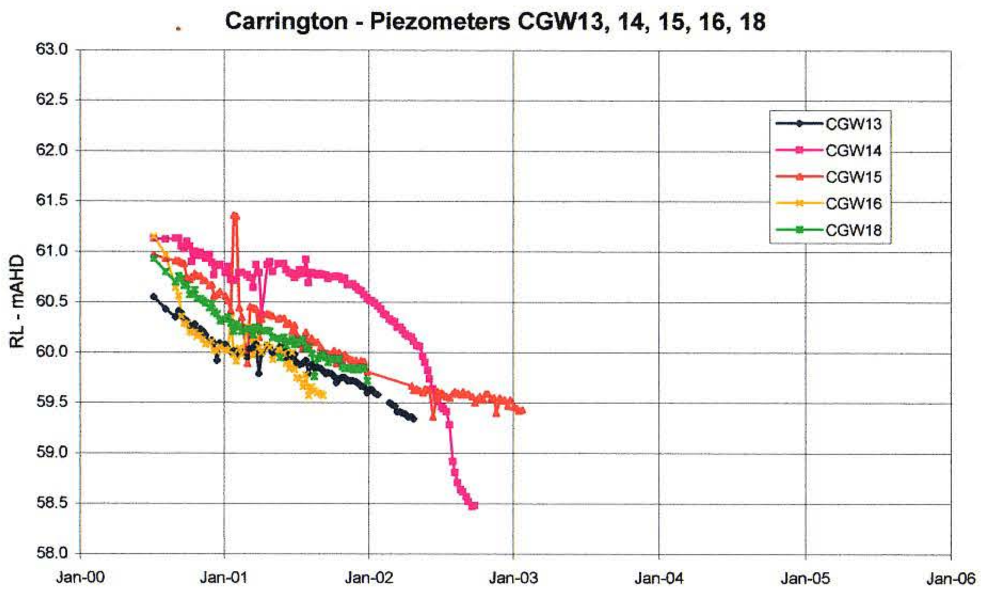
Locations of piezometers installed in palaeo channel

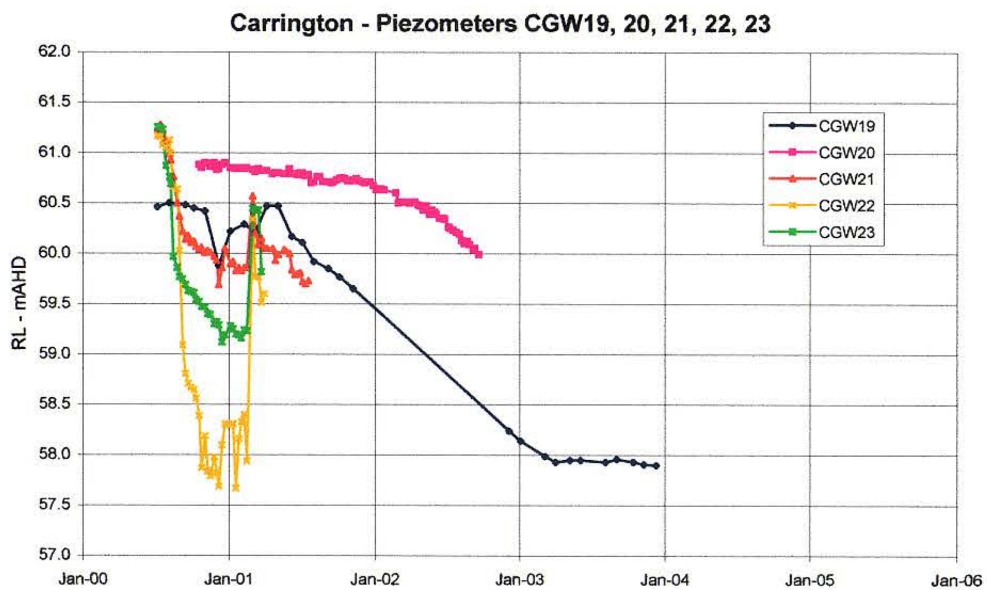
Figure A1

Mackie Environmental Research



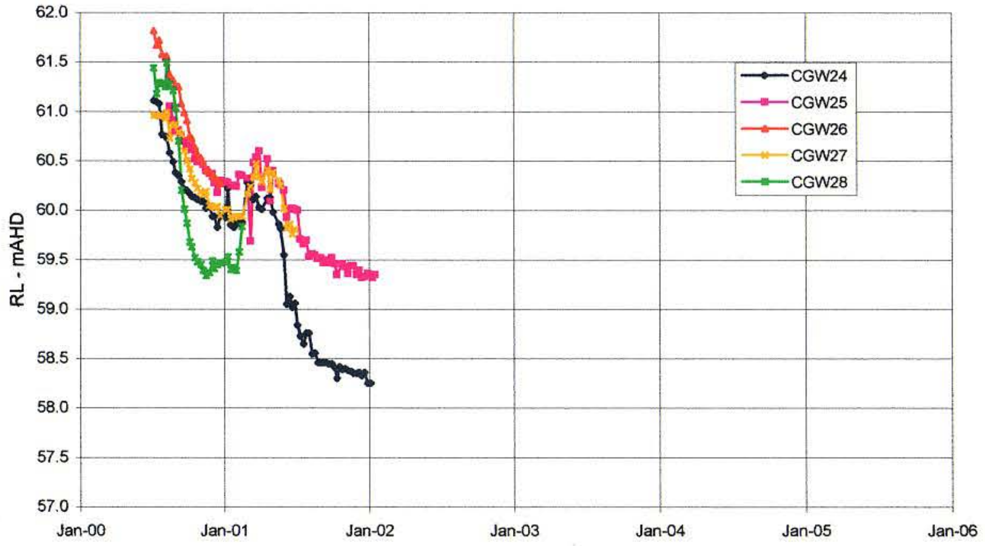




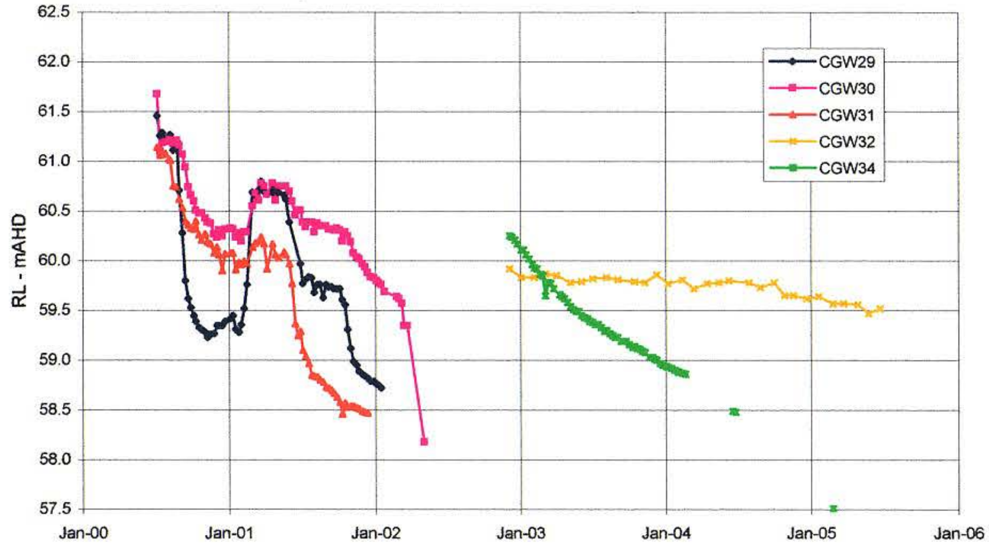


Piezometric elevations
Figure A2

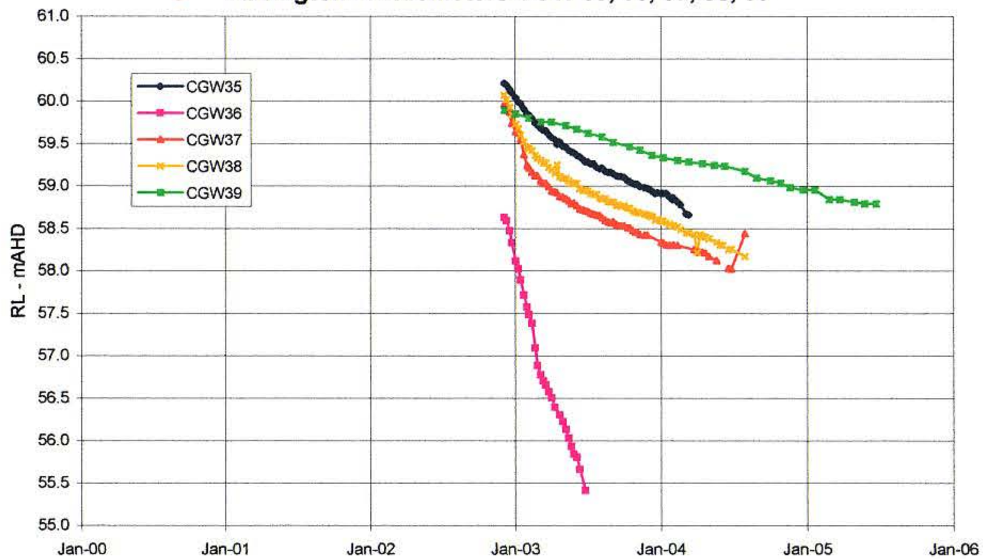
Carrington - Piezometers CGW 24, 25, 26, 27, 28



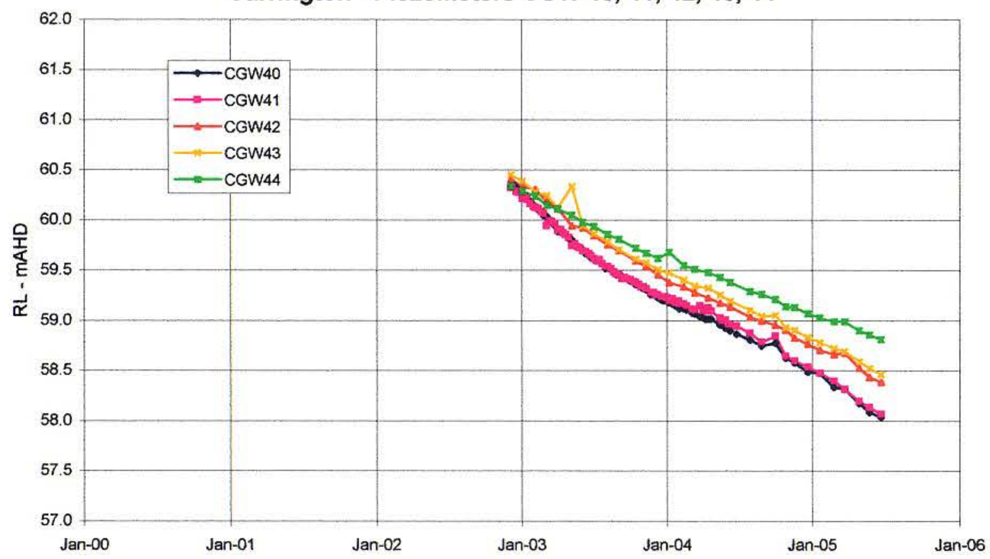
Carrington - Piezometers CGW 29, 30, 31, 32, 34



Carrington - Piezometers CGW 35, 36, 37, 38, 39

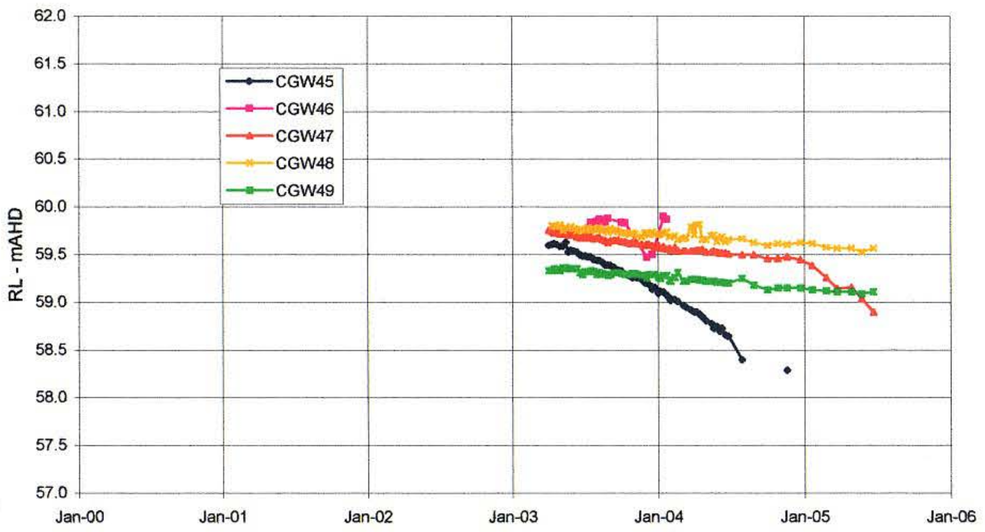


Carrington - Piezometers CGW 40, 41, 42, 43, 44

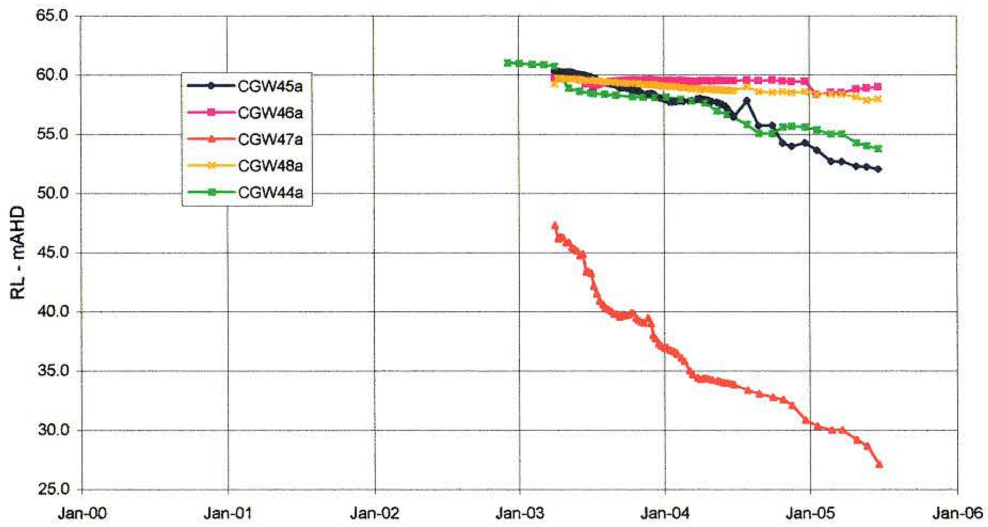


Piezometric elevations
Figure A2

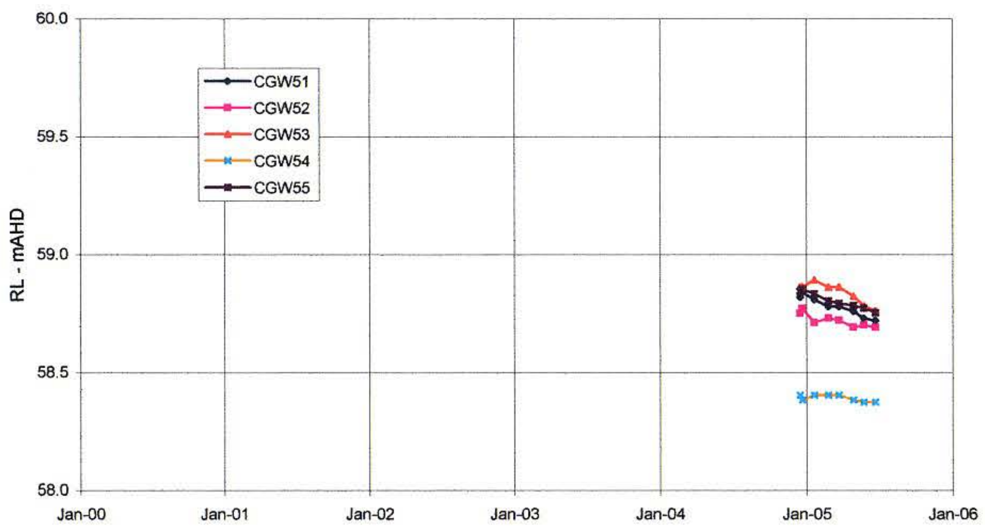
Carrington - Piezometers CGW45, 46, 47, 48, 49



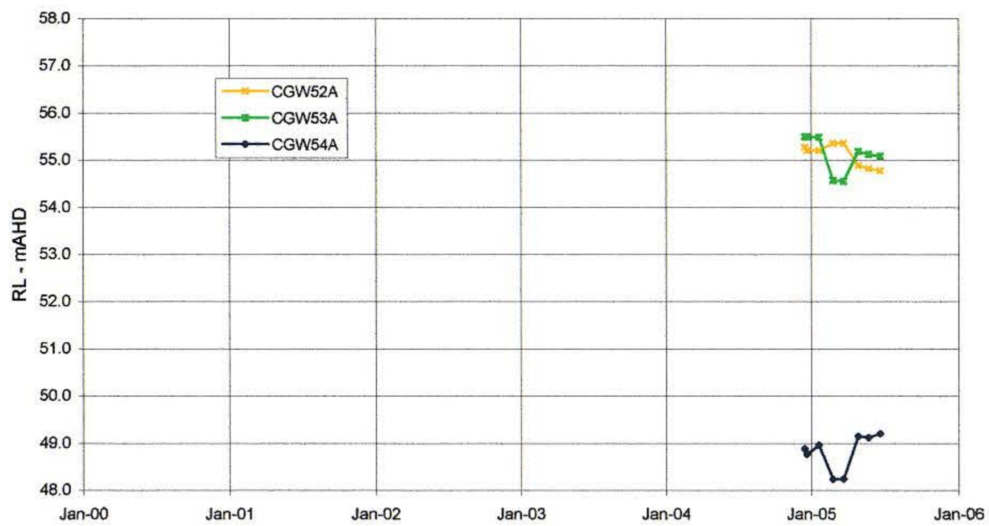
Carrington - Piezometers CGW44a, 45a, 46a, 47a, 48a



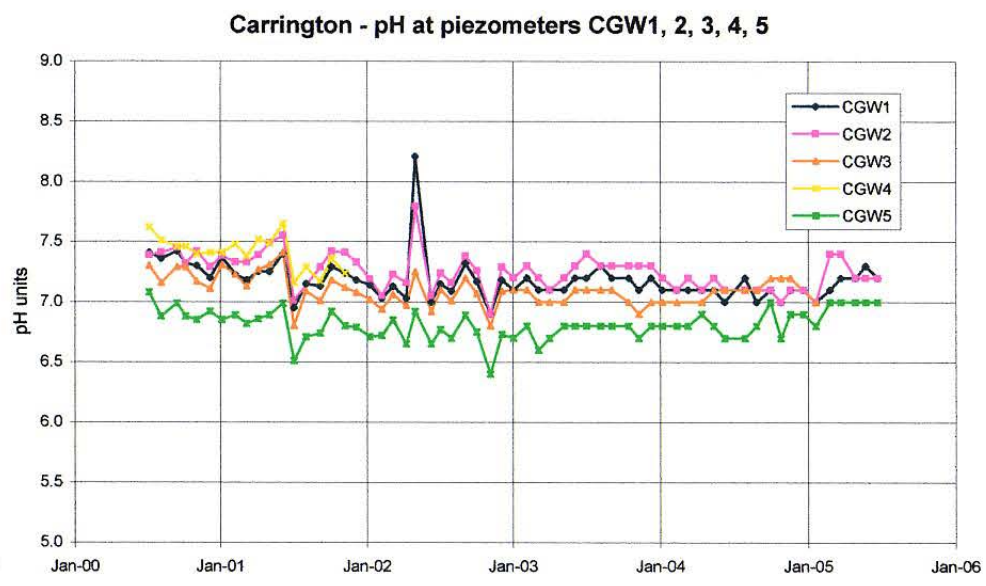
Carrington - Piezometers CGW51, 52, 53, 54, 55

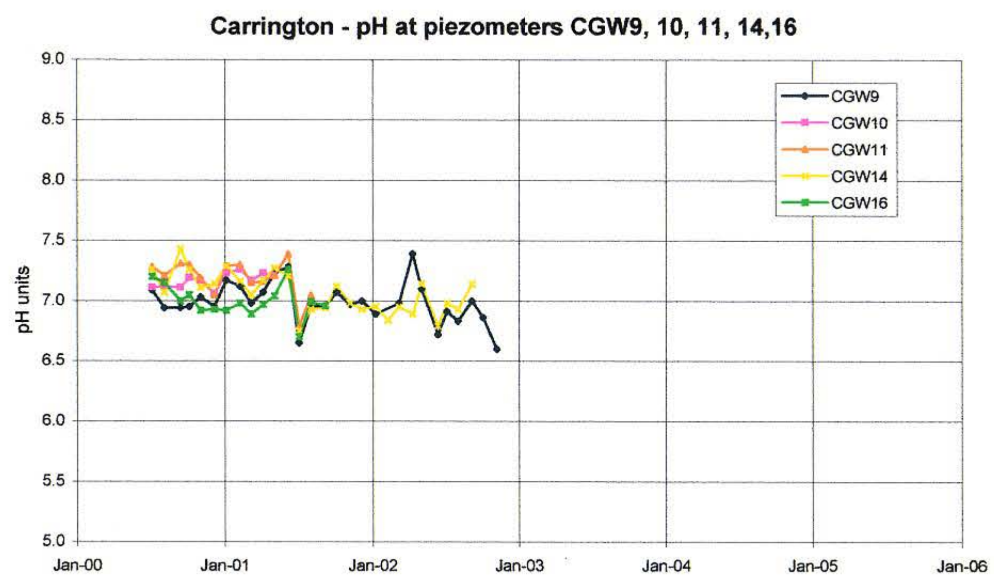


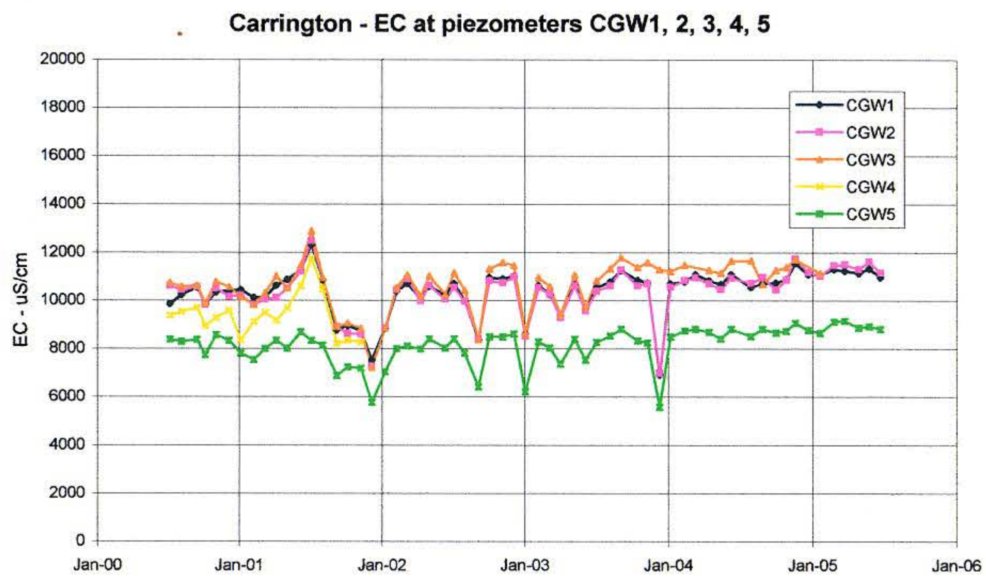
Carrington - Piezometers CGW52A, 53A, 54A

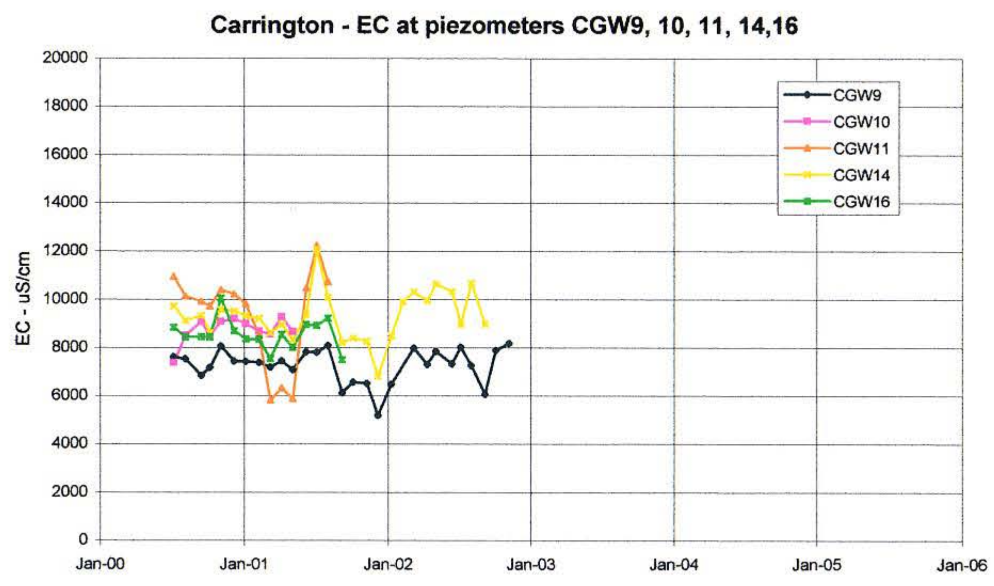


Piezometric elevations
Figure A2







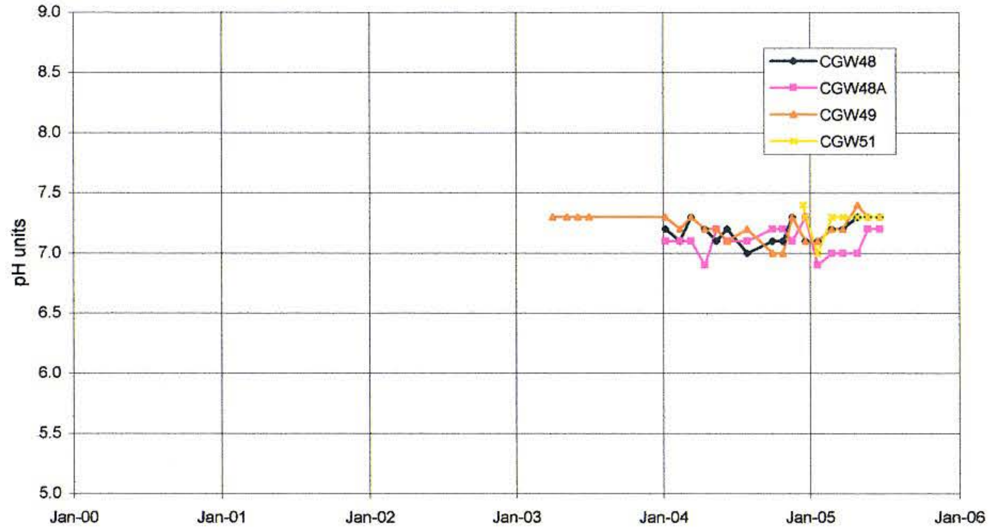


pH and EC data

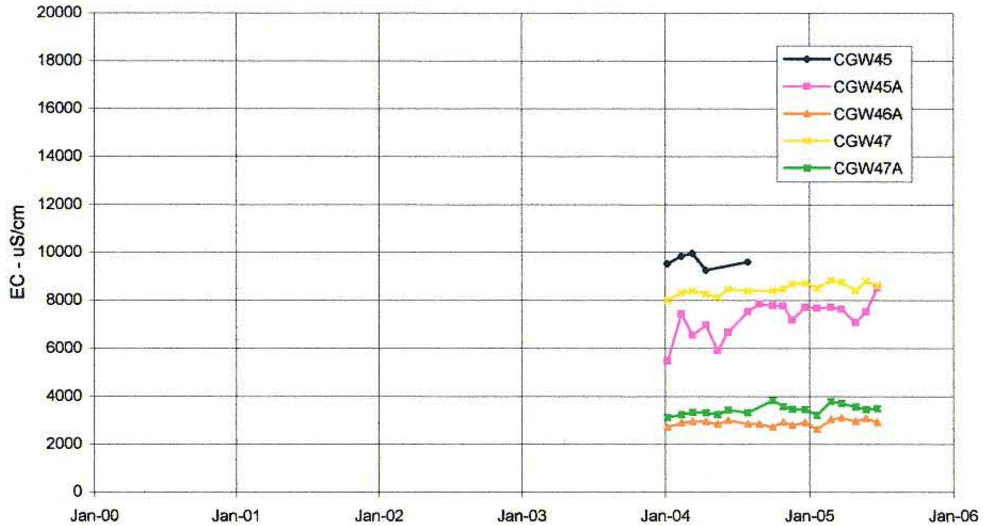
Figure A3

Carrington - pH at piezometers CGW45, 45A, 46A, 47, 47A

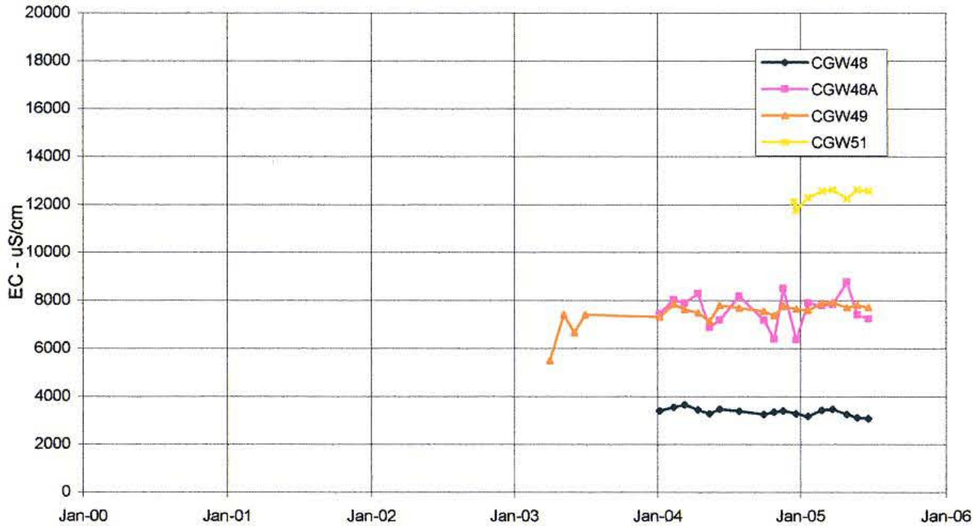
Carrington - pH at piezometers CGW48, 48A, 49, 51



Carrington - EC at piezometers CGW45, 45A, 46A, 47, 47A

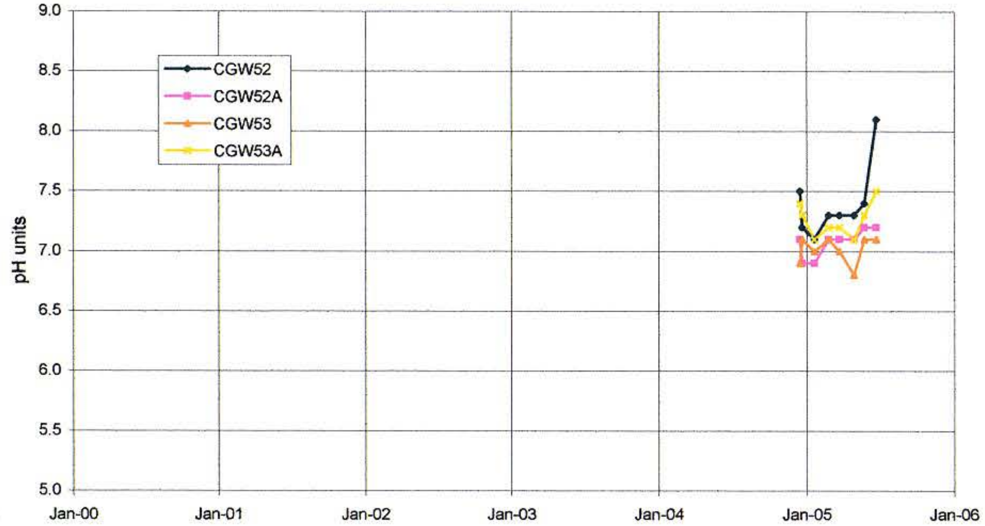


Carrington - EC at piezometers CGW48, 48A, 49, 51

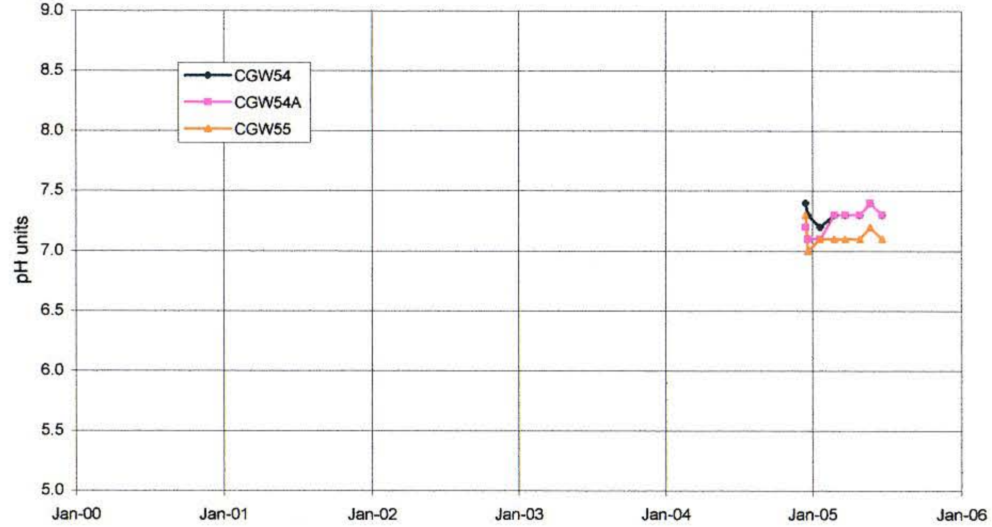


pH and EC data
Figure A3

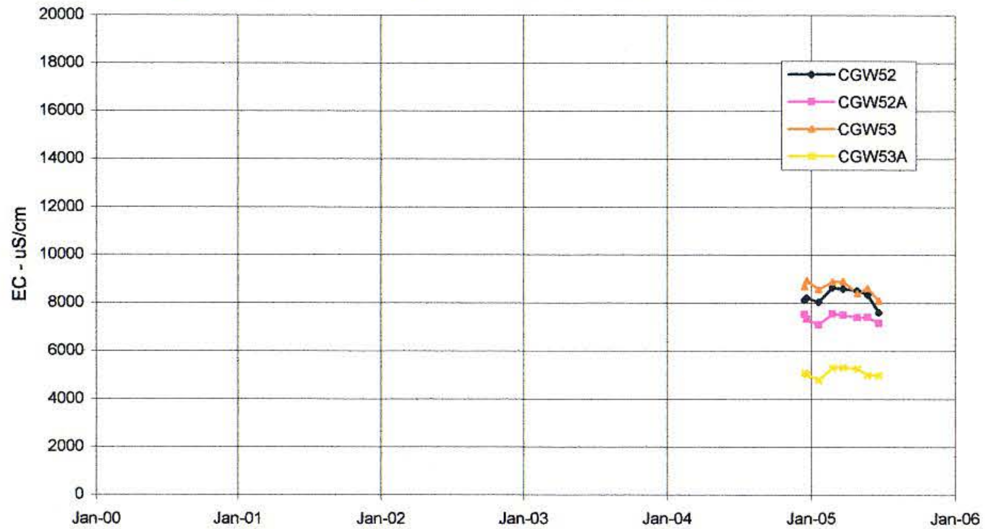
Carrington - pH at piezometers CGW52, 52A, 53, 53A



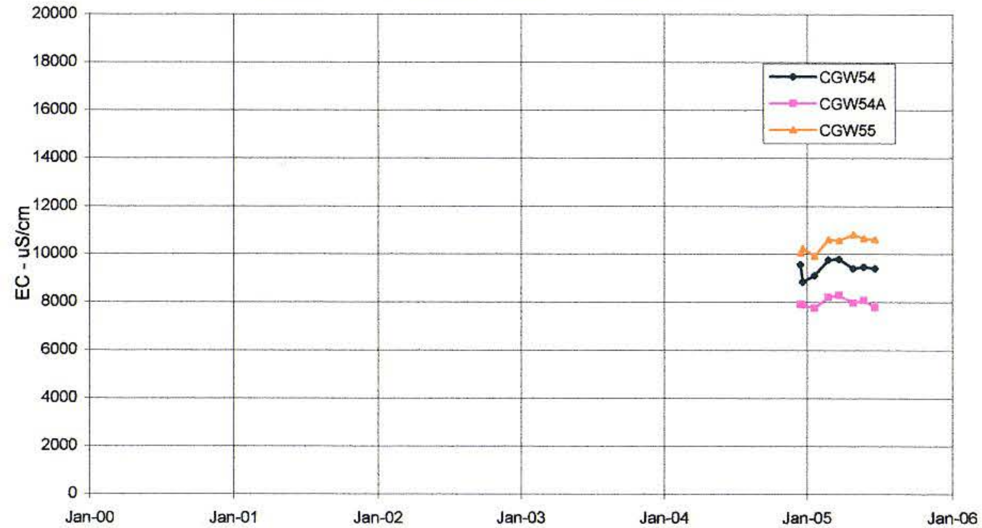
Carrington - pH at piezometers CGW54, 54A, 55



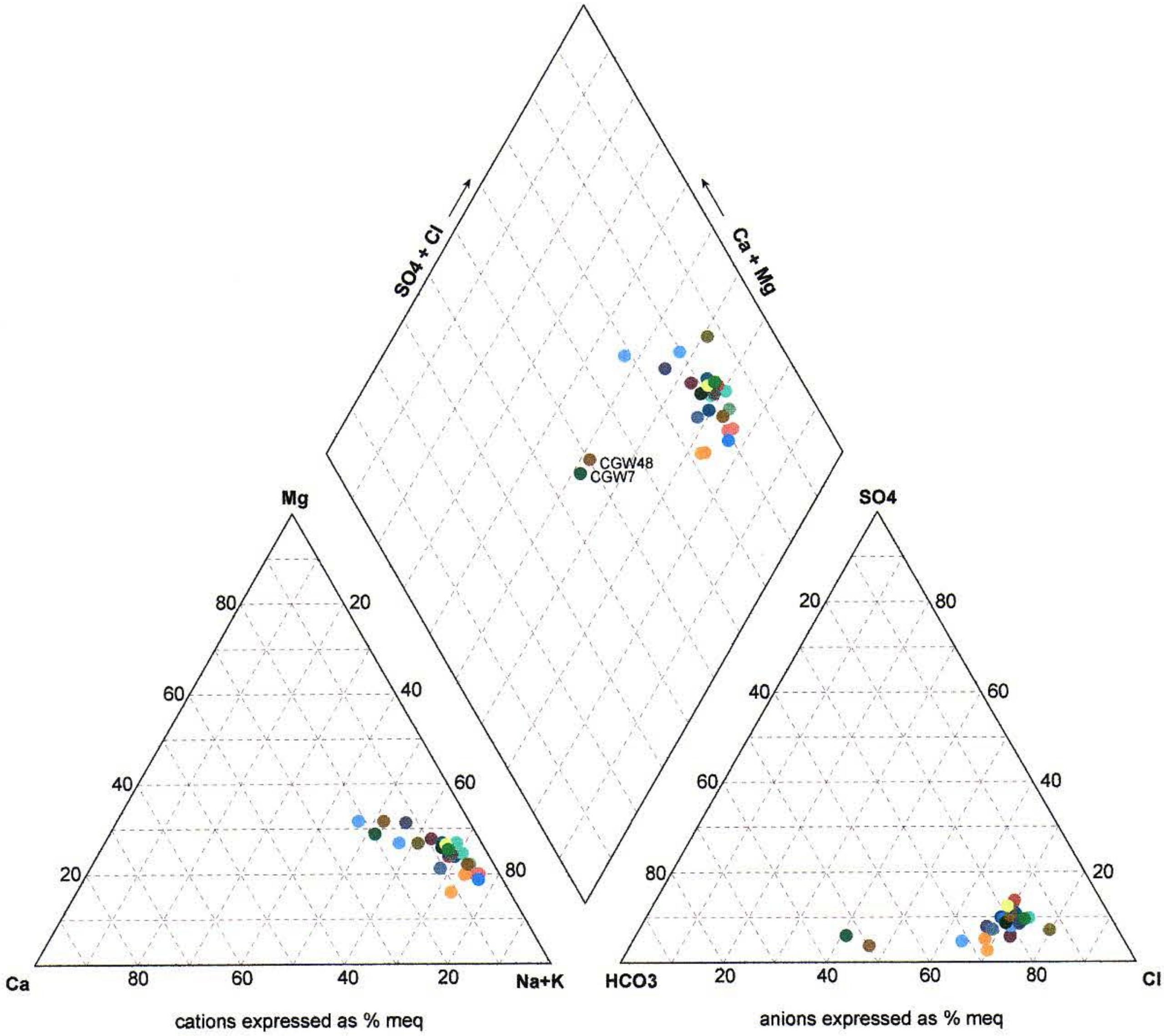
Carrington - EC at piezometers CGW52, 52A, 53, 53A



Carrington - EC at piezometers CGW54, 54A, 55



pH and EC data
Figure A3



CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Speciation of major ions for groundwaters

Mackie Environmental Research

Figure A4

APPENDIX B: FORMATION HYDRAULIC CONDUCTIVITIES

Aquifer testing provides a means of estimating the groundwater transmission and storage characteristics of a geological formation. Various procedures can be employed depending upon the saturated aquifer thickness, regional extent, transmission properties and bore completions. Testing in the area includes historical packer testing of seams (AGC, 1984) and laboratory core testing of interburden.

B1.1 Historical packer test data

AGC (1984) provide packer test estimates of hydraulic conductivity for the Barrett, Liddell, Arties and Pikes Gully seams. Reported values are represented in Table B1 for completeness. These tests support a mean value (log normal) of about 0.066m/day. This conductivity is higher than is generally expected as a mean value for seams in the region but has been adopted in bulk conductivity estimates in the absence of more recent data. The high values for all seams could be attributed to dilation, rupture or even poor sealing (of packers) when compared to interburden sections. The reported values are considered to reflect an upper limit to seam conductivities.

Table B1: Hydraulic conductivity estimates from packer tests (source AGC, 1984)

Seam	Depth (m)	Kxy (m/day)
Howick South - Barrett	75	1.60E-01
Howick South - Barrett	140	2.00E-02
Howick South - Barrett	108	6.00E-03
Howick South - Barrett	84	1.60E-01
Howick South - Liddell	42	1.01e+00
Howick South - Liddell	56	5.00E-02
Howick South - Liddell	104	1.10E-01
Howick South - Liddell	109	1.20E-02
Howick South - Liddell	121	1.20E-02
Howick South - Liddell	72	1.20E-01
Howick South - Liddell	92	1.50E-02
Howick South - Liddell	53	1.50E-01
Howick South - Liddell	69	9.80E-02
Howick South - Liddell	54	1.70E-02
Howick South - Arties	18	7.00E-01
Howick South - Arties	77	3.00E-01
Howick South - Arties	51	3.80E-01
Howick South - Arties	60	3.00E-02
Howick South - Arties	36	5.00E-01
Howick South - Pikes Gully	27	5.00E-03
Howick South - Pikes Gully	27	6.00E-03
Howick South - Pikes Gully	41	1.60E-01
Howick South - Pikes Gully	46	1.10E-01

B1.2 Piezometer airlift tests

Airlift V-notch weir measurements were conducted on exploration holes in the Ravensworth West area (MER, 1997). These measurements provide an indication of the bulk conductivity of coal measures strata to the north-east of Carrington. An average value for the coal measures in this area (mainly coal seams) is 1.30E-02m/day.

B1.3 Pumping and falling head tests in selected piezometers

Pumping and falling head tests have been conducted at a number of locations where a piezometer has been located either in alluvium or in interburden. Results of these tests are summarised in MER 1999 and more recent tests in the following Table B2.

Table B2: Hydraulic conductivity estimates from falling head tests

Piezometer	Lithology	Kxy (m/day)
CGW6	alluvium	1.35E+01
CGW48A	alluvium	1.19E+01
CGW49	alluvium	5.60E+00
CGW51A	alluvium	5.10E-01
CGW52A	alluvium	8.00E-01
CGW53A	alluvium	5.30E+01
CGW54A	alluvium	8.40E-01
CGW55A	alluvium	1.40E-01
CGW48	Broonie 1	3.00E-01
CGW52	Broonie 1	3.60E-02
CGW53	Broonie 1	3.10E-02
CGW54	Broonie 1	3.10E-02

B1.4 Interburden core tests

Laboratory core testing provides a means of determining the hydraulic conductivity of materials at an intergranular scale consistent with porous media (Darcian) flow. This estimate is typically the lowest conductivity for a specific rock type and is most representative of strata where fracturing and jointing is limited, or where fractures and joints are relatively disconnected.

Core from 6 holes in the Carrington area and one hole to the north of Carrington have previously been sampled and subjected to hydraulic conductivity testing (MER 1997, MER 1999, MER 2003. The test method employed helium gas as the test 'fluid' and generated an estimate of Klinkenberg permeability (K_{inf}). Certain core slugs were cut in both the vertical and horizontal directions thereby enabling an estimate of the prevailing 'micro' anisotropy within a specific rock type. Results are summarised in the following Table B3.

Table B3: Hydraulic conductivity estimates for interburden from core laboratory tests

Area	Depth (m)	Core	Stratigraphic location	Kxy (m/day)	Kz (m/day)	Anisotropy
West Pit ext.	13.8	sandstone - fg with lams of siltstone	between Lemington seams	7.67E-06	6.60E-06	1.16
West Pit ext.	33.3	sandstone - fg with lams of siltstone	between Lemington seams	4.92E-06		
West Pit ext.	47.6	sandstone - fg with frequent lams of siltstone	between Lemington seams		2.16E-06	
West Pit ext.	66.3	sandstone - fg	between Pikes Gully seams	1.00E-05	2.57E-06	3.92
West Pit ext.	77.0	siltstone - mfg with finer lams	below Pikes Gully seams		2.03E-06	
West Pit ext.	86.0	sandstone - mfg to fg	above Arties seam		1.20E-05	
West Pit ext.	101.4	sandstone - laminated with silty bands	between Arties seams	1.05E-05	3.74E-06	2.80
West Pit ext.	115.0	siltstone - laminated	below Arties seam		8.00E-07	
West Pit ext.	117.5	sandstone-siltstone - laminated	below Arties seam		1.18E-06	
West Pit ext.	126.4	sandstone - mg	above Liddell seam	4.60E-05		
West Pit ext.	145.6	sandstone - mg with carb lams	between Liddell seams	2.80E-06	2.46E-06	1.14
West Pit ext.	166.3	sandstone - mg with carb lams	above Barrett seam	2.67E-06		
West Pit ext.	178.0	sandstone - mg with carb lams	below Barrett seam	1.66E-06	1.49E-06	1.12
Ravensworth	70.3	sandstone - mg well cemented	Archerfield Sandstone	1.25E-05	1.99E-05	0.63
Ravensworth	52.3	siltstone	between Broonie seams	2.49E-06		
Ravensworth	56.5	sandstone		2.32E-05	1.08E-05	2.15
Ravensworth	51.6	sandstone		3.82E-05	2.82E-05	1.35
Ravensworth	97.5	siltstone	above Bayswater seam		8.30E-07	
Ravensworth	60.9	sandstone - siltstone	between Broonie seams	8.30E-07	8.30E-07	1.00
Ravensworth	90.5	sandstone - mfg	between Broonie seams		5.93E-06	
Ravensworth	91	sandstone	between Broonie seams	1.25E-05	7.47E-06	1.67
Ravensworth	63	sandstone	between Broonie seams		1.58E-05	
Ravensworth	59	sandstone - mg	between Broonie seams		5.06E-05	
Ravensworth	84.1	sandstone - cg	between Broonie seams	1.29E-04	1.11E-04	1.16
Ravensworth	88.9	sandstone - mg well cemented	Archerfield Sandstone	8.30E-06		
Carrington	45	sandstone mg to fg	between Broonie seams	4.76E-04	4.10E-05	11.61
Carrington	34.9	sandstone - silty	above Broonie seam	4.19E-06	3.46E-06	1.21
Carrington	52	sandstone - mg	between Broonie seams	4.57E-05	3.02E-05	1.51
Carrington	62.5	sandstone - mg	between Broonie seams	3.15E-04	2.04E-04	1.54
Carrington	51	sandstone - mg	above Bayswater seam		2.13E-05	
Carrington	33.2	sandstone - mg weathered	between Broonie seams	8.07E-03	2.32E-03	3.48
Carrington	35.8	sandstone - mg weathered	between Broonie seams	6.77E-03	2.37E-03	2.86
Carrington	63	sandstone - mg	above Bayswater seam	4.60E-04	5.08E-04	0.91

APPENDIX C: GROUNDWATER NUMERICAL MODELS

Two aquifer models have been utilised in the assessment of groundwater impacts. These include:

1. a relatively localised single layer model addressing the palaeochannel alluvium, the management of seepage and river leakage during mining, and the recovery of water levels post mining;
2. a regional three layer model addressing the hardrock coal measures, cumulative impacts and the magnitude of leakage induced by depressurisation specifically within the coal measures.

Two models were adopted on the basis of the large contrast in hydraulic conductivities between the unconsolidated alluvium and the underlying hardrock coal measures. By generating a single layer simulation of the alluvium, it was possible to achieve increased efficiencies both in model calibrations and in simulations relating to removal of the alluvium (mining). It was also possible to examine interactions with the Hunter River in increased detail when compared to the regional model.

The regional model was targeted at the coal measures and the leakage pathways from the regionally extensive alluvial lands to the mine pit. Cumulative impacts arising from West Pit and North Pit were also considered within this model.

C1.1 Palaeochannel alluvial aquifer model

The palaeochannel model is an amended version of the original aquifer model employed for EIS assessments (MER 1999). It has been progressively refined through a number of re-calibrations for the purpose of mine planning. These recalibrations were undertaken in 2002 and 2004 in order to assess the need for seepage interception structures or 'slots' to assist in gravity draining the alluvium.

The current model utilises the Modflow-Surfact code – an enhanced version of the widely used Modflow code (Modflow 96). Key factors for adopting this code relate to the robust way in which desaturation and resaturation of model cells is handled, efficient equation solver techniques, and the ability to undertake transient simulations using adaptive time stepping. The latter is especially useful in achieving accurate volumetric balances and flux estimates.

The palaeochannel model is a single layer with the base assigned to the base of alluvium which was interpolated from extensive exploration borehole data. Model design provides for a regularly gridded array of cells comprising 195 rows and 165 columns resulting in 32175 cells with dimensions of 20m x 20m as shown on Figure C1. This small cell size was deemed appropriate for detailed simulation of alluvium stripping during mining, representation of barriers to seepage, and representation of the Hunter River. Beyond the alluvial palaeochannel all model cells have been de-activated. Hence hardrock areas have been considered as no flow areas.

Numerous model variations have been employed in the prediction of impacts. These include:

- forward calibration model;
- forward prediction of water tables, seepages and leakages for the currently approved extents to mining without installation of clay barriers between the mining operations and the river;
- forward prediction of water tables, seepages and leakages for the proposed extended mining area without installation of clay barriers between the mining operations and the river;

- forward prediction of water tables, seepages and leakages for the currently approved extents to mining with clay barriers constructed between the mining operations and the river;
- forward prediction of water tables, seepages and leakages for the proposed extended mining area with clay barriers constructed between the mining operations and the river;
- recover of water tables post mining

C1.1.1 Alluvium hydraulic properties

Hydraulic properties were initially generated from field testing conducted as part of EIS studies (MER, 1999). However the hydraulic conductivity distribution has been progressively refined through re-calibration of the model. That is, conductivity distributions have been amended by undertaking model simulations that reflect actual mining operations and adjusting individual cell conductivities until model predicted water levels matched measured (historical) water levels at the numerous monitoring piezometers installed throughout the area. Seepage fluxes were also matched (see Section C1.4 below). The resulting permeability distribution is shown on Figure 6 of the main text while model properties are summarised in the following Table C1.

Table C1: Adopted hydraulic properties for palaeochannel model

Parameter	Value
alluvium hydraulic conductivity (Kx, Ky)	1.0E+00 to 9.5E+01 m/day
alluvium anisotropy Kx/Ky	1.0
clay barrier hydraulic conductivity	1.0E-04m/day
clay barrier thickness	1.0m
alluvium effective (drainable) porosity (Sy)	0.1 (10%)

C1.1.2 Alluvium boundary conditions and initial head distribution

Boundary conditions applied to the model include fixed heads (1^{st} type – conductance limiting) applied to river cells, and drain cells (1^{st} type - flux constrained) applied to the pit face and areas of abstracted alluvium.

River cell stage heights have been assigned from survey of river water levels for low regulated flow conditions, and interpolated over relevant reaches between survey points. River bed conductance or the ability for the river to source or sink groundwater through a particular cell, has been set arbitrarily high consistent with a sandy bed to ensure efficient coupling between the river and the underlying alluvium.

Drain cells representing the mining process have been programmed to activate in accordance with the historical removal of alluvium but simplified to 3 monthly intervals commencing in July 2000 through to the planned end of mining in the alluvium after 2007. Drain conductance or the ability for a drain cell to sink or drain groundwater from the model, has been set arbitrarily high. Minimum saturated thickness of each drain cell was assigned at 0.25m (above base of alluvium at each cell location) after a number of trials to ensure a free draining pit face prevailed.

Rainfall recharge has been applied at an initial rate of 21mm/year declining to 2mm/year over the calibration period. The low and declining rate of recharge is consistent with observed negligible water table movements from rainfall events subsequent to commencement of mining, and an extended drought period which has prevailed since 2001.

Initial head distributions throughout the alluvium have been generated from an initial steady state model. This same steady state model was also used to explore/generate water tables for different recharge conditions. In the case of recovery simulations (post mining), initial head distributions have been assigned to alluvium water levels predicted for the end of mining, or the base of the final void pit shell, which ever is the deeper.

C1.1.3 Calibration of the palaeochannel model

Calibration procedure has involved a trial and error adjustment of hydraulic properties within the model domain and examination of many simulations comparing model water levels with historically measured water levels while mining progressed southward and westward. Parameter optimisation was employed during this process using the PEST automated optimisation code to generate estimates of hydraulic conductivities for distributions that were continually amended. Simulations for calibration purposes have been conducted over the period from commencement of mining (July 2000) to June 2005.

Figure C2 shows the initial water table adopted for July 2000. Figure C3 provides numerous hydrographic plots for observation bores showing measured and predicted levels at selected locations. Reference to these plots indicates generally acceptable agreement between measured and predicted responses. Some departures are attributed to differences between the times adopted for alluvium stripping within the model, and actual mining dates eg. CGW19 while others may be attributed to local scale change in the hydraulic properties of the alluvium. Figure C3 also provides a correlation plot for all piezometers and all times used during the calibration process (measured and predicted heads). Points plotting along a 45^0 line on this plot indicate high correlation. In most cases the agreement between measured and predicted is considered to be acceptable.

Calibration was locked to a volumetric water balance by simultaneous correlation to measured pit seepage from dewatering slot 3 constructed in 2002. Figure C3 also provides a plot of measured and predicted seepage to slot 3 where a reasonable correlation is noted.

As with all groundwater model calibrations, the palaeochannel model calibration is considered to be 'non unique' in so far as hydraulic conductivities could be adjusted over a range of values and distributions, while generating similar water table responses to mining.

C1.2 Regional hardrock aquifer model

The regional hardrock model is an amended version of the aquifer model employed for West Pit EIS assessments (MER, 2003). It has been used mainly to assess impacts of depressurisation within the coal measures and to generate a broad estimate of the magnitude of vertical leakage from the regional alluvium to the underlying strata as depressurisation increases. The model has been translated from Modflow 96 to the Modflow-Surfact code. Extents have been adjusted to include parts of the Hunter River alluvium south of the river but simulations largely address cumulative impacts of mining including West Pit and North Pit as shown on Figure C1. Cheshunt Pit and Riverview Pit operations on the south side of the Hunter River are not included as these are either masked by North Pit (Alluvial Lands pit) or are considered too distant to have measurable cumulative impacts.

Two separate models have been designed to represent

- approximate steady state conditions for the period before mining activity commenced – water table generated for 1980;
- transient simulation over a period of mining from 1980 through to the present time then forward for a period of 9 years to 2014. The simulation includes development of Hunter Valley North Pit, the Alluvial Lands Pit and West Pit. A cut off wall has been installed within the palaeochannel in order to more closely examine the magnitude of long term leakage through the coal measures.

C1.2.1 Model geometry

Layer 1 represents both the topographically elevated hardrock coal measures across the model domain and the alluvial lands adjacent to the Hunter River. The base of layer 1 beneath the alluvial lands has been interpolated to reflect a generalised grade downstream from near Jerrys Plains. The elevation is broadly based on terrain mapping in areas near the current mining operations and assuming a thickness of alluvium of 20 to 25 m at the deepest point. In other areas beyond the unconsolidated alluvium, the base of layer 1 is situated at about 80mAHD. Layer 2 represents coal measures from the base of layer 1 to the base of the Vane Subgroup at a depth of about 50 m below the Barrett Seam. Layer 3 represents the underlying Saltwater Creek Formation and the Mulbring Siltstone.

C1.2.2 Model hydraulic properties

Hydraulic conductivities assigned to each layer have been determined by a process of 'assignment by lithologic type' followed by consolidation to hydraulically equivalent model layers. The methodology comprised calculation of the vertical conductivity distribution at exploration borehole EL5243B which is considered to be reasonably representative of coal measures strata north of the river. Laboratory core analyses (MER, 2003) were used in generating representative hydraulic conductivities for lithologies given in the following Table C2. These conductivities were then used to develop a full vertical section for EL5243B as indicated on Figure C4 based on detailed logging of core by site geologists. The full section was then reduced to an hydraulically equivalent layer conductivity and transverse anisotropy using established formulae.

Table C2: Adopted hydraulic conductivities for different lithologies

Lithology	Hydraulic conductivity (m/day)
alluvium	2.5E+01
sandstone	3.0E-05
siltstone	1.0E-05
mudstone	1.0E-07
claystone	1.0E-07
shale	1.0E-07
coal – average	1.0E-02
shaley coal	1.0E-04

Since jointing is relatively infrequent and has not been mapped in detail, correction for enhanced conductivity that might be attributed to jointing has been applied in an arbitrary but conservative manner by raising the calculated vertical conductivity determined from Figure C6, by two orders of magnitude. Compressibility and subsequent estimates of specific storage (as S_s) have been calculated from regional measurements of Youngs Modulus for typical interburden core. These estimates range from 1.0E-06 to 3.2E-06 for a Modulus range from 10 to 30GPa. Table C3 provides a summary of properties used in the aquifer model.

Table C3: Hydraulic properties assigned to the regional aquifer model

Layer	Lithology	Kxy (m/day)	Kz (m/day	Ss (1/m)	Sy
1	alluvium/coal measures	2.5E+01 / 6.0E-03	2.5E+01/6.0E-04	2.0E-06	0.25/0.005
2	coal measures	1.1E-03	1.10E-04	2.0E-06	0.005
3	sandstone-siltstone	1.0E-07	1.0E-07	2.0E-06	0.005

Kxy = horiz. conductivity, Kz = vert. conductivity, Ss = specific storage

C1.2.3 Boundary conditions

Boundary conditions assigned to the regional model include fixed heads (1st type – conductance limiting) within Plashett Dam, Lake Liddell and along the Hunter River, drain nodes (1st type - flux constrained) along creeks and in pit areas, and distributed elemental flux conditions to represent regional rainfall recharge. Drain nodes have also been assigned to pit floor elevations in accordance with the mining history. Utilisation of 1st type conditions along the river enforces seepage from surrounding areas of elevated water table to the river, or seepage from the river to surrounding strata if pressures in those strata are lower than river levels.

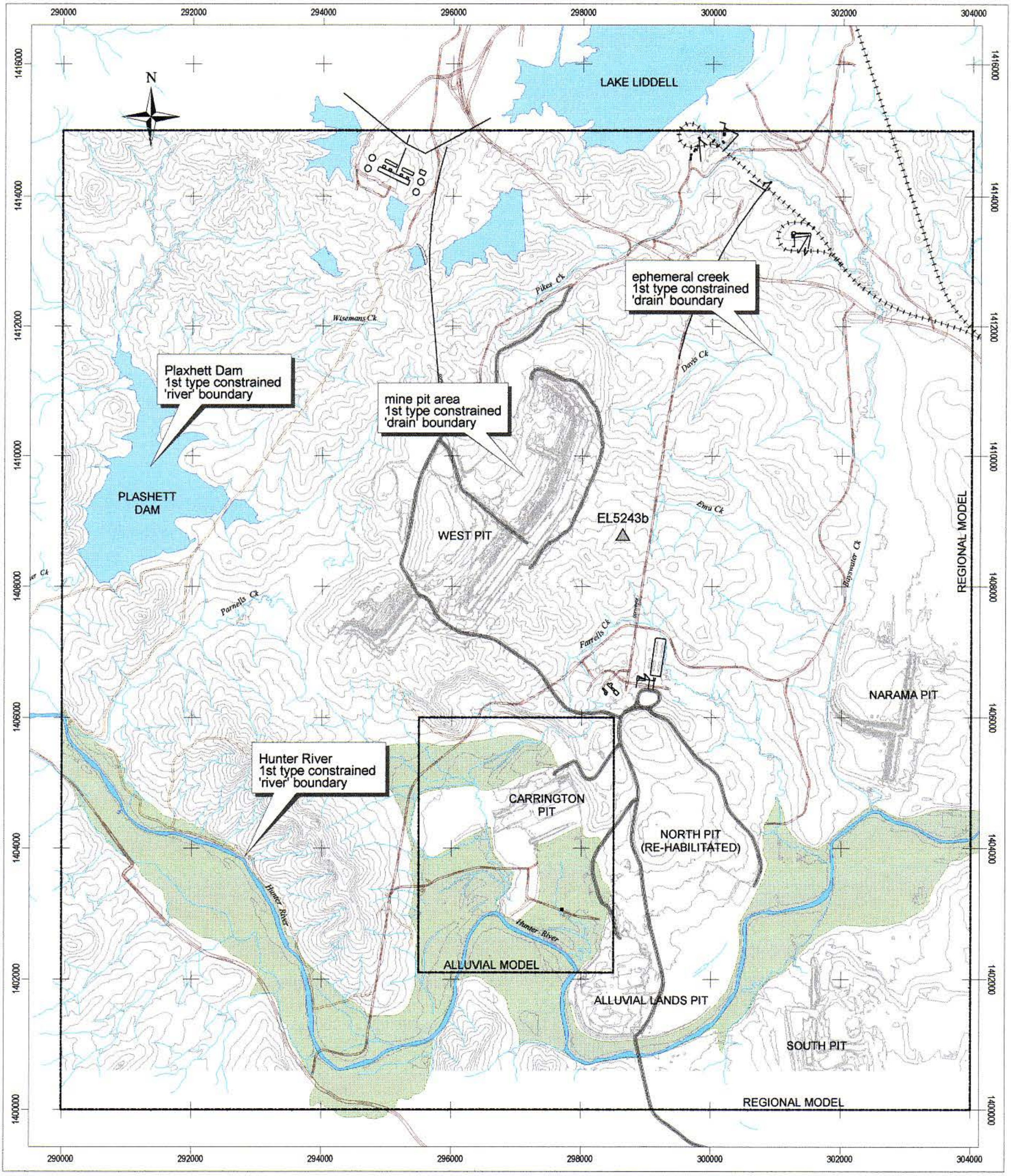
Rainfall recharge has been applied at a constant rate of 0.5 mm/annum over hardrock areas. This coal measures rate has been determined through a number of steady state simulation trials where recharge was progressively increased until regional pressures broadly matched the sparse regional field data. Since the model is fundamentally a forward model based on determination of prevailing conductivities, the actual rainfall recharge is relatively insensitive to the simulated depressurisation process. Recharge at a rate of 90 mm/annum has been applied over alluvial lands along the Hunter River where sandy soils and sands are known to facilitate rapid infiltration during sustained rainfall periods. Infiltration could vary over short distances but the use of an average figure provides a simplification and is considered adequate for planning purposes. Because the rate for the alluvium is much higher than for hardrock areas, it is also a relatively insensitive boundary condition in respect of deeper hardrock depressurisation.

C1.2.4 Non calibration of the regional model

The regional model has not been calibrated against groundwater levels-pressures other than in a coarse manner. The reason for this is twofold: 1) the lack of three dimensional pressure measurment data to calibrate against, and 2) simplification of highly layered anisotropic strata into three model layers. Instead the model has been designed from a preferred physical basis ie. representative hydraulic conductivities for different strata have been adopted and consolidated into the simplified layer distributions. The adopted distributions result in pit seepage fluxes (at large scale) that are similar to observed seepage rates into the mine pits.

C1.2.5 Simulation schemes

Model output for each stage of mining has been examined for nodal water balance budgets together with vertical and horizontal components of flux.



0 1000 2000 3000 4000 5000 Metres

Scale 1:80000 Base map information from 1:25,000 topo series (Central Mapping)
Additional data supplied by Hunter Valley Operations

- creeks
- dirt roads
- sealed road
- main road
- haul road
- alluvial lands
- topographic contour (10m intervals)
- railway
- model extents

CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Alluvial and regional aquifer models (extents)

Figure C1

Mackie Environmental Research

0 500 1000 1500 Metres

ISG co-ordinate system. Scale 1:20000

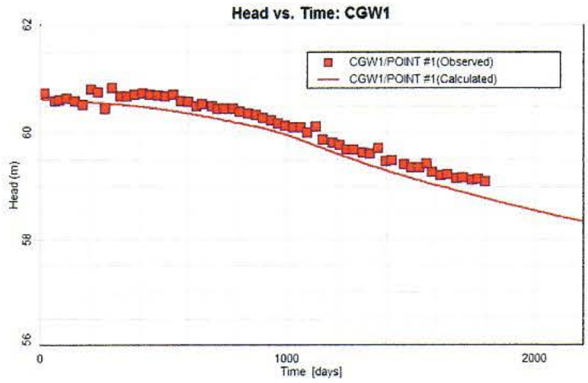
- piezometric surface (mAHD)
- topographic contours 10m intervals
- perimeter of alluvial palaeo channel
- Hunter River

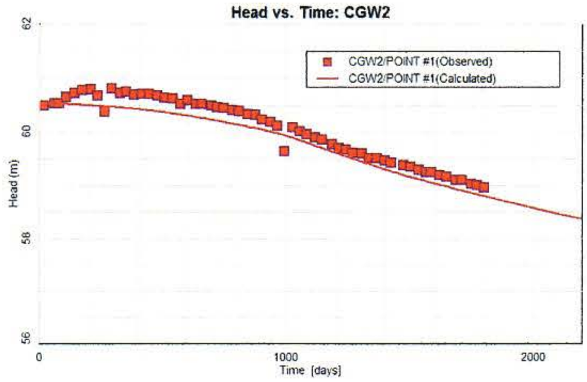
CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Model initial head distribution at July 2000

Figure C2

Mackie Environmental Research


Head vs. Time: CGW1
CGW1/POINT #1(Observed)
CGW1/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]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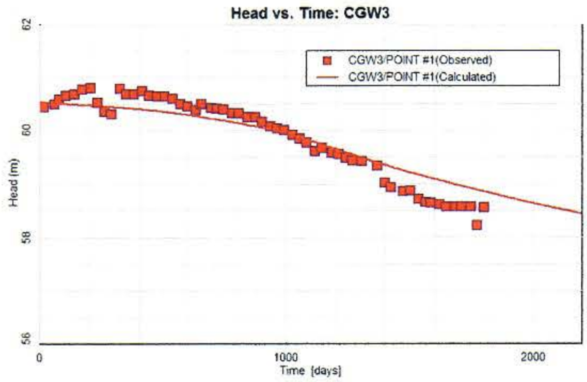
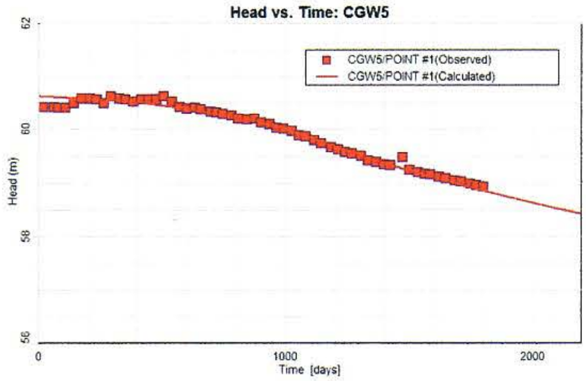
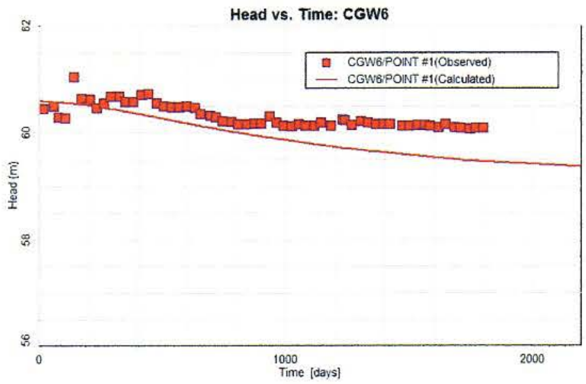
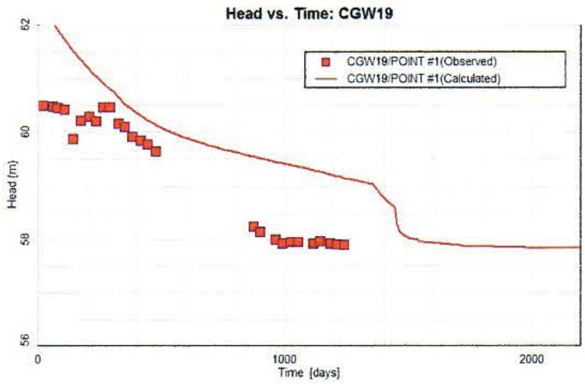
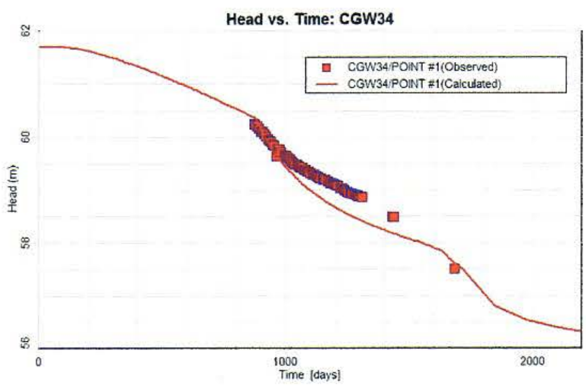
CGW2/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]

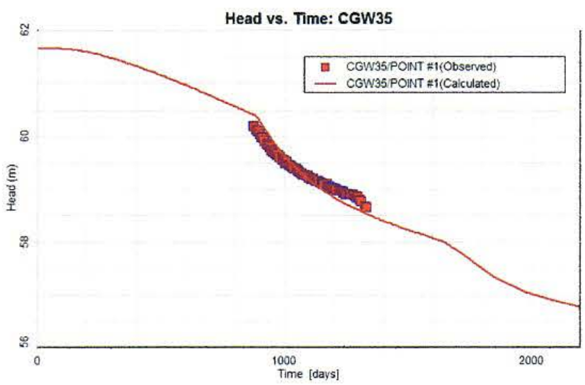

Head vs. Time: CGW3
CGW3/POINT #1(Observed)
CGW3/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]


Head vs. Time: CGW5
CGW5/POINT #1(Observed)
CGW5/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]


Head vs. Time: CGW6
CGW6/POINT #1(Observed)
CGW6/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]


Head vs. Time: CGW19
CGW19/POINT #1(Observed)
CGW19/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]


Head vs. Time: CGW34
CGW34/POINT #1(Observed)
CGW34/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]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CGW35/POINT #1(Observed)
CGW35/POINT #1(Calculated)
Head (m)
62
60
58
56
0
1000
2000
Time [days]

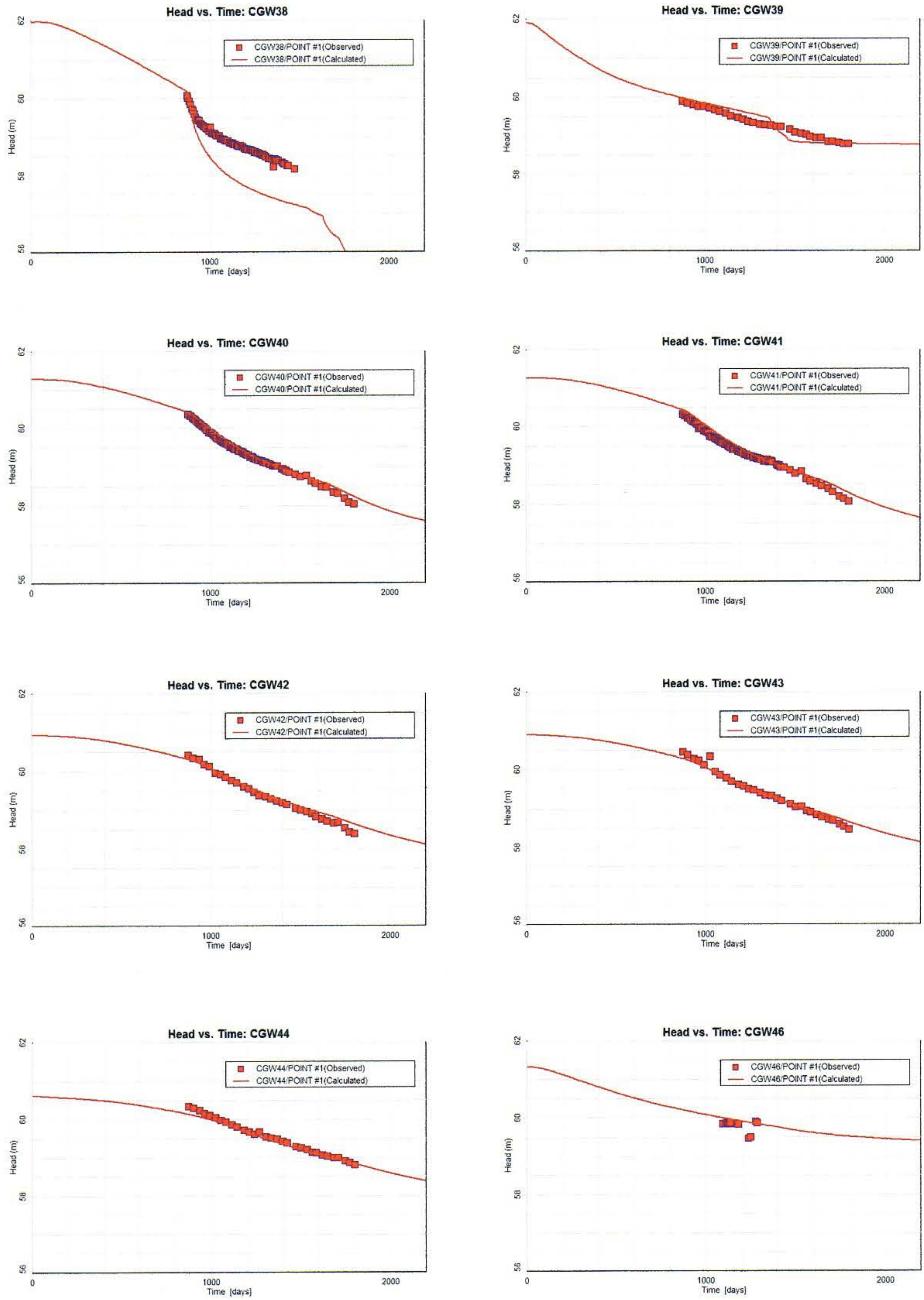
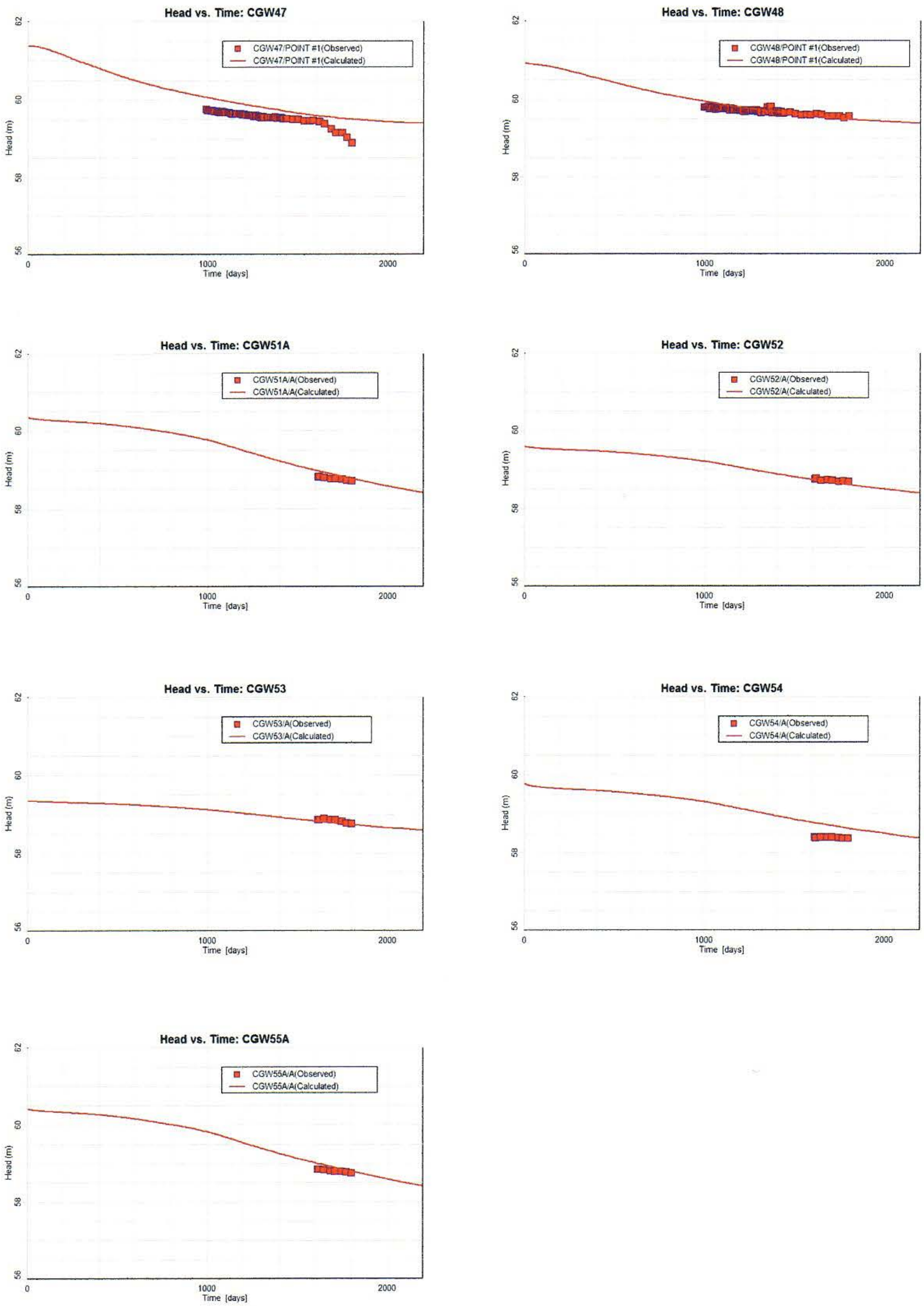
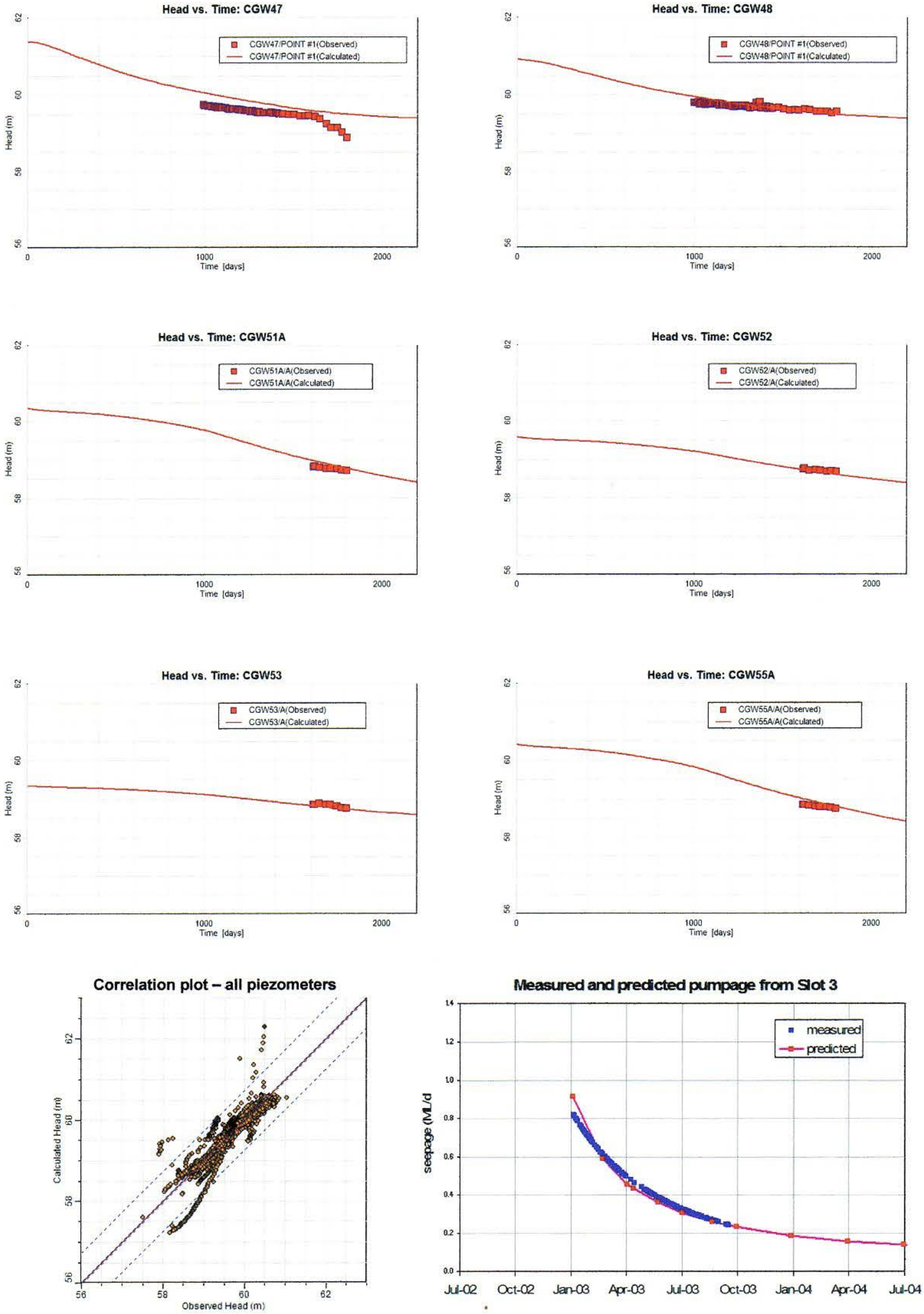

Head vs. Time: CGW38
CGW38/POINT #1(Observed)
CGW38/POINT #1(Calculated)
Head vs. Time: CGW39
CGW39/POINT #1(Observed)
CGW39/POINT #1(Calculated)
Head vs. Time: CGW40
CGW40/POINT #1(Observed)
CGW40/POINT #1(Calculated)
Head vs. Time: CGW41
CGW41/POINT #1(Observed)
CGW41/POINT #1(Calculated)
Head vs. Time: CGW42
CGW42/POINT #1(Observed)
CGW42/POINT #1(Calculated)
Head vs. Time: CGW43
CGW43/POINT #1(Observed)
CGW43/POINT #1(Calculated)
Head vs. Time: CGW44
CGW44/POINT #1(Observed)
CGW44/POINT #1(Calculated)
Head vs. Time: CGW46
CGW46/POINT #1(Observed)
CGW46/POINT #1(Calculated)
Head (m)
Time [days]
56
58
60
62
0
1000
2000

Figure C3



Head vs. Time: CGW47
CGW47/POINT #1(Observed)
CGW47/POINT #1(Calculated)
Head vs. Time: CGW48
CGW48/POINT #1(Observed)
CGW48/POINT #1(Calculated)
Head vs. Time: CGW51A
CGW51A/A(Observed)
CGW51A/A(Calculated)
Head vs. Time: CGW52
CGW52/A(Observed)
CGW52/A(Calculated)
Head vs. Time: CGW53
CGW53/A(Observed)
CGW53/A(Calculated)
Head vs. Time: CGW54
CGW54/A(Observed)
CGW54/A(Calculated)
Head vs. Time: CGW55A
CGW55A/A(Observed)
CGW55A/A(Calculated)
Head (m)
56
58
60
62
Time [days]
0
1000
2000

Figure C3


Head vs. Time: CGW47
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CGW47/POINT #1(Calculated)
Head vs. Time: CGW48
CGW48/POINT #1(Observed)
CGW48/POINT #1(Calculated)
Head vs. Time: CGW51A
CGW51A/A(Observed)
CGW51A/A(Calculated)
Head vs. Time: CGW52
CGW52/A(Observed)
CGW52/A(Calculated)
Head vs. Time: CGW53
CGW53/A(Observed)
CGW53/A(Calculated)
Head vs. Time: CGW55A
CGW55A/A(Observed)
CGW55A/A(Calculated)
Head (m)
Time [days]
0
1000
2000
56
58
60
62
Correlation plot – all piezometers
Calculated Head (m)
Observed Head (m)
Measured and predicted pumpage from Slot 3
seepage (ML/d)
measured
predicted
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04

Figure C3

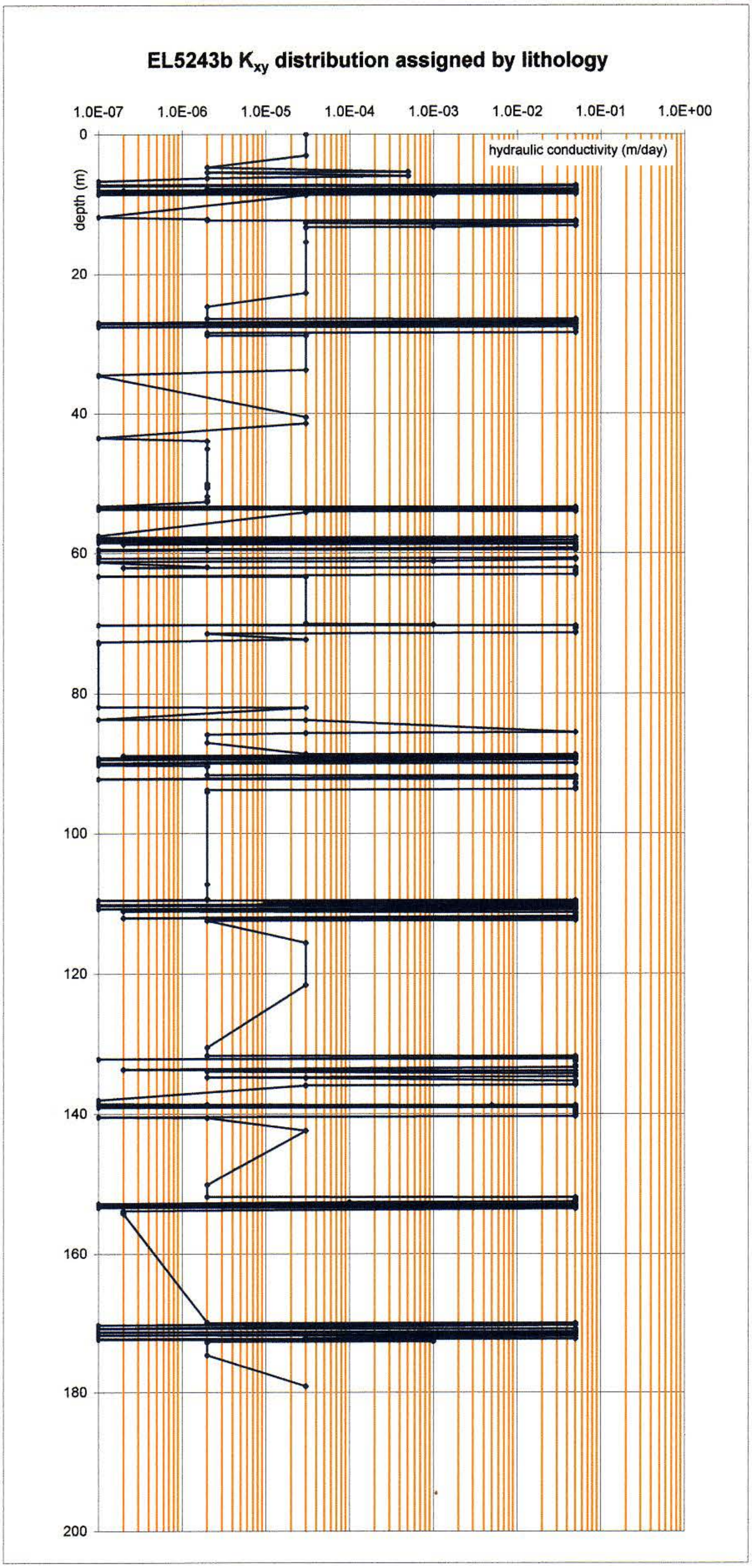
EL5243b K_{xy} distribution assigned by lithology
1.0E-07
1.0E-06
1.0E-05
1.0E-04
1.0E-03
1.0E-02
1.0E-01
1.0E+00
hydraulic conductivity (m/day)
depth (m)
0
20
40
60
80
100
120
140
160
180
200

Figure C4

Environmental Resources Management Australia

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Broadway NSW 2007
www.erm.com

17 October, 2005

Anna McMullen
Coal & Allied
PO Box 135
Singleton, NSW 2330

Our Reference: CARRINGTON TECHNICAL PEER REVIEW - WATER.DOC

Dear Anna,

RE: TECHNICAL PEER REVIEW - CARRINGTON STATEMENT OF ENVIRONMENTAL EFFECTS, WATER MANAGEMENT STUDY

1. INTRODUCTION

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Coal & Allied (CNA) to provide a technical peer review of the draft water management study undertaken by Mackie Environmental Research (MER). This study was related to proposed extensions to the mining operations at the Carrington Mine Pit.

The specific report reviewed was: Carrington Extended Water Management Studies (Draft, August 1995).

It should be noted that this review was limited to the information included in the above report, and materials referenced in this report were not provided for review. In addition, a technical assessment of potential impacts to surface hydrology, mine water management and permitting was beyond the expertise of the reviewer, and has not been included in this review.

2. BACKGROUND AND OVERVIEW

The CNA mining operations at Carrington Pit were subject to the approval of an Environmental Impact Statement issued in 1999. CNA operations currently comprise mining of a number of coal seams that subcrop beneath a significant paleochannel filled with alluvial deposits north of the Hunter River. Mining operations within the current approved mine lease have comprised stripping of the alluvial sediments to access the coal seams, with operations beginning in the north of the approved mine lease and extending southwards towards the Hunter River.

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A.C.N. 002 773 248
A.B.N. 12 002 773 248

Offices worldwide

CNA plan to submit a Statement of Environmental Effects (SEE) to support a request for increasing the current mine lease to include an additional area (~60ha) to the south of the east channel lease area, and another portion of land (~80 ha) to the east of the current mine lease boundary.

To support the SEE submission, MER has undertaken an additional water management study to assess the potential additional impacts to the water resources resulting from mining activities in the proposed extension areas. The tasks included in this study were as follows:

- Recalibration of the two existing numerical groundwater models (alluvial and regional) using current field data;
- Reanalysis of the predicted influence of mining activities on the water levels (hydraulic head values) within the approved mine lease areas using the recalibrated model;
- Analysis of the additional predicted influence on hydraulic head values of mining activities within the proposed extension areas;
- Analysis of the volume of mine pit seepage and leakage from the Hunter River associated with the current and extended lease areas;
- Analysis of the effectiveness of the installation of barrier walls in the alluvium to mitigate potential mining-induced leakage from the Hunter River;
- Analysis of water level recovery following completion of mining and redevelopment of the mine pit void;
- Analysis of potential impacts to the surface water catchments associated with mining; and
- Recommendations for assessment of groundwater and surface water impacts.

It should be noted that this technical review focused on the development and results of the numerical groundwater models used to predict the potential impacts to the groundwater resource associated with the proposed mine lease extension.

3. REVIEW OF NUMERICAL GROUNDWATER MODELS

To simulate the two significant aquifer systems associated with the mine lease area, MER developed two separate models:

- A single-layer model to simulate the response to mining in the alluvial paleochannel aquifer, assess the hydraulic interaction with the Hunter River, and to assess the recovery of water levels in the redeveloped mine pit following mining; and

- A three-layer regional model to simulate the depressurisation of the coal seam aquifers in response to mining in the lease area and to assess anticipated inflows to the mine pits.

The initial models were developed for the original study associated with the Carrington EIS (MER, 1999) and were revised to reflect various scenarios associated with the current mine plan and the proposed extension area. A brief technical review of the models is provided in the following sections, based on the checklist for model compliance provided in the Murray Darling Basin Commission Groundwater Flow Modelling Guideline (November 2000).

3.1 ALLUVIAL AQUIFER MODEL

3.1.1 Objectives

The stated objectives of the MER alluvial model development were as follows:

- To simulate the influence of mining activities on the groundwater resource within the alluvial aquifer, and the associated hydraulic interactions with the Hunter River;

- To assess the effectiveness of installing a barrier wall in the alluvial channels to isolate the mining impacts to the groundwater resource from the Hunter River; and

- To simulate the recovery of water levels in following completion of mining.

To achieve the objectives, a total of seven variations on the model were developed to both recalibrate the model and to assess the key objectives. ERM considers that the objectives of the model development are clearly stated, and are appropriate for the purposes of the SEE.

3.1.2 Conceptual Model

This aquifer is generally described as comprising alluvial and colluvial material deposited within an ancient paleochannel of the Hunter River. There appears to have been significant field investigation of the alluvial material, and the geological and hydrogeological properties of the aquifer are reasonably well-defined. It is recognised that the deposits within the paleochannel exhibit significant spatial heterogeneity, and the proposed conceptual model appears to be a reasonable large-scale representation of a complex depositional environment.

3.1.3 Model Development

The alluvial model comprised a single layer model incorporating drain cells to simulate mine pit progression, and constant head cells representing the Hunter River. Cells outside of the paleochannel were deactivated, suggesting a no-flow boundary. The range of hydraulic conductivity values appears to be reasonable for a complex, heterogeneous depositional environment, and the drainable porosity value was considered to be a reasonable compromise for the area. A 20-metre grid spacing was adopted throughout the model domain, which provides sufficient detail for the scale of the assessment. ERM considers the model development to be an appropriate representation of the study area.

3.1.4 Model Calibration

MER states that the model has undergone several iterations of significant recalibration since initial development in 1999. The initial model development was based on extensive field data, and then periodically recalibrated against measured water levels to refine the hydraulic parameter estimates. The alluvial model calibration for this study was based on recent water level data, and reflected the influence of mining to date in the alluvial aquifer. In addition, the distribution of hydraulic parameters was optimised using an industry-standard parameter optimisation code (PEST).

Significant calibration data is provided in Appendix C, including correlations between measured and modelled water levels at multiple observation wells, a total correlation for all observation wells for each time step, and a correlation of measured and modelled seepage volume to a dewatering slot. With a few minor exceptions, the model predictions closely match the field measured values, and as such the model is considered to be appropriately calibrated.

3.1.5 Model Results

The results of model simulations of mining to the current lease extent indicate significant localised depression of water levels in the alluvial aquifer. A reversal of the hydraulic gradient adjacent to the Hunter River is predicted in 2006 (west channel) and 2007 (east channel), at which time the volume of leakage from the river into the alluvial aquifer becomes greater than groundwater discharge into the river.

The modelling predictions incorporating the proposed lease extension areas result in a similar impact to the groundwater resource, both in terms of the extent of water level drawdown and timing of hydraulic gradient reversal adjacent to the Hunter River. The pit seepage volume is anticipated to be slightly increased under this scenario, as is the induced leakage volume from the Hunter River following reversal of the hydraulic gradient, which stands to reason since the mine pit would be approximately 500 m closer to the river.

Modelling results simulating the installation of barrier walls in each of the channels indicate this would be an effective measure to mitigate induced leakage from the Hunter River. The modelling results, including barrier walls, for the current mine lease and proposed extension are virtually identical.

Modelling results simulating the recovery of water levels in the proposed rehabilitated mine pit, following completion of mining, indicate that groundwater levels will recover to a level below river stage elevation within the reinstated mine pit, and groundwater discharge will be directed to a large surface water body proposed along the eastern mine lease boundary. The modelling results indicate minimal impact to groundwater levels adjacent to the Hunter River assuming that barrier walls are installed within the east and west channels, which appears, from the modelling results, to be an appropriate measure to mitigate induced leakage from the river. However no simulation was provided to assess the potential magnitude of induced leakage from the Hunter River in the absence of barrier wall installation. It is assumed from this omission that some form of mitigating action similar to that incorporated into MER's model will be a requirement for the final mine void rehabilitation. If the potential options under consideration for this scenario are significantly revised, it is recommended that additional predictive modelling is undertaken to assess the performance of the proposed rehabilitation design.

Considering the volume of field data and recalibration efforts associated with the model development, the predictions appear to be reasonable. ERM agrees with MER's conclusion that the difference in the predicted impacts to the groundwater resource in the alluvial aquifer under the original and extended mine lease scenarios is minor. ERM further agrees with MER's conclusion that installation of barrier walls in each of the alluvial channels would effectively separate the mining-related impacts to the alluvial groundwater resource from the Hunter River, thus mitigating the predicted increased leakage from the river associated with the proposed mine extension.

3.2 REGIONAL COAL MEASURES MODEL

3.2.1 Objectives

The stated objective of MER in their regional model development was to simulate the influence of mining activities on the regional groundwater resource within the coal measures, and the associated hydraulic interactions with the mine pit and Hunter River.

To achieve the objective, a single transient model run was developed to both recalibrate the model and to assess the key objectives. ERM considers that the objectives of the model development are clearly stated, and are appropriate for the purposes of the SEE.

3.2.2 Conceptual Model

The regional hard rock 'coal measures' aquifer is described as comprising a series of relatively permeable coal seams separated by low permeability sedimentary interburden units. Coal seams with well developed cleating were identified as reasonable aquifers, whilst coal seams with undeveloped cleating and interburden (sandstone, siltstone, claystone) units are generally considered to act as aquitards or aquicludes. The hydraulic conductivity data presented in Appendix B appears to support this conceptual model.

3.2.3 Model Development

The regional model comprised a three layer model incorporating drain cells to simulate various mine pits in the region, and constant head cells representing various surface water features. The hydraulic parameters for the various layers were based on detailed laboratory testing of a rock core extending through the full thickness of the coal measures. Whilst the model is a simplified representation of the regional hydrogeological setting, ERM considers the model development to be appropriate for the intended purpose.

3.2.4 Model Calibration

No information was provided regarding model calibration for the regional model, and it is assumed that insufficient data was available to calibrate the model against. As such, the results of the regional model should be considered to be indicative at best, with an undefined level of uncertainty associated with it.

3.2.5 Model Results

The results of regional model simulations indicate a significant depression in water levels associated with the progression of mine pit development, with drawdown extending several kilometres to the north, east and west of the mine site. The regional model incorporates the barrier walls in the alluvium, and as such a negligible influence in water levels adjacent to the Hunter River is observed.

ERM considers the regional model predictions to be generally representative of anticipated impacts to the regional groundwater resource, but the lack of model calibration indicates that a significant degree of uncertainty should be assumed to be associated with the results.

3.3 MODEL REVIEW CONCLUSIONS

The modelling approach adopted by the modeller appears to be appropriate and the overall model design appropriate for the stated objectives. It is noted that the regional model is considered to have a significant degree of uncertainty associated with it due to a lack of model calibration, but it is also less significant to the overall project objectives. The modeller has endeavoured to incorporate an appropriate degree of conservatism to those parameter estimates that are poorly constrained by field data.

ERM concludes that the results of the numerical models are valid, and are technically sufficient to address the project objectives.

4. WATER QUALITY ASSESSMENT – MINE VOID REHABILITATION

In addition to assessing the recovery of the groundwater levels within the rehabilitated mine void post mining, MER has also assessed the predicted water quality associated with groundwater residing within the backfilled mine void. Water quality assessments comprised a combination of leachate tests using proposed backfill material, and geochemical modelling to simulate long-term equilibration of groundwater in contact with the backfill material.

The leachate tests indicated TDS values similar to the lower values currently observed in the alluvial aquifer, with a chemical signature reflecting an increased influence from rainfall recharge with respect to vertical leakage from the coal measures aquifers. The geochemical modelling results generally agreed with the results of the leachate tests, and indicated the potential for greater dilution of TDS values over time from the long-term influence of rainfall recharge.

ERM considers that the approaches to the water quality assessment appear to be valid, and provide the best estimate of long term water quality within the backfilled mine pit. The slight variation in the predicted chemical composition of groundwater from the pre-mining conditions should be insignificant in terms of impacts to regional water quality; the additional dilution from enhanced rainfall recharge should actually improve water quality associated with the rehabilitated aquifer.

5. CONCLUSIONS

ERM concludes that the methodology and scope of work undertaken by MER in its draft Water Management Study is in line with best practices and is appropriate for the objectives of the SEE. The reviewer notes that the results of the regional groundwater model should be considered indicative only, as a significant and unquantified uncertainty may be associated with the results due to the lack of model calibration. ERM agrees with the conclusions reached by MER with regards to the predicted influence of mining activities on the alluvial, and to a lesser extent regional, groundwater resources, both in the active and post mining scenarios. ERM further agrees that installation of barrier walls within the east and west paleochannels (or similar measure) to hydraulically isolate the Hunter River from the influence of mining-related dewatering/depressurisation would be a reasonable mitigating measure to minimise the potential for induced leakage from the river. The difference in the predicted leakage rate from the river by the end of mining, calculated with and without barrier installation, amounts to 0.11 ML/day, the significance of which would need to be assessed against stream flow objectives for the management of the Hunter River.

ERM recommends that further modelling should be undertaken if significant variations to the mine pit rehabilitation are proposed. ERM also endorses the recommendations for ongoing surface and groundwater monitoring programs proposed by MER to assess the ongoing impacts of mining to the groundwater and surface water resources, and to validate the predictions of the numerical modelling.

We trust that this technical review is sufficient for your requirements. Should you have any queries, please do not hesitate to contact Lange Jorstad on 02 8584 8888.

Yours sincerely,
for Environmental Resources Management Australia Pty Ltd

Lange Jorstad

Lange Jorstad
Senior Hydrogeologist

Annex E

Noise Assessment

FINAL REPORT

Coal & Allied Operations Pty. Ltd.

Carrington Pit Extended Statement of Environmental Effects

Noise Assessment

October 2005

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Pyrmont, NSW 2009
Telephone +61 2 8584 8888
Facsimile +61 2 8584 8800
www.erm.com

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1 INTRODUCTION

This report was prepared for Coal & Allied (CNA) to assess environmental noise associated with the proposed Carrington Extension within Hunter Valley Operations (HVO) north of the Hunter River. The Carrington Pit is now well developed and it is proposed to extend the pit to the south and east to utilise its coal resources whilst maintaining the approved rate of mining of 10 Mtpa ROM coal.

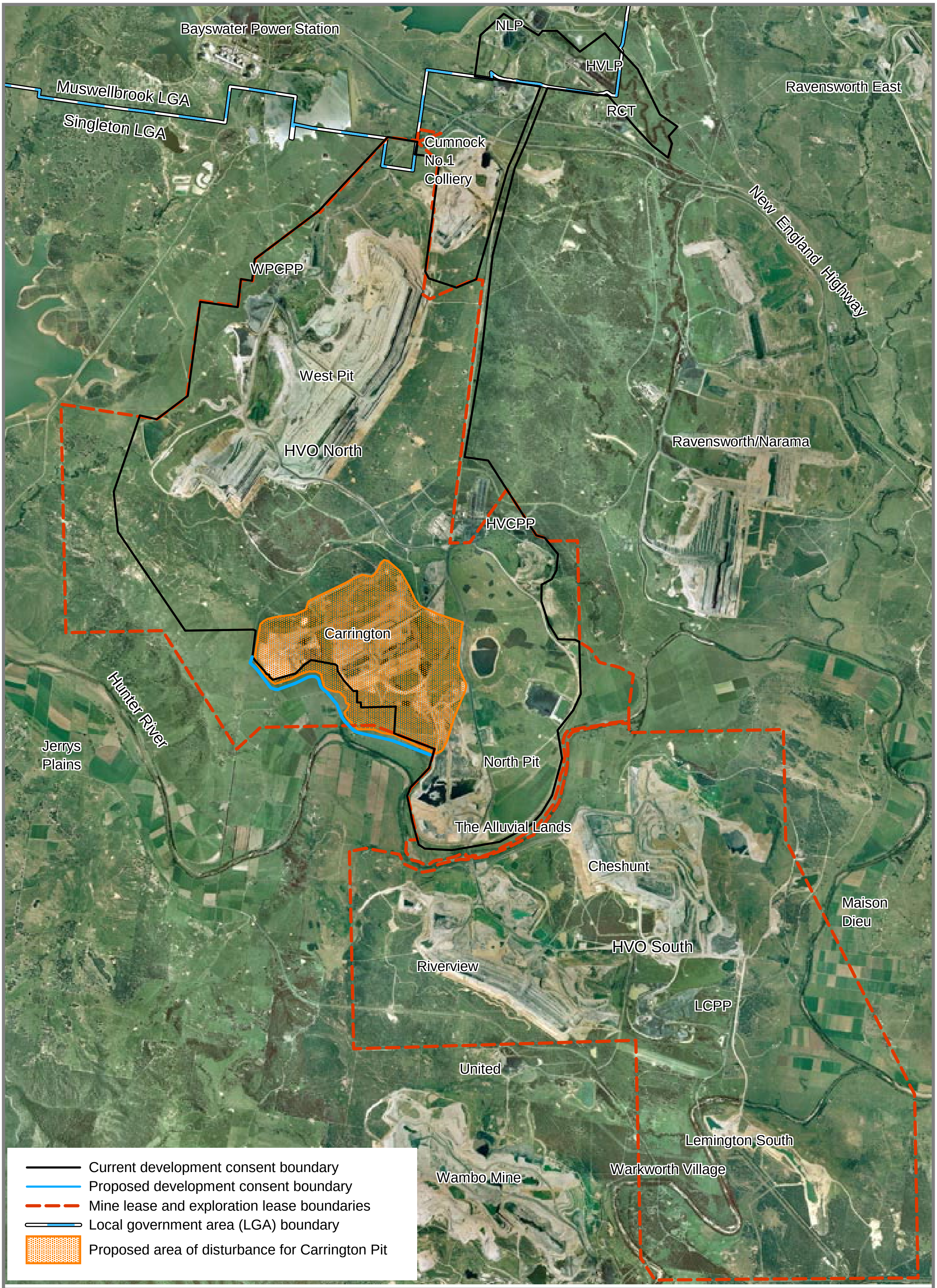
The proposed Carrington Extension will involve the following activities:

- extending the main Carrington Pit to the south toward the Hunter River and to the east through an existing overburden dump;
- construction of up to three levees to protect the mining works from flood events;
- diversion of an existing drainage line to the west rather than the east as originally proposed;
- a service corridor around the southern extension area to allow room for roads, water pipelines and other services; and
- development of the final mine void as an evaporative sink.

The noise implications of the proposed Carrington Extension apply across three mining stages representing the 2006, 2011 and 2014 activities. These were therefore modelled and predictions described herein.

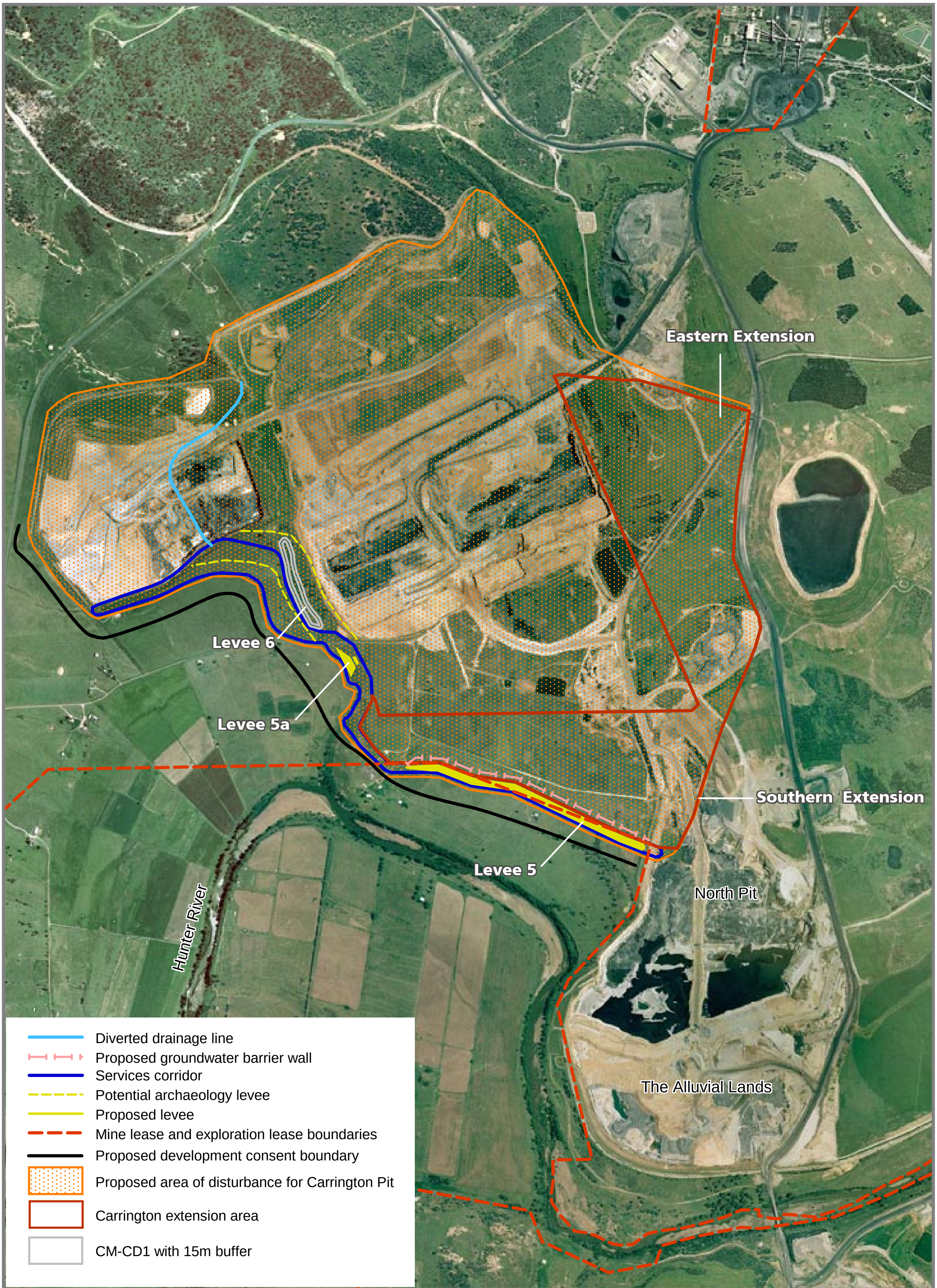
The approval for the Carrington pit was recently integrated into HVO north of the Hunter River in the West Pit consent which was assessed in the "West Pit Extension and Minor Modifications" EIS of October 2003 ("2003 EIS"). This EIS included a detailed noise and vibration assessment that provides relevant background information and modelling for the present Carrington Extension and formed the basis for the noise and vibration levels included in the consent. The location of HVO north of the Hunter River and the proposed Carrington Extension is shown on *Figure 1.1* and *Figure 1.2* respectively.

This assessment has been prepared in accordance with the EPA's *Industrial Noise Policy* (*INP*), which was published in January 2000.



0 2
Kilometres

Figure 1.1 **HVO North of the Hunter River**



X:\Minor Projects\0025235 CarringtonFigures July 2005F 2-1(A4).wor 25 07 2005 Environmental Resources Management Australia Pty Ltd

0 500

Metres

Figure 1.2 **Proposed Carrington Extension and Features**

1.1 ACOUSTIC GLOSSARY

A number of technical terms used in this report describe various noise levels from the mine. These are explained in *Table 1.1*.

Table 1.1 Glossary of Terms

Term	Description
ABL	Assessment Background Level (ABL) is defined in the *Industrial Noise Policy* (*INP)* as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L_{90} statistical noise levels.
dB(A)	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(LinPeak)	The peak sound pressure level (not RMS) expressed as decibels with no frequency weighting.
L_1	The noise level exceeded for 1 % of a measurement period.
L_{10}	A noise level which is exceeded 10 % of the time. It is approximately equivalent to the average of maximum noise levels.
L_{90}	Commonly referred to as the background noise, this is the level exceeded 90 % of the time.
Leq	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
Lmax	The maximum root mean squared (RMS) sound pressure level received at the microphone during a measuring interval.
MIC_{8MS}	Maximum Instantaneous Charge (with a minimum 8 milli-sec delay).
Peak Particle Velocity (PPV)	The maximum velocity of a particle of the transmission medium, used in assessment of vibration.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABL's.
RMS	Root Mean Square which is a measure of the mean displacement (velocity or acceleration) of a vibrating particle.
sigma-theta (σ_θ)	The standard deviation of horizontal wind fluctuation.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude to some height.

The following indicates what an average person perceives about noise levels in practice:

- noise differences of less than approximately 2 dB are generally imperceptible; and
- a difference of around 10 dB seems to be a doubling or halving of loudness.

1.2 *REPRESENTATIVE RECEPTORS*

The following noise assessment provides a graphical representation of the proposal's noise emissions in the form of noise contours. In addition, to provide a higher level of accuracy for specific off-site locations, noise levels at a number of surrounding receptors were modelled individually.

A total of 15 receptors were considered representative of assessable locations surrounding Carrington Pit. Of these 15 representative receptors, nine are private residential properties or representatives thereof (Location Nos. 1 through to 6 and 13, 14 and 39) while the others are owned by either CNA or Wambo mine, have agreements with CNA or are covered under existing mine noise affectation zones. These are shown in *Table 1.2* and illustrated in *Figure 1.3*. The receptor number convention is consistent with the West Pit 2003 EIS.

Table 1.2 Surrounding Representative Receptors Used for Modelling Purposes

Receptors		ISG Coordinates		Location from West Pit Mine
No.	**Property Owner**	**Easting**	**Northing**	**Compass Point**
1	Hayes	292153	1402554	SW
2	Skinner	292801	1401825	SW
3	Gee	293074	1401571	SW
4	Muller	293884	1400207	S
5	Bowman	305645	1399385	SE
6	Moxey	305748	1400194	SE
7[1]	Stapleton	303750	1403450	SE
8[1]	Holz	301500	1404300	SE
9[2]	CNA owned	295525	1403350	SW
10[3]	Moses	294700	1402575	SW
11[5]	Wambo Owned	294850	1399525	S
12[2]	CNA owned	301150	1402050	SE
13[4]	Jerrys Plains Centre	291092	1403349	W
14[4]	Jerrys Plain North	290294	1403963	W
39	Kanaar	302041	1395132	S

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

2. Owned by CNA.

3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.

4. Additional Jerrys Plains locations were added to ensure calculations are representative of the area.

5. Owned by Wambo Mine.

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Figure 1.3 **Receptor Locations**

2 *CONSENT NOISE AND VIBRATION LIMITS*

2.1 *INTRODUCTION*

Consent for the proposed Carrington Extension is being sought as a modification to the West Pit consent (DA450-10-2003) which was issued by the Minister for Infrastructure and Planning in 2004. As such, the results of the noise and vibration assessment for the proposed extension will be compared to the existing noise and vibration limits specified in the West Pit consent. These limits include:

- Noise limits;
- Land acquisition limits; and
- Airblast overpressure limits.

These limits are provided in the tables below.

2.2 *NOISE LIMITS*

The noise limits specified for the West Pit consent are provided in *Table 2.1* below.

Table 2.1 Development Consent Noise Limits (DA450-10-2003)

Day/Evening/Night $L_{Aeq(15\ minute)}$	Night $L_{A1(1\ minute)}$	Property Number
40	46	4 – (from year 1 to year 7
36	46	4 – (from year 8 to year 21)
40	46	Jerrys Plains Village –residence locations 13 and 14 (years 20 & 21)
39	46	2, 3, 11, 19, 31, 36, 54
38	46	1,18, 51 and 52 (from year 1 to year 19)
40	46	1, 18, 51 and 52 (years 20 & 21)
35	46	All other residential or sensitive receptors, excluding the receptors listed above.

1. Receptor locations are shown on Figure 1.3

2.2.1 *Land Acquisition Criteria*

If the noise generated by the development exceeds the criteria provided in *Table 2.2* below, the Applicant shall, upon receiving a written request for acquisition from the landowner, acquire the land in accordance with the procedures in conditions 9-11 of schedule 5 of the consent (DA450-10-2003).

Table 2.2 Land Acquisition Criteria

Day/Evening/Night $L_{Aeq(15\ minute)}$	Property Number
43	11
42	7
41	All residential or sensitive receptors, excluding the receptors listed in condition 1 of the consent.

2.2.2 *Airblast Overpressure Limits*

The Applicant shall ensure that the airblast overpressure level from blasting at the development does not exceed the criteria provided in *Table 2.3* below at any residence on privately-owned land.

Table 2.3 Airblast Overpressure Limits

Airblast Overpressure Level (dB(Lin Peak))	Allowable exceedance
115	5% of the total number of blasts in a 12 month period
120	0%

2.2.3 *Ground Vibration Impact Assessment Criteria*

The Applicant shall ensure that the ground vibration level from blasting at the development does not exceed the criteria provided in *Table 2.4* below at any residence on privately-owned land.

Table 2.4 Ground Vibration Impact Assessment Criteria

Peak particle velocity (mm/s)	Allowable exceedance
5	5% of the total number of blasts in a 12 month period
10	0%

3 NOISE MODELLING

3.1 MODELLING SCENARIOS

As the Carrington pit was assessed as part of HVO north of the Hunter River for the *HVO West Pit Extension and Minor Modifications EIS* (ERM 2003) consent, all operations within HVO north of the Hunter River were included in the modelling scenarios for the proposed Carrington Extension.

Three operating scenarios were modelled to cover the life of the proposed Carrington Extension and included operating years 2006, 2011 and 2014. Appropriate operating years for other pits within HVO north of the Hunter River such as West Pit and the Alluvial Lands dumps were also modelled. A summary of the scenarios modelled including these other pits is provided in *Table 3.1* below.

Table 3.1 Operations Modelled in Each Scenario

Proposal Year	West Pit	Carrington	Alluvial Lands dumps
2006	Yr 3	**2006**	Yr 3
2011	Yr 8	**2011**	Yr 8
2014	Yr 14	**2011**	Not operating

The mine plans and equipment locations used in the noise modelling are provided in *Appendix A*. They present worst-case operating scenarios. This allows a conservative assessment to be made of potential impacts the proposal may have on the area surrounding the mine.

3.2 PLANT NOISE LEVELS

The representative noise emission levels used in modelling are summarised in *Table 3.2*. These are consistent with those of the West Pit Extension and Minor Modifications EIS (ERM, 2003).

Typical equipment used during earth-moving and associated operations in the pit and overburden emplacement areas is listed in *Table 3.2*. Sound power levels shown in *Table 3.2* are indicative and are based on measurements obtained from equipment in the existing West Pit, coal preparation plants and loading points.

Table 3.2 Equipment Sound Power Levels

Typical Item	Representative $L_{eq,15minute}$ Sound Power Level, dB(A)
Haul truck (Komatsu 830E, 240t Leibherr, 190 CAT)	114
Large drill	118
Medium drill	118
Shovels (2800, 4100 and 5700)	118
Fuel truck	103
Lube truck	103
Water truck	116
Front end loader (L1400)	113
Dragline	114
Excavator	113
Dozer (Komatsu)	116
Dozer (CATD11)	110
Rubber tyred dozer (CAT 690D in low gear)	116
Grader	113
Scraper	110
Pump	113
Light plant	104
Cable reeler	115
CPPs and loading points	112
Conveyor	83 per linear meter

3.3 *MINING EQUIPMENT SCHEDULE*

The typical equipment schedules for the modelled mining scenarios are described in *Table 3.3* and cover equipment in both West Pit and Carrington. The specific type of plant used may vary, however the associated sound emissions will be unchanged.

It should be noted that daytime and night time (including evening) operations vary and thus were modelled separately. More specifically, the main difference between day and night (plus evening) operations is the use of lighting plant at night and the cable reeler operations during the day.

Table 3.3 Typical Mining Equipment Schedule

Description	Modelled Year					
	2006		2011		2014	
	West Pit Year 3	Carrington 2006	West Pit Year 8	Carrington 2011	West Pit Year 14	Carrington 2011
Loader	3	2	1	2	2	2
Excavator	0	1	0	1	3	1
Shovel	1	2	2	1	2	1
CAT cable reeler	1	0	1	0	1	0
Coal haul to HVCPP	6	9	6	19	8	19
Coal haul to WPCPP	6	0	7	0	19	0
Diesel pump	4	0	4	0	4	0
Dragline	1	0	1	0	1	0
Drill	2	3	3	1	4	1
Dozer	6	5	6	4	10	4
Electric pump	9	2	8	2	8	2
Grader	2	2	2	2	4	2
Coal from WPCPP to NLP	6	0	6	0	6	0
Lighting plant	7	4	8	4	13	4
West Pit reject	1	0	1	0	1	0
Rubber tyred dozer	1	1	1	0	1	0
Scraper	1	1	1	1	0	1
Water truck	2	2	2	1	4	1
Waste truck	14	13	19	0	19	0
Fuel/Lube Truck	0	2	0	2	0	2
TOTAL	**73**	**49**	**79**	**40**	**110**	**40**

3.3.1 *Other Equipment – Alluvial Lands*

In addition to the equipment operating at West Pit and Carrington, dumping within the Alluvial Lands area may also occur concurrently. For modelling purposes, the overlap between these operations is expected to occur for the 2006 (Year 3 West Pit) and 2011 (Year 8 West Pit) scenarios. *Table 3.4* summarises the equipment that is typically associated with the Alluvial Lands. It should be noted that it is likely that these operations will cease from Year 8 onwards.

Table 3.4 Typical Mining Equipment Schedule – Alluvial Lands

Description	Modelled Year (West Pit EIS)	
	Year 3	Year 8
Waste Haul truck	5	5
Coal Haul truck	5	5
Dozer	2	2
Lighting plant	2	2
Total	**14**	**14**

3.3.2 *Other Equipment – Additional Coal Transportation And Fixed Plant*

In addition to the mining and dumping operations described above, other coal transportation and processing activities form part of the existing operations. These were included in the noise model as on-going activities and are:

- coal truck haulage from south of the Hunter River to the Hunter Valley Coal Preparation Plant - HVCPP (17 haul trucks were dedicated to these activities);

- auxiliary coal haulage can occur intermittently using road trucks to transport coal between the HVCPP and Hunter Valley Load Point, (HVLP) and between the HVLP to Newdell Load Point, (NLP) and Ravensworth Coal Terminal, (RCT) (conservatively 8 trucks were dedicated to this activity);

- Belt Line Conveyor – this conveyor system spans several kilometres between the HVCPP and HVLP;

- conveyor from West Pit Coal Preparation Plant (WPCPP) to Bayswater Power Station;

- HVCPP and WPCPP; and

- HVLP, NLP and RCT.

4 *PREDICTED NOISE LEVELS*

This chapter provides results of noise level predictions for the proposed mining operations.

4.1 *CALCULATION PROCEDURES*

The Environmental Noise Model (ENM) noise prediction software was used for modelling purposes. ENM takes into account distance, ground effect, atmospheric absorption and topographic detail. ENM is a Department of Environment and Conservation (DEC) accepted noise prediction model as it gives consistently reliable predictions of environmental noise. Initial calculations were performed under calm weather conditions, that is, no wind or temperature gradients. Assumed night time air temperature and relative humidity were 10°C and 80 % respectively. Noise levels during other conditions are discussed in *Section* 4.3.

The model incorporates three-dimensional digitised ground contours for the surrounding land and mine plans. Contours of the mine and overburden emplacement areas for each project stage were superimposed on surrounding base topography. Mining equipment was placed at various locations and heights, representing realistic operating conditions throughout the life of the mine. These locations were chosen to represent operations for each period and represent worst case situations.

The noise model predicts L_{eq} noise levels based on equipment sound power levels determined from measurements conducted at West Pit. The results assume all plant and equipment operate simultaneously. In practice, such an operating scenario would be unlikely to occur. The results are therefore considered conservative.

4.2 *CALM WEATHER RESULTS*

Table 4.1 summarises noise modelling results for calm weather conditions. These results represent all newly modelled operations for 2006, 2011 and 2014.

It is clear from *Table 4.1* that mine operations will satisfy consent noise limits during calm weather conditions at all private residences not already within a zone of affectation.

Table 4.1 ***$L_{eq,15minute}$ Noise Under Calm Meteorology, dB (A)***

Location	Day, Evening and Night Time			Consent Limits`
Receptor No.	**2006**	**2011**	**2014**	**Day/Evening/Night**
1	18	17	17	38-40
2	22	22	21	39
3	23	22	22	39
4	26	25	25	36-40
5	19	19	19	35
6	18	18	17	35
7[1]	32	33	33	40
8[1]	38	41	40	NA (Acquisition)
9[2]	37	36	36	NA (Acquisition)
10[3]	37	35	35	NA (Acquisition)
11[5]	24	22	22	39
12[2]	44	44	44	NA (Acquisition)
13[4]	16	15	16	40
14[4]	17	17	18	40
39	21	19	18	35

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
2. Owned by CNA.
3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
4. Additional Jerrys Plains assessment locations were added to ensure calculations are representative of the area.
5. Owned by Wambo Mine.

4.3 *PREDICTED NOISE LEVELS - PREVAILING WEATHER CONDITIONS*

Under various wind and temperature gradient conditions, noise levels may increase or decrease compared with calm conditions (ie zero wind and negligible temperature gradient). This is due to refraction of sound propagating through the atmosphere, brought about by a change in sound speed with height. Sound levels increase when the wind blows from source to receiver or under temperature inversion conditions and decrease when the wind blows from receiver to source or under temperature lapse conditions.

The noise criterion has traditionally been applied under calm conditions. Experience indicates that if the criterion is met under calm conditions, higher noise under prevailing meteorology is generally acceptable. This is because the ambient noise at properties also increases during such weather conditions and mine noise is masked (for example, wind induced vegetation noise).

Based on experience throughout the Hunter Valley, people become more noise sensitive if night time levels exceed approximately 40 dB(A) on a regular basis. This is 5 dB above the minimum level that would be traditionally set under calm conditions.

The Industrial Noise Policy (INP) sets out recommended procedures to assess noise under a range of meteorological conditions. Specific adverse meteorological conditions which are referred to as INP weather conditions are applied which should be used in assessment (in lieu of monitored data) and the criteria are applied under these conditions.

4.3.1 Discussion

For private residences, *Table 4.2* indicates that noise levels for INP weather conditions will generally be within the consent noise limits. The exception is Year 2006, where conservative predictions are marginally (up to 2 dB) higher than the limits for Receptors 2 to 4. Hence, a review by CNA mine planners was undertaken to further refine the required plant at night in order to reduce noise emissions. This resulted in the elimination of 1 shovel, drill and dozer within the Carrington Pit, which reduce overall received noise levels as shown in *Table 4.2* for '2006 Mitigated'.

The weather combined worst case noise levels for the three new modelling scenarios of the project are shown in *Figures 4.1 to 4.3* for each stage, and for all new stages in *Figure 4.4.* A comparison between the modelled wind affected and the calm results (*Table 4.1)* demonstrates an increase of up to 22 dB for these properties under weather enhanced conditions.

The highest difference between calm and adverse weather is predicted for Jerrys Plains residences. There exists a significant ridge (spanning several kilometres and up to 200m above sea level) between the mining area and these receptors. This ridge is the reason the ENM software models such an enhancement between calm and adverse wind results. Previous field validation by ERM of the ENM software results, has demonstrated that ENM can over predict noise levels by at least 3 dB under wind enhanced conditions. Where significant topography exists such as the aforementioned ridge, the ENM over-predictions are likely to be more than 3dB. In practice, an increase of 22 dB for Jerrys Plains is considered atypical. Additionally, the modelling assumes simultaneous operations of all equipment. The background noise at properties is also expected to rise during such adverse wind conditions due to wind induced vegetation noise and other mining or industrial activities. These will assist in masking noise from the proposal.

Assessing the noise predictions shown in *Table 4.2* against corresponding consent acquisition limits, *Table 2.1,* shows that all private residences not currently within a zone of affectation are at or below these limits. Of the properties that are owned by CNA, within a current zone of affectation or subject to a private land holders agreement, Receptors 8, 9, 10 and 12 are predicted to exceed likely noise acquisition targets. It should be noted that Receptor 4 is representative of dwellings situated on localised elevated ground.

As discussed in the *HVO West Pit Extension and Minor Modification EIS* (ERM, 2003), the Year 1 model results demonstrate good or conservative correlation with monitoring data for 2002. It should be noted that whilst this does provide some degree of certainty, the model results are for specific worst case assessable INP weather conditions and the monitoring conditions are likely to have varied from these conditions.

The applicable INP wind conditions and a 3 °C/100 m temperature inversion were modelled separately and the highest resulting noise level for each receptor is presented in *Table 4.2*.

These results are also presented graphically as noise contours that incorporate all assessable INP weather conditions (ie calm and INP weather for night time operations).

Table 4.2 Noise for INP Weather – Night

Location	Predicted $L_{eq,15\ minute}$ Noise Level, dB(A)				L_{eq} Consent Limit, dB(A)	L_{eq} Noise Consent Acquisition, dB(A)
Receptor No.	**2006**	**2006 Mitigated**	**2011**	**2014**	**Day/Evening/Night**	
1	40	39	36	35	38-40	>41
2	41	40	37	36	39	>41
3	41	40	37	37	39	>41
4	41	40	38	38	36-40	>41
5	29	29	29	29	35	>41
6	29	29	29	29	35	>41
7[1]	41	40	40	40	40	>42
8[1]	**48**	**48**	**49**	**49**	**NA (Acquisition)**	**NA (Acquisition)**
9[2]	**55**	**53**	**48**	**48**	**NA (Acquisition)**	**NA (Acquisition)**
10[3]	**49**	**48**	**44**	**44**	**NA (Acquisition)**	**NA (Acquisition)**
11[5]	40	39	39	38	39	>41
12[2]	**53**	**53**	**53**	**53**	**NA (Acquisition)**	**NA (Acquisition)**
13[4]	38	37	35	34	40	>41
14[4]	37	36	34	33	40	>41
39	32	31	30	30	35	>41

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
2. Owned by CNA.
3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
4. Additional Jerrys Plains assessment locations were added to ensure calculations are representative of the area.
5. Owned by Wambo Mine.

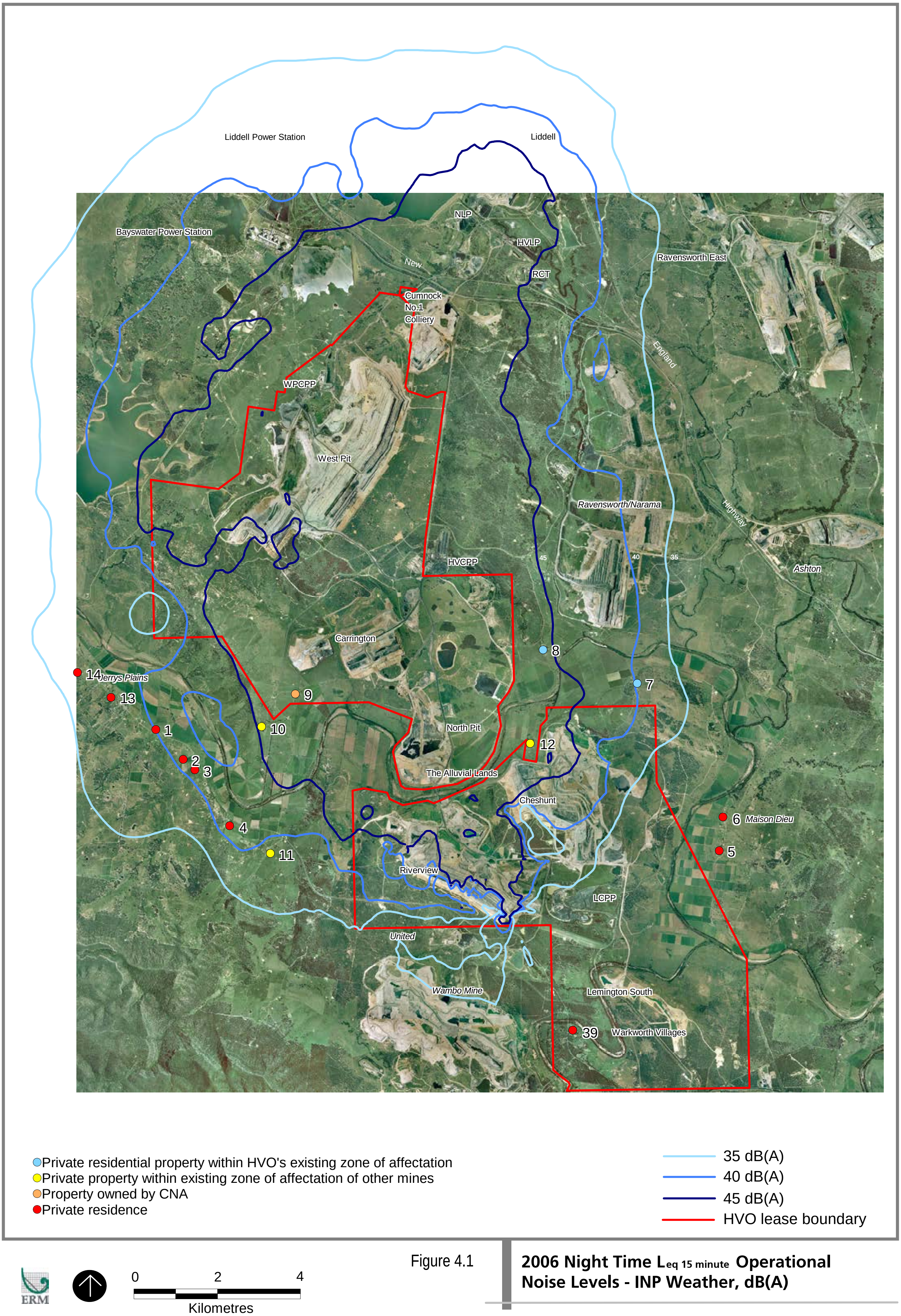

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Figure 4.1

2006 Night Time $L_{eq\ 15\ minute}$ Operational Noise Levels - INP Weather, dB(A)

Private residential property within HVO's existing zone of affectation
Private property within existing zone of affectation of other mines
Property owned by CNA
Private residence

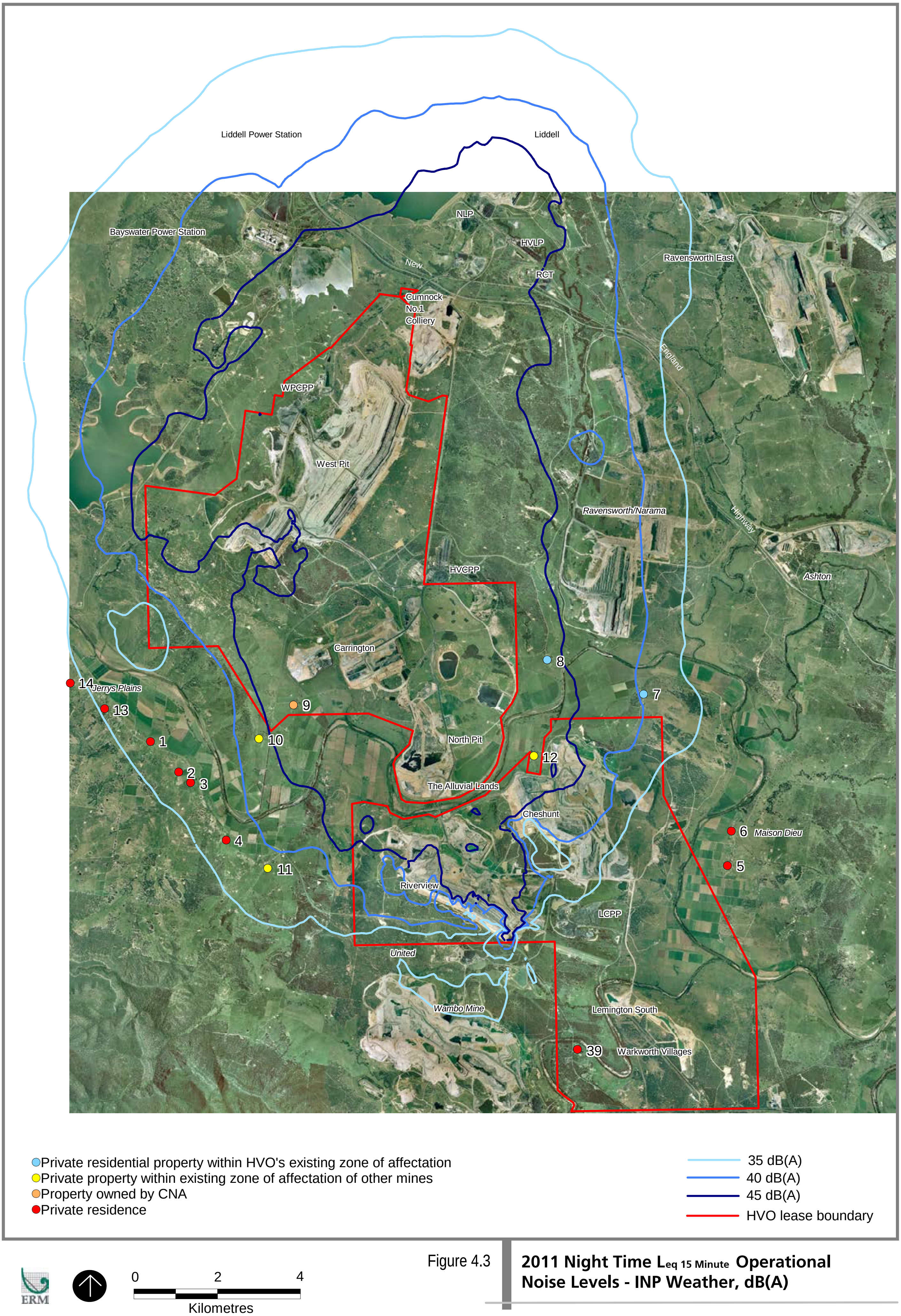
35 dB(A)
40 dB(A)
45 dB(A)
HVO lease boundary

ERM

0 2 4
Kilometres

Figure 4.2

2006 Mitigated Night Time $L_{eq\ 15\ minute}$ Operational Noise Levels - INP Weather, dB(A)



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ERM

Figure 4.3

2011 Night Time $L_{eq\ 15\ Minute}$ Operational Noise Levels - INP Weather, dB(A)

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Figure 4.4

2014 Night Time $L_{eq\ 15\ Minute}$ Operational Noise Levels - INP Weather, dB(A)

4.4 SLEEP DISTURBANCE

There is a potential for sleep of residents to be disturbed by transient noise such as shovel gates banging, bulldozer track plates, truck engine at fast revving and vehicle reversing alarms. *Table 4.3* presents noise levels for the noisiest of these sources measured by ERM for previous projects.

Table 4.3 ***Maximum Transient Noise***

Noise Source	Measured L_{max} Noise Level, dB(A)	Distance from Source (metres)
Shovel gate banging	60	400
Bulldozer with reversing alarm	69	80

A single truck movement may cause sleep disturbance, particularly if it is isolated from other mine-related noise. From the model results, it was determined that for most cases, truck movements would give higher noise levels at residences than the events listed in *Table 4.3*. The maximum sound power level (L_{max}) of haul trucks was measured at up to 125 dB(A)Lmax.

Maximum noise levels were calculated under INP wind conditions for each location and each operational scenario. *Table 4.4* shows calculated maximum noise levels from the highest ranked source for a given receptor. This is based on the typical equipment locations used for mining operations and corresponds to the maximum sound power level for the particular item of plant (generally that for a truck or 125 dB(A)). Calculations were undertaken for a single event, rather than the simultaneous operation of a number of plant items because the values given are instantaneous maxima and such events are not expected simultaneously. The criteria used to assess sleep disturbance are based on the EPA's background plus 15 dB for the $L_{1,1min}$ noise level (which in this case is conservatively approximated by the maximum noise level (L_{max})).

Table 4.4 demonstrates that calculated noise levels under prevailing weather conditions for HVO north of the Hunter River with the Carrington Extension are within the DEC's conservative sleep disturbance criterion at all private residences not currently within a zone of affectation. Receptors 9 and 12 are likely to experience noise levels above the DEC's sleep disturbance goal. For Receptor 9, this is attributed to operations at Carrington, and for Receptor 12, this is associated with truck haulage operations. Both Receptors 9 and 12 are owned by CNA.

Table 4.4 Sleep Disturbance Impact – INP Weather

Location	External L_{max} Noise Level From On-Site Plant, dB(A)			$L_{1,1min}$ Night Consent Limit, dB(A)
Receptor No.	2006	2011	2014	
1	37	35	35	46
2	36	36	36	46
3	36	37	37	46
4	37	38	38	46
5	28	28	28	46
6	28	28	28	46
7[1]	40	40	40	46
8[1]	46	52	52	NA (Acquisition)
9[2]	52	50	50	NA (Acquisition)
10[3]	45	44	44	NA (Acquisition)
11[5]	39	39	39	46
12[2]	61	61	61	NA (Acquisition)
13[4]	31	32	34	46
14[4]	31	34	34	46
39	37	34	34	46

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
2. Owned by CNA.
3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
4. Additional Jerrys Plains assessment locations were added to ensure calculations are representative of the area.
5. Owned by Wambo Mine.

4.5 CUMULATIVE NOISE ASSESSMENT

Adjoining industrial activity also influences the noise climate at receptors potentially exposed to the proposal. However, for most receptors this is limited, as the proposal constitutes the main contributor of industrial noise. Other industrial operations of significance are Riverview and Cheshunt Pits, Wambo, Ravensworth-Narama and Ashton Coal Mine.

Noise from surrounding mines was sourced from the following documents:

- an EIS produced by Resource Strategies Pty Limited in June 2003 for the Wambo Development Project;
- an SEE produced by ERM Australia Pty Limited in November 2001 for a Section 96(2) modification of the development consent for South Pit;
- an EIS produced by ERM Mitchell McCotter in August 1997 for the extension of mining operations at Ravensworth-Narama; and
- an EIS produced by HLA-Envirosciences Pty Limited in November 2001 for the Ashton Coal Project.

The aforementioned documents provide predicted L_{10} or L_{eq} noise levels for calm and adverse weather. For the purposes of this cumulative assessment, the following was adopted:

- For the Wambo project, the L_{eq} predicted noise levels enhanced under south easterly winds were used as those present the worst case impact on the private residences being addressed. It is assumed that operations extend to 2017 or Year 14 of operations in HVO north of the Hunter River;

- For HVO south of the Hunter River, the predicted noise levels were presented as L_{10}, and additional weather effects were predicted through statistically determining the frequency of occurrence of particular noise levels. These levels presented in the SEE are the 90th percentile point in that occurrence frequency set. These have been used as L_{eq} weather enhanced results in this assessment;

- For Ravensworth-Narama the predictions under a 3 °C/100 m temperature inversion were adopted. This is considered more appropriate than say winds in a given direction, given the relative locations of residences potentially affected by the proposed Carrington Extension and Ravensworth-Narama. That is, winds that enhance noise from one mine will not enhance noise from the other at the same residential location; and

- For the Ashton Coal Project, the predicted results for temperature inversions were used. These range from 31 dB(A) to 35 dB(A) Leq for potentially the most exposed Maison Dieu residence for various operating scenarios. However, a timeline breakdown is not provided hence the upper level of the range was adopted for the cumulative assessment.

The cumulative noise from these operations was added to the results for worst case INP weather from the proposal. This is a conservative approach as, for example, a south easterly wind that may enhance noise from Wambo will not equally enhance noise from the proposal. Nonetheless, this approach does provide a crude method of assessing cumulative noise during prevailing weather.

4.5.1 *Cumulative Noise Impact*

Table 4.5 summarises the cumulative noise effects of surrounding mines and related infrastructure. The percentage values in the parenthesis indicate the contribution of the proposed Carrington Extension (in noise terms) at that receptor.

The results are for prevailing weather conditions as described earlier and are therefore conservative. It should be noted that based on the information provided in corresponding EIS's, Wambo and Ravensworth/Narama mines will cease operations in 2016 (year 14) and 2007 (year 4) respectively. However, the Ravensworth Narama mine was presumed to operate until 2012 (year 8) for assessment purposes. The predicted noise from these operations were therefore cumulatively assessed accordingly. From beyond Year 14, noise is attributed to the proposal, Ashton and HVO south of the Hunter River.

Table 4.5 *Cumulative Night-time L_{eq} Noise Levels at Properties*

Location	Proposal Year		
Property No.	2006 (Mitigated)	2011	2014
	Cumulative Noise Level (Proposal contribution), dB(A)		
1	40 (79%)	37 (79%)	37 (63%)
2	41 (79%)	39 (63%)	39 (50%)
3	42 (63%)	40 (50%)	39 (63%)
4	43 (50%)	41 (50%)	41 (50%)
5	41 (6%)	40 (8%)	38 (13%)
6	41 (6%)	40 (8%)	37 (16%)
7[1]	43 (50%)	42 (63%)	40 (100%)
8[1]	**49 (79%)**	**50 (79%)**	**49 (100%)**
9[2]	**53 (100%)**	**48 (100%)**	**48 (100%)**
10[3]	**48 (100%)**	**45 (79%)**	**45 (79%)**
11[5]	**45 (25%)**	42 (50%)	41 (50%)
12[2]	**56 (50%)**	**54 (79%)**	**53 (100%)**
13[4]	38 (79%)	37 (63%)	36 (63%)
14[4]	37 (79%)	36 (63%)	35 (63%)

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
2. Owned by CNA.
3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
4. Additional Jerrys Plains assessment locations were added to ensure calculations are representative of the area.
5. Owned by Wambo Mine.

Applying a night time cumulative noise criterion equivalent to the DEC's night time amenity goal of 40 dB(A) $L_{eq,9hour}$, applicable for a rural residence according to the INP, shows that all private residences not currently within a zone of affectation will be within or marginally (not more than 3 dB) above the DEC's amenity goal. As discussed earlier, the predictions above are based on a worst case $L_{eq,15minute}$ noise level from each operation. Adopting a conservative 3 dB correction that is expected between the predicted worst case $L_{eq,15minute}$ and $L_{eq,9hour}$ noise level, implies that noise levels at these private residences are predicted to be below the DEC's amenity goal. This correction is due to the inherent downtime of plant over the 9 hour night-time period as compared with a worst case 15-minute noise emission level.

It should be noted that this 3 dB intrusiveness to amenity correction has not been applied to any results.

The private residence predicted to experience cumulative noise above the DEC criterion is Receptor 8. This receptor is currently inside a zone of affectation or subject to a private land holders agreement. The proposal's contribution to this exceedance is displayed in percentage terms in *Table 4.5*.

5 BLASTING NOISE AND VIBRATION

The proposed 2006 and 2011 Carrington operations blast details were provided by the proponent to ERM. These were used to calculate potential noise overpressure and ground vibration in accordance with Blastronics published data. The results indicate that noise overpressure and ground vibration consent limits (refer to Section 2) will be achieved at all private residential receptor locations. The results are summarised in *Tables 5.1* and *5.2*.

Table 5.1 Carrington 2006 Blast Calculations

Receptor No.	Closest Blast Distance (m)	MIC (Kg)	Blastronics 95% O/pressure, dB	Blastronics 95% Ground Vibration, PPV (mm/s)
1	4953	680-840	107.6-108.3	0.8-1.0
2	4504	680-840	108.6-109.3	1.0-1.1
3	4375	680-840	108.9-109.6	1.0-1.2
4	4446	680-840	108.7-109.4	1.0-1.1
5	9473	680-840	100.9-101.7	0.3-0.4
6	9262	680-840	101.2-101.9	0.3-0.4
7[1]	6714	680-840	104.5-105.0	0.5-0.6
8[1]	4554	680-840	108.5-109.0	0.9-1.1
9[2]	1546	680-840	119.6-120.3	4.5-5.2
10[3]	2486	680-840	114.7-115.5	2.2-2.6
11[5]	4403	680-840	108.8-109.5	1.0-1.1
12[2]	4311	680-840	109.0-109.8	1.0-1.2
13[4]	5954	680-840	105.7-106.4	0.6-0.7
14[4]	6815	680-840	104.3-105.0	0.5-0.6
39	9063	680-840	101.4-102.1	0.3-0.4

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
2. Owned by CNA.
3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
4. Additional Jerrys Plains assessment locations were added to ensure calculations are representative of the area.
5. Owned by Wambo Mine.

MIC – Maximum Instantaneous Charge, PPV – Peak Particle Velocity

Table 5.2 Carrington 2011 Blast Calculations

Receptor No.	Closest Blast Distance (m)	MIC (Kg)	Blastronics 95% O/pressure, dB	Blastronics 95% Ground Vibration, PPV (mm/s)
1	6175	680-840	105.3-106.1	0.6-0.7
2	5823	680-840	105.9-106.7	0.7-0.8
3	6009	680-840	105.6-106.3	0.6-0.7
4	5852	680-840	105.9-106.6	0.6-0.8
5	8229	680-840	102.4-103.1	0.4-0.5
6	7862	680-840	102.9-103.6	0.4-0.5
7[1]	5068	680-840	107.4-108.1	0.8-0.9
8[1]	2750	680-840	113.7-114.4	1.9-2.3
9[2]	3100	680-840	112.4-113.2	1.6-1.9
10[3]	4144	680-840	109.4-110.2	1.1-1.2
11[5]	5735	680-840	106.1-106.8	0.7-0.8
12[2]	2919	680-840	113.1-113.8	1.8-2.1
13[4]	7044	680-840	104.0-104.7	0.5-0.6
14[4]	7755	680-840	103.0-103.7	0.4-0.5
39	8660	680-840	101.9-102.6	0.4-0.4

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.
2. Owned by CNA.
3. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.
4. Additional Jerrys Plains assessment locations were added to ensure calculations are representative of the area.
5. Owned by Wambo Mine.

MIC – Maximum Instantaneous Charge, PPV – Peak Particle Velocity

6 NOISE AND VIBRATION MANAGEMENT

The Carrington extension forms part of the consolidated HVO north of the Hunter River. As part of HVO all activities at Carrington will be conducted in accordance with CNA's certified EMS (ISO14001).

A detailed noise management procedure (including monitoring) exists for the proposal and will be used to reduce impacts further. Features of the noise monitoring program include attended as well as unattended monitoring in specified locations and operating conditions.

In particular, monitoring will include noise levels during night time operations under adverse weather conditions. Management of noise emissions during these periods will include the modification of equipment usage such as the shovel, drills and bulldozers.

The CNA EMS includes procedures for noise and blasting which details requirements to manage activities to minimise impacts.

Environmental Procedure EP 9.1 Noise includes requirements for:

- Training in noise control procedures;
- Maintenance and testing for plant and equipment;
- Equipment operation;
- Timing of activities and equipment operations;
- Equipment purchase requirements;
- Management of community complaints; and
- Monitoring programmes.

Environmental Procedure EP 9.2 Blasting includes requirements for:

- Overpressure and vibration limits;
- Timing of blasts;
- Blast design including MIC;
- Restrictions due to weather conditions; and
- Monitoring of blasts.

Noise and vibration management in the Carrington Pit will be undertaken in accordance with these procedures and the Noise Management Plan developed for HVO north of the Hunter River.

7 *CONCLUSION*

This study considers the potential noise impacts of the proposed Carrington Extension as it contributes in the larger scheme of HVO north of the Hunter River. The acoustic assessment includes modelling of all major mining equipment at representative operational locations. The study had the following features:

- current noise and vibration consent limits;
- almost 4 years of site-specific hourly meteorological data analysed in accordance with the DEC's INP;
- source sound power levels for all equipment measured under operational conditions at mines, rather than using catalogue values or estimations; and
- the modelling itself addressed the DEC's INP with regard to weather effects.

The noise modelling has shown that under INP assessable weather conditions most private residential properties not currently located within a zone of affectation will experience noise levels below the consent limits. The exceptions are receptors in the vicinity of receptors 2 to 4 for the 2006 activities where noise is predicted to be marginally (2 dB) above limits. However, noise acquisition limits are predicted to be satisfied.

The proposal's noise impacts at all these locations are predicted to remain similar to existing levels for the life of the proposal.

As discussed in the *HVO West Pit Extension and Minor Modifications EIS (ERM, 2003)*, the Year 1 model results demonstrate good or conservative correlation with monitoring data for 2002. It should be noted that whilst this does provide some degree of certainty, the model results are for specific worst case assessable INP weather conditions and the monitoring conditions are likely to have varied from these conditions.

Ongoing noise monitoring will be used to assess the performance of the mining operations against the predicted noise levels.

Blast design will incorporate control on the MIC (maximum instantaneous charge) as described in this study and ensure acceptable limits are maintained. This will also be addressed through monitoring.

REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC) "Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration".

Blastronics Pty Ltd Drill & Blast Study, Mount Pleasant, prepared for CNA in September 1994.

Environment Protection Authority of NSW (January 2000) Industrial Noise Policy.

Environment Protection Authority (1994), Environmental Noise Control Manual (ENCM).

ERM Australia Pty Ltd SEE of November 2001 for Hunter Valley Operations Section 96(2) Modification of Development Consent.

ERM Mitchell McCotter EIS of August 1997 for the Extension of Mining Operations at Ravensworth Mine.

HLA Envirosciences Pty Limited EIS of November 2001 for the White Mining Limited Ashton Coal Project.

Resource Strategies Pty Ltd, EIS of June 2003 for the expansion of Wambo Development Project.

RTA Technology, Environmental Noise Model (ENM), Windows Version 3.06.

Appendix A

Mine Plans and Equipment Locations

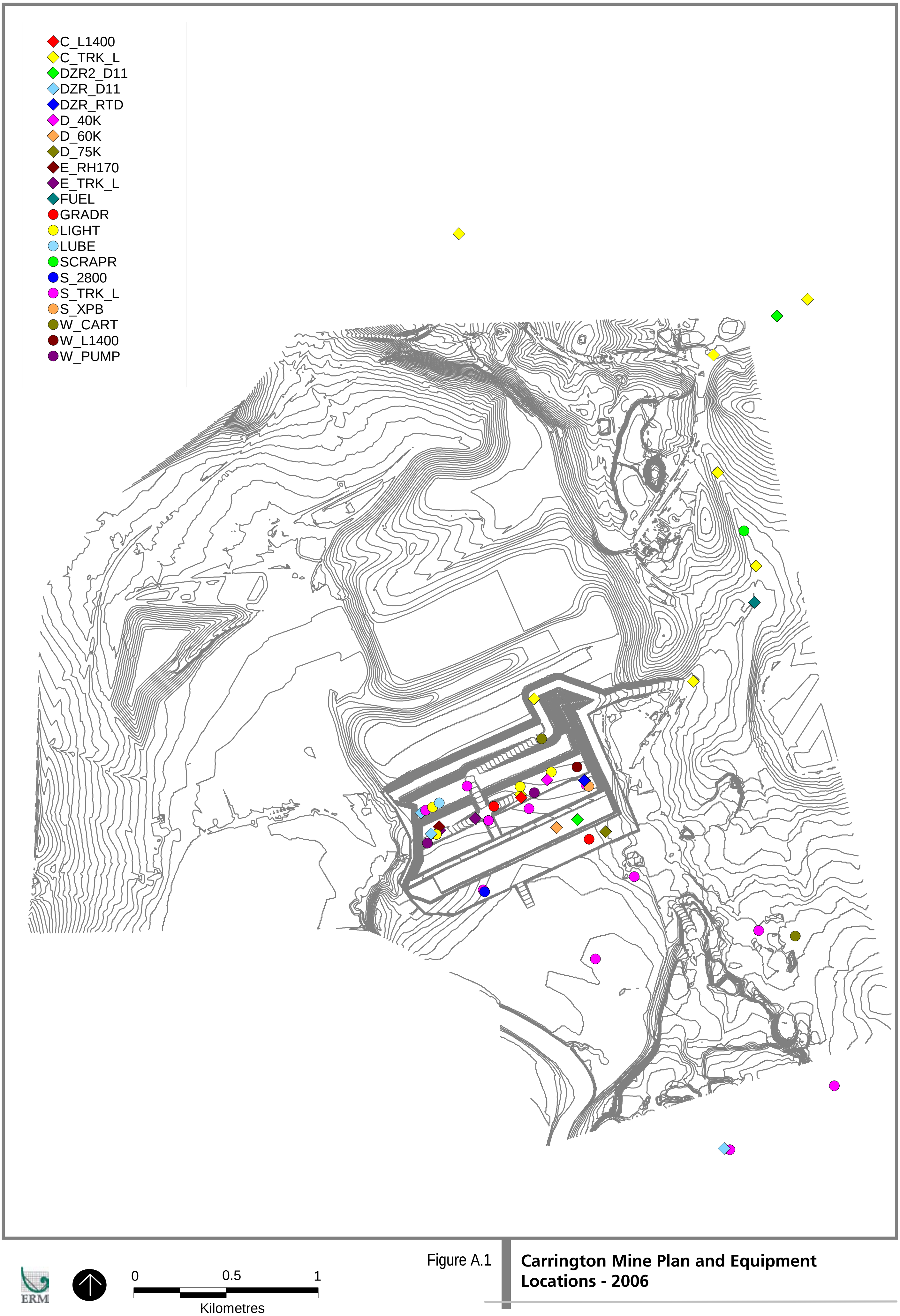
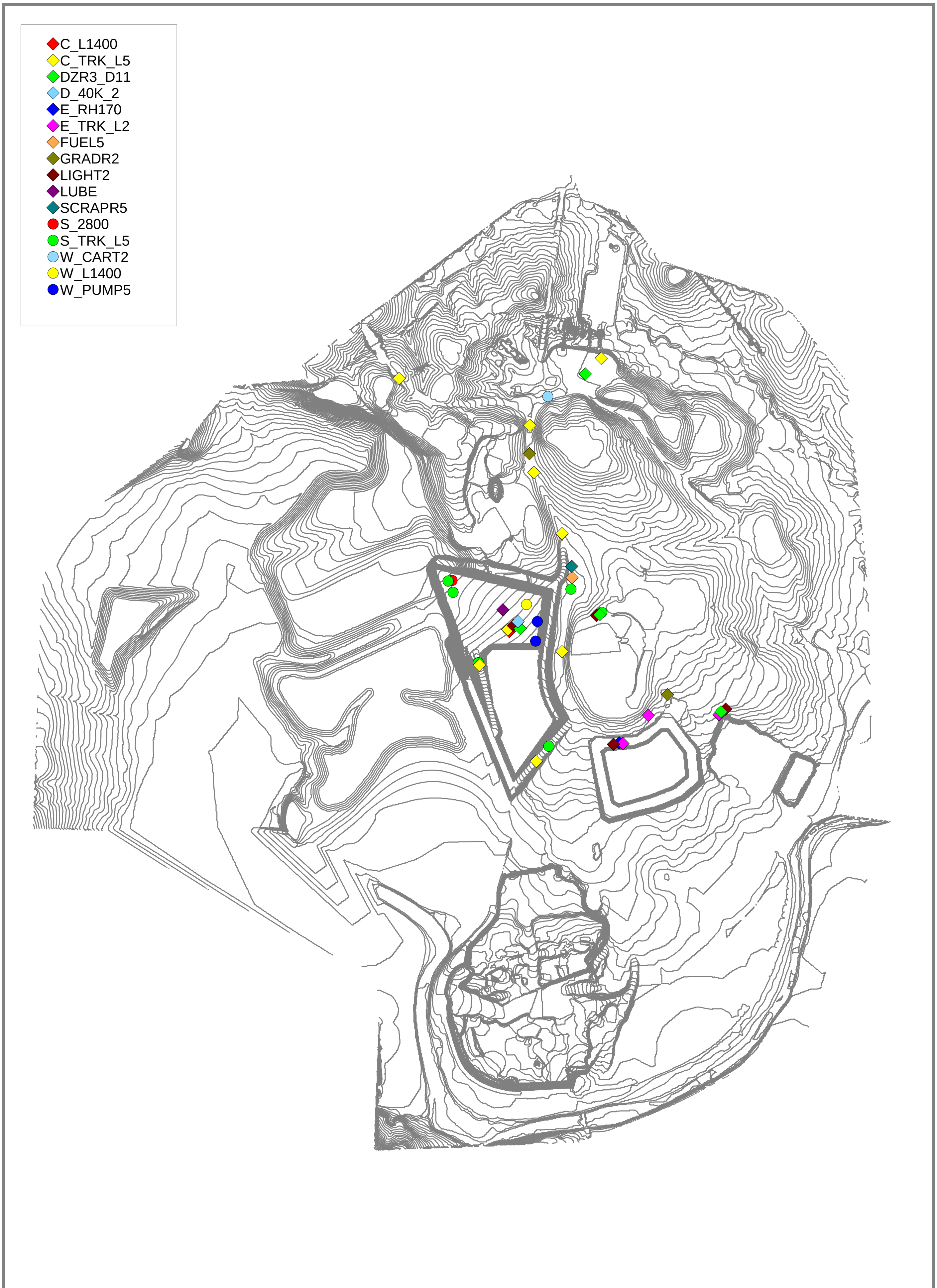


Figure A.1

Carrington Mine Plan and Equipment Locations - 2006



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Kilometres

Figure A.2

Carrington Mine Plan and Equipment Locations for Scenarios 2011 and 2014

Annex F

Air Quality Assessment

AIR QUALITY ASSESSMENT
CARRINGTON PIT EXTENSION

FINAL 17 October 2005

Prepared for
ERM (Australia) Pty Limited

on behalf of
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by

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GLOSSARY

CNA	Coal & Allied
HVO	Hunter Valley Operations
HVCPP	Hunter Valley Coal Preparation Plant
HVLP	Hunter Valley Loading Point
NSW DEC	New South Wales Department of Environment and Conservation
NLP	Newdell Loading Point
RCT	Ravensworth Coal Terminal
WPCPP	West Pit Coal Preparation Plant
LCPP	Lemington Coal Preparation Plant

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24. Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the Proposal and other sources in 2014 ($\mu g/m^3$)
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26. Predicted annual average PM_{10} concentrations due to emissions from the Proposal and other sources in 2014 ($\mu g/m^3$)
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EXECUTIVE SUMMARY

Introduction
Coal & Allied (CNA) own and operate Hunter Valley Operations (HVO), an open cut coal mine in the upper Hunter Valley. HVO consists of a number of open cut pits and is bisected by the Hunter River. HVO's mining activities north of the Hunter River include West Pit and Carrington Pit. Additional dust generating activities include the rehabilitation of the Alluvial Lands and North Pit, the associated coal preparation plants (CPPs) at Hunter Valley (HVCPP) and West Pit (WPCPP), and rail loading facilities at the Hunter Valley Loading Point (HVLP), Newdell Loading Point (NLP) and the Ravensworth Coal Terminal (RCT) (see **Figure 1**). This report examines air quality effects due to the proposed Carrington Extension operating in the context of HVO north of the Hunter River (the Proposal).

Local Setting, Description of the Operation and Identification of Issues
Terrain in the area is gently undulating and for the most part cleared. Open cut coal mining is currently the predominant land use having progressively replaced grazing and dairy farming over the past forty years or so. Agriculture grazing and dairy farming are important land uses on and beyond the boundaries of the mining area. Isolated rural residences associated with these agricultural enterprises are the most important land uses as far as air quality assessment is concerned. The town of Jerrys Plains is the largest population centre in the area.

Figure 1 shows the location and extent of HVO north of the Hunter River and identifies key infrastructure components.

An air quality assessment was completed in 2003 for the HVO West Pit Extension and Minor Modifications EIS in 2003 (**Holmes Air Sciences, 2003a**). Carrington Pit was included in this assessment.

This revised air quality assessment incorporates more detailed modelling for Carrington Pit than was available previously, along with the information for the other HVO north of the Hunter River operations. Modelling has been undertaken for three operational periods and considers operating modes that give a conservative assessment of the dust impacts.

The Proposal will also give rise to emissions of greenhouse gases such as methane from the exposed coal and emissions of carbon dioxide from fuel used by earth moving equipment, blasting and indirectly from electricity usage. Estimates of greenhouse gas emissions are also provided in this report.

In summary the issues dealt with in the assessment are:

1. The impacts likely to arise from emissions of particulate matter (PM) from HVO north of the Hunter River
2. The impacts likely to arise from emissions of PM from the Proposal including open cut mines at nearby mining operations including Cumnock, Wambo, Ravensworth-Narama and HVO south of the Hunter River, and
3. Greenhouse emissions from the Proposal

Air Quality Assessment Methods and Criteria
The air quality assessment has been carried out following the NSW DEC's guidelines for the assessment of air quality using dispersion modelling. This involves the following:

- Reviewing ambient air quality monitoring data to establish existing air quality
- Identifying ambient air quality criteria for assessing impacts
- Developing representative meteorological data files for use in the modelling
- Analysing the Proposal to develop estimates of dust emissions for three representative periods in the life of the development taking account of the flexibility required by CNA for operational reasons
- Predicting the concentration and deposition levels of dust due to emissions from the:

(i) Proposal

(ii) the Proposal plus all other sources in the area expected to be affected by the emissions from the Proposal

- Assessing the predicted concentration and deposition levels by comparing them with the assessment criteria.

Existing Air Quality

Data from monitoring programs operated by CNA provide measurements of 24-hour average concentrations of TSP and PM_{10} on a six-day cycle and monthly averages of dust fallout levels. Deposition data are available from a network of gauges (see **Figure 2**) and concentration data are available from the following sites:

- Cornfield TSP from 4 April 1998 to 26 December 2001 (discontinued station)
- Cheshunt TSP from 4 April 1998 to 30 December 2004
- Wandewoi TSP from 2 January 2002 to 30 December 2004
- Warkworth School PM_{10} and TSP from 3 January 2004 to 28 December 2004
- Stapleton TSP from 20 April 2003 to 23 September 2004
- Moxey TSP and PM_{10} from 3 January 2003 to 28 December 2004
- Knodlers TSP from 3 January 2004 to 30 December 2004
- HV2 (also known as River EOC) TSP from 3 January 2004 to 28 December 2004.

These data are reviewed in **Section 4**.

When interpreting the data it should be noted that they include the effects of existing mining operations. The data cannot be used directly to determine the background levels that should be added to predicted concentrations of TSP and PM_{10} that arise from the Proposal. This is because the Proposal includes activities that are already occurring and thus adding predicted Proposal concentrations to monitored levels would double count the effects of existing emissions.

The annual average concentrations at the Cornfield and Wandewoi monitoring sites have been below the 90 $\mu g/m^3$ annual criterion. Annual average concentrations of TSP at the Cheshunt monitor have exceeded the DEC criterion of 90 $\mu g/m^3$ on four out of the past six years and air quality at this site is clearly affected by emissions from the Cheshunt open cut, which is only a few hundred metres to the east. The data are not representative of the wider area where most non-mine residences are located.

Much of the data were collected during one of the most severe droughts in NSW over the past 100 years and were affected by smoke from bushfires associated with the dry period.

Many of the dust deposition gauges are located within the mining lease close to areas where active mining is taking place. The data from these gauges can be used to show the rate at which dust deposition levels decrease with distance from actively mined areas.

Monitoring data from gauges D5, D9, D112 and D102 to D104 provide data that is representative of conditions near residential areas.

Inspection of the data indicates that rural residential areas that are not already substantially affected by mining operations could accommodate an increment of annual dust deposition of 2 g/m^2/month without causing the DEC's 4 g/m^2/month criterion to be exceeded.

It should be noted that these data include the effect of existing mining operations and are unlikely to experience a significant change as a result of the continuation of mining.

Climate and Meteorology

Meteorological data are available from a number of different sites including a meteorological station operated by CNA near the HVCPP. This is referred to as the HVO meteorological station. A total of 8,736 hours of data were available for 2002. This corresponds to 99.7% of the data potentially available in a year. The distribution of winds for the site for the year 2004 are consistent with the 2002 data and, they are also consistent with long-term patterns observed in the central parts of the Hunter Valley. The data were therefore considered to be representative of dispersion conditions at the site and in the area covered by the modelling.

Long-term climatic data have been taken from records collected since 1884 by the Bureau of Meteorology at Jerrys Plains.

Estimated Emissions of Particulate Matter

The mining plans for proposed Carrington Pit Extension have been analysed and detailed emissions inventories have been prepared for three operating years:

1. **2006**

   - 2006 Carrington Pit with data from the West Pit Extension and Minor Modifications assessment for Year 3 (2006)

2. **2011**

   - 2011 Carrington Pit with data from the West Pit Extension and Minor Modifications assessment for Year 8 (2011)

3. **2014**

   - 2011 Carrington Pit with data from the West Pit Extension and Minor Modifications assessment for Year 14 (2017)[1]

[1] Carrington Pit operations are due to be completed by 2011. This scenario represents a contingency to allow for changes in market forces. It assumes the mining activities occur in the same location as in 2011. For the rest of the activities, the data from the closest year to 2014 in the West Pit Extension and Minor Modifications assessment (that is, the year 2017) were used.

The West Pit Extension and Minor Modifications inventories include both estimated emissions from all other HVO operations north of the Hunter River and emissions from other nearby mines, namely Wambo, Ravensworth-Narama, Riverview, Cheshunt and Cumnock.

Appendix D provides details as to how dust emissions from each dust producing activity have been calculated including the effect of dust controls and the assumptions that have been made in estimating the emissions. **Table 24** summarises the estimated TSP emission rates for each scenario.

Other mines and other sources, in addition to those identified above, will of course contribute to $PM_{2.5}$, PM_{10}, TSP concentrations and to dust deposition. In the past, the annual average quantity of particulate matter contributed by these more distant sources has been set at 5 $\mu g/m^3$ for PM_{10}, 10 $\mu g/m^3$ for TSP and 0.5 g/m^2/month for deposited dust.

Assessment Methodology

The assessment methodology follows the DEC guidelines. This report however provides a more comprehensive discussion of relevant issues that arise when the DEC methodology is applied to this type of assessment.

Assessment of Impacts – Particulate Matter

The report provides isopleth diagrams showing the following for each of the three operational periods assessed.

1. The predicted maximum 24-hour average PM_{10} concentration for the Proposal alone
2. The predicted maximum 24-hour average PM_{10} concentration for the Proposal with other sources of PM
3. The predicted annual average PM_{10} concentration for the Proposal
4. The predicted annual average PM_{10} concentration for the Proposal with other sources of PM
5. The predicted annual average TSP concentration for the Proposal
6. The predicted annual average TSP concentration for the Proposal with other sources of PM
7. The predicted annual average dust deposition for the Proposal, and
8. The predicted annual average dust deposition for the Proposal with other sources of PM

Similar predictions for 24-hour and annual average $PM_{2.5}$ concentrations for the Proposal by itself and the Proposal considered with the effects of other mines are provided in **Appendix A**.

Air Quality Criteria

The air quality criteria used for deciding which properties are likely to experience air quality impacts above those specified in the DEC's modelling guidelines as interpreted by recent conditions of consent for mines in the Hunter Valley are:

- 50 $\mu g/m^3$ for 24-hour PM_{10} for the Proposal considered alone;
- 150 $\mu g/m^3$ for 24-hour PM_{10} for the Proposal considered with the contributions of other sources;
- 30 $\mu g/m^3$ for annual average PM_{10} due to the Proposal and other sources

- 90 µg/m^3 for annual average TSP concentrations due to the Proposal and other sources
- 2 g/m^2/month for annual average deposition (insoluble solids) due to the Proposal considered alone and
- 4 g/m^2/month for annual predicted cumulative deposition (insoluble solids) due to the Proposal and other sources

Following the practice established in recent conditions of consent, with the exception of the 2 g/m^2/month goal and the 24-hour PM_{10}, the assessment criteria are interpreted to be cumulative assessment criteria.

The 24-hour PM_{10} criterion of 50 µg/m^3 is interpreted as being applicable to the Proposal when considered in isolation and the US EPA 24-hour PM_{10} standard of 150 µg/m^3 has been taken to be the cumulative criterion.

Rather than provide a detailed discussion of each isopleth figure, the results have been summarised in tabular form for each year showing the residences located in the area and highlighting those that are predicted to experience particulate matter deposition or concentration levels above the DEC's assessment criteria. Three residences are predicted to experience concentrations or deposition levels above the DEC assessment criteria. All of the residences are either owned by mining companies, are within an existing zone of affectation, or are subject to agreements between mining companies and the owners.

Greenhouse Gases
The Proposal will give rise to emissions of greenhouse gases such as methane (CH_4) and carbon dioxide (CO_2) from the exposed coal and emissions of CO_2 from fuel used by earth moving equipment, blasting and indirectly from electricity usage. An assessment of greenhouse gas emissions is provided in **Section 10**.

Conclusions
This report has developed emissions inventories for integrated operations of HVO north of the Hunter River for three representative operational periods. These have been used with local meteorological data and the US EPA's Industrial Source Complex Short Term (Version 3) model ISCST3 to predict the maximum 24-hour PM_{10}, annual average PM_{10}, annual average TSP and annual average dust deposition (insoluble solids) over an area extending approximately 14 km (east-west) and 21 km (north-south). The modelling has been undertaken to show both the effects of HVO north of the Hunter River including the Proposal and the effects of these modified operations taking into account the effects of emissions from neighbouring mines and other sources of dust.

It is concluded that three residences will be impacted by dust levels exceeding the DEC assessment criteria. Two of these residences are already within an existing zone of affectation or have private agreements in place either with CNA or with other mining companies. Emissions from HVO north of the Hunter River make little contribution to the exceedances.

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1. INTRODUCTION

Coal & Allied (CNA) own and operate Hunter Valley Operations (HVO), an open cut coal mine in the Hunter Valley. HVO consists of a number of open cut pits and is bisected by the Hunter River. HVO's mining activities north of the Hunter River include West Pit and Carrington Pit. Additional dust generating activities include the rehabilitation of the Alluvial Lands and North Pit, the associated coal preparation plants (CPPs) at Hunter Valley (HVCPP) and West Pit (WPCPP), and rail loading facilities at the Hunter Valley Loading Point (HVLP), Newdell Loading Point (NLP) and the Ravensworth Coal Terminal (RCT) (see **Figure 1**). This report examines air quality effects due to the proposed Carrington Extension operating in the context of HVO north of the Hunter River (the Proposal).

2. LOCAL SETTING, DESCRIPTION OF THE OPERATION AND IDENTIFICATION OF ISSUES

Terrain in the area is gently undulating and for the most part cleared. Open cut coal mining is currently the predominant land use having progressively replaced grazing and dairy farming over the past forty years or so. Agriculture, grazing and dairy farming are important land uses on and beyond the boundaries of the mining area. Isolated rural residences associated with these agricultural enterprises are the most important land uses as far as air quality assessment is concerned. The town of Jerrys Plains is the largest population centre in the area.

Figure 1 shows the location and extent of HVO north of the Hunter River and identifies key infrastructure components. Apart from the open cut pits labelled West Pit and Carrington Pit with their associated haul roads, the key components include:

- Rehabilitation of the Alluvial Lands
- Rehabilitation of North Pit
- West Pit Coal Preparation Plant (WPCPP)
- Hunter Valley Coal Preparation Plant (HVCPP)
- Newdell stockpiles and rail loading point (NLP)
- Hunter Valley stockpiles and loading point (HVLP)
- Ravensworth Coal Terminal (RCT)
- Conveyor from HVCPP to HVLP
- Conveyor to Bayswater Power Station from WPCPP
- Pikes Gully Road coal transport route
- Belt Line Road intermittently used as haul road from HVCPP to HVLP

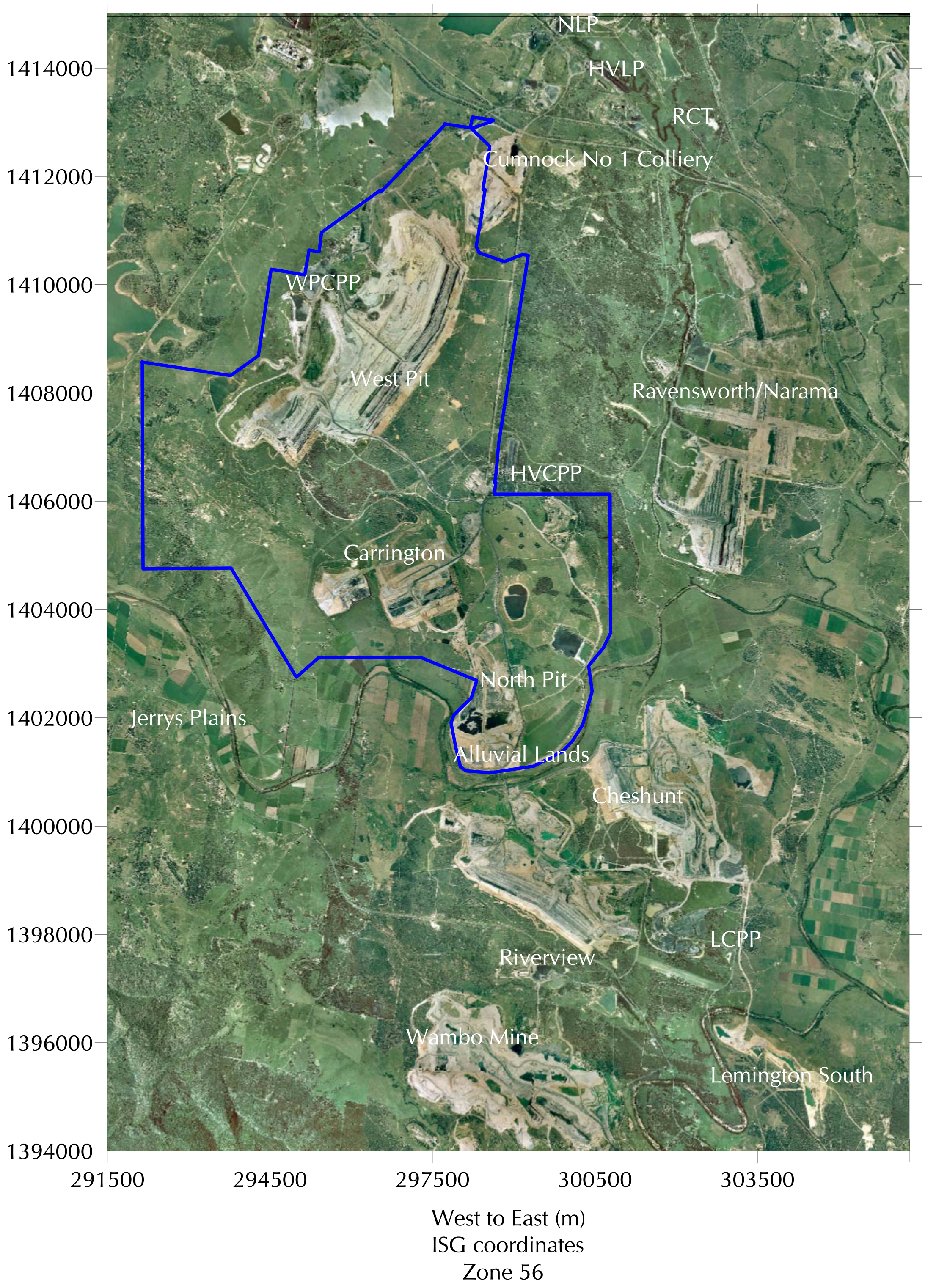
An air quality assessment was completed for the West Pit Extension and Minor Modifications EIS in 2003 (**Holmes Air Sciences, 2003a**). Carrington Pit was included in this assessment but since that time an opportunity has been identified to extend the Carrington Pit.

This revised air quality assessment incorporates detailed modelling for Carrington Pit along with the information for the other HVO north operations. Modelling has been undertaken for three operational periods and considers operating modes that give a conservative assessment of the impacts.

In addition the Proposal will give rise to emissions of greenhouse gases such as methane (CH_4) and carbon dioxide (CO_2) from the exposed coal and emissions of CO_2 from fuel used by earth moving equipment, blasting and indirectly from electricity usage. An assessment of greenhouse gas emissions is provided in **Section 10**.

In summary this assessment addresses:

1. The impacts likely to arise from emissions of particulate matter (PM) from HVO north of the Hunter River
2. The impacts likely to arise from emissions of PM from the Proposal including open cut mines at nearby mining operations including Cumnock, Wambo, Ravensworth-Narama and HVO south of the Hunter River, and
3. Greenhouse emissions from the Proposal



Location of study area

Figure 1

3. AIR QUALITY ASSESSMENT METHODS AND CRITERIA

In its guidelines (**NSW EPA, 2001**) the New South Wales Department of Environment and Conservation (NSW DEC) (formerly the New South Wales Environment Protection Authority - NSW EPA) specifies air quality assessment criteria relevant for assessing impacts from mining. These are summarised in **Tables 1**, **2** and **3**.

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPMs (see **NEPC, 1998**)). However, the NSW DEC's criteria include averaging periods, which are not included in the Air-NEPMs and references to other measures of air quality, namely dust deposition and total suspended particulate matter (TSP), which are also not part of the Air-NEPMs.

Table 1: NSW DEC impact assessment criteria for pollutants (for use in modelling)

Pollutant	Averaging period	Concentration	
		pphm	**mg/m^3**
PM_{10}	1-day annual	- -	50* 30
SO_2	10 minutes 1-hour 1-day 1-year	25 20 8 2	712 570 228 60
NO_2	1-hour 1-year	12 3	246 62
		ppm	**mg/m^3**
CO	15 minutes 1-hour 8-hours	87 25 9	100 30 10

* Non-cumulative for purposes of impact assessment

In addition, the guidelines provide the criteria for TSP (see **Table 2**) and for the insoluble component of deposited dust (see **Table 3**).

Table 2: NSW DEC assessment criteria for TSP

Pollutant	**Averaging period**	**Concentration**
TSP	Annual	90 $\mu g/m^3$

Table 3: NSW DEC amenity based criteria for dust fallout

Pollutant	**Averaging period**	**Maximum increase in deposited**	**Maximum total dust deposition**
Deposited dust (insoluble)	Annual	2 g/m^2/month	4 g/m^2/month

In May 2003, NEPC released a variation to the NEPM (**NEPC, 2003**). The advisory reporting standards for $PM_{2.5}$ are a 24-hour average of 25 µg/m³ and an annual average of 8 µg/m³. There is no time line for compliance. The goal is to gather sufficient data nationally to facilitate the review of the Air Quality NEPM scheduled to commence in 2005. The variation includes a protocol setting out monitoring and reporting requirements for particles as $PM_{2.5}$.

At this stage, the advisory reporting $PM_{2.5}$ standards are not part of the NSW DEC assessment criteria and while predictions have been made as to the likely contribution that emissions from the mine will make to ambient $PM_{2.5}$ concentrations, these predictions have not been used to assess impacts against the proposed advisory standard. Predictions of $PM_{2.5}$ concentrations are provided in **Appendix A**.

The sulphur content of Australian diesel is too low and mining equipment is too widely dispersed over mine sites to cause sulphur dioxide (SO_2) goals to be exceeded even in mines that use large quantities of diesel. For this reason, no detailed study is required to demonstrate that emissions of SO_2 from the mine will not significantly affect ambient SO_2 concentrations. Similarly, NO_x and CO emissions are too small and too widely dispersed to require a detailed modelling assessment.

Thus, the focus of the study is on the potential effects of PM emissions. PM has the capacity to affect human health and to cause nuisance effects.

To assist in interpreting the significance of predicted concentration and deposition levels some background discussion on the potential harmful effects is provided below.

PM can be categorised by size and/or by chemical composition. The potential harmful effects depend on both.

The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 µm from reaching the more sensitive parts of the respiratory system. Particles with aerodynamic diameters less than 10 µm are referred to as PM_{10}. Particles larger than 10 µm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air. This is referred to as TSP. In practice, particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 µm. TSP includes PM_{10}.

The suite of ambient air quality criteria used in the assessment is comprehensive and would be expected to protect against all harmful effects of the emissions from the Proposal including health and nuisance effects.

4. EXISTING AIR QUALITY

Emissions from the Proposal and the criteria for assessment were discussed in **Section 3**. Emissions comprise PM_{10}, TSP and deposited PM. In addition, there will be emissions of carbon monoxide (CO) and small quantities of nitrogen dioxide (NO_2) from diesel equipment and blasting and trace amounts of SO_2. In practice, the sources of CO, NO_2 and SO_2 in mining operations are too small and too widely dispersed to give rise to significant concentrations of these pollutants and these are not discussed in any detail in this report.

Data from monitoring programs operated by CNA provide measurements of 24-hour average concentrations of TSP and PM_{10} on a six-day cycle and monthly averages of dust fallout levels. The locations of the relevant monitoring sites are shown in **Figure 2**.

Data from these networks are reviewed below.

4.1 PM Concentrations (TSP and PM_{10})

Twenty-four hour average concentrations of TSP and PM_{10} (on a six-day cycle) have been measured over various periods at the ten sites: Cornfield, Cheshunt, Wandewoi, Warkworth, Warkworth School, Stapleton, Moxey, Knodlers Lane (also known as Curlewis) and HV2 (also known as River EOC) (see **Figure 2)**. The available data are summarised below:

- Cornfield TSP from 4 April 1998 to 26 December 2001
- Cheshunt TSP from 4 April 1998 to 26 June 2005
- Curlewis (Knodlers Lane) TSP from 3 January 2004 to 30 December 2004
- HV4 TSP from 9 January 2004 to 26 June 2005
- Jerrys Plains School PM_{10} from 2 February 2005 to 26 June 2005
- Kilburnie South TSP from 20 February 2005 to 26 June 2005 and PM_{10} from 28 December 2004 to 26 June 2005
- Moxey TSP and PM_{10} from 8 January 2003 to 26 June 2005
- Oaklands PM_{10} from 10 December 2004 to 26 June 2005.
- Stapleton TSP from 20 April 2003 to 23 September 2004
- Wandewoi TSP from 23 July 2001 to 26 June 2005 and PM_{10} from 30 December 2004 to 26 June 2005
- Warkworth School PM_{10} and TSP from 27 December 2002 to 26 June 2005

When interpreting the data it should be noted that the data include the effects of existing mining operations. As a result, the data cannot be used directly to determine the background levels that would apply in the absence of the Proposal. This is because the Proposal is an extension of activities that are already occurring. Adding predicted concentrations due to the Proposal to monitored levels will double count the effects of existing emissions. That is the monitored data includes the effects of emissions that are also included in the model predictions. However to simplify the assessment for cumulative impacts this is what has been done. Readers should be aware of the fact that some of the impacts are double counted.

Tables 4 to **19** summarise the data showing the annual average, maximum 24-hour, minimum 24-hour and number of observations for each year.

Table 4: Concentrations of TSP measured at Cornfield 1998 to 2002

Year	Annual average TSP (μg/m^3)	Maximum TSP (μg/m^3)	Minimum TSP (μg/m^3)	Number of samples
1998	27.9	64.4	2.4	39
1999	38.2	84.2	6.8	52
2000	38.2	85.3	3.9	54
2001	32.9	91.8	5.2	47
2002	Site discontinued			

Table 5: Concentrations of TSP measured at Cheshunt 1998 to June 2005

Year	Annual average TSP (μg/m^3)	Maximum TSP (μg/m^3)	Minimum TSP (μg/m^3)	Number of samples
1998	105.3	230.0	6.5	41
1999	110.7	361.6	25.1	60
2000	86.6	189.9	21.1	59
2001	82.4	217.8	17.3	60
2002	149.2	390.2	26.2	61
2003	155.9	478.8	21.9	61
2004	96.7	386.0	13.3	57
2005 (to June)	86.6	243	27.3	29

Table 6: Concentrations of TSP measured at Curlewis (Knodlers Lane) 2004

Year	Annual average TSP (μg/m^3)	Maximum TSP (μg/m^3)	Minimum TSP (μg/m^3)	Number of samples
2004	56.2	117.1	12.1	59

Table 7: Concentrations of TSP measured at HV2 (also known as River EOC) 2004 to June 2005

Year	Annual average TSP (μg/m^3)	Maximum TSP (μg/m^3)	Minimum TSP (μg/m^3)	Number of samples
2004	49.5	126.5	7.8	56
2005 (to June)	48.4	205	16.7	28

Table 8: Concentrations of TSP measured at HV4 2004 to June 2005

Year	Annual average TSP (μg/m^3)	Maximum TSP (μg/m^3)	Minimum TSP (μg/m^3)	Number of samples
2004	56.5	117.1	12.1	58
2005 (to June)	46.8	116.0	11.3	29

Table 9: Concentrations of TSP measured at Kilburnie South 2004 to June 2005

Year	Annual average TSP (mg/m^3)	Maximum TSP (mg/m^3)	Minimum TSP (mg/m^3)	Number of samples
2005 (to June)	29.6	64.7	5.7	22

Table 10: Concentrations of TSP measured at Moxey 2003 to June 2005

Year	Annual average TSP (mg/m^3)	Maximum TSP (mg/m^3)	Minimum TSP (mg/m^3)	Number of samples
2003	139.9	2,781.7	19.4	50
2004	51.2	107.1	14.7	62
2005 (to June)	47.1	126	16.2	30

Table 11: Concentrations of TSP measured at Stapleton (from Ravensworth monitoring program) 2003 to 2004

Year	Annual average TSP (mg/m^3)	Maximum TSP (mg/m^3)	Minimum TSP (mg/m^3)	Number of samples
2003	60.6	223	18	43
2004	71.7	226	18	45

Table 12: Concentrations of TSP measured at Wandewoi 2002 to June 2005

Year	Annual average TSP (mg/m^3)	Maximum TSP (mg/m^3)	Minimum TSP (mg/m^3)	Number of samples
2002	54.5	148.9	5.7	62
2003	45.1	173.0	6.4	61
2004	39.2	83.1	3.7	61
2005 (to June)	45.6	96.4	5.6	30

Table 13: Concentrations of TSP measured at Warkworth School 2003 to June 2005

Year	Annual average TSP (mg/m^3)	Maximum TSP (mg/m^3)	Minimum TSP (mg/m^3)	Number of samples
2003	68.1	236	19	61
2004	58.8	141	17.1	54
2005 (to June)	52.3	148	13.4	30

Table 14: Concentrations of PM_{10} measured at Jerrys Plains School February to June 2005

Year	Annual average PM_{10} (mg/m^3)	Maximum PM_{10} (mg/m^3)	Minimum PM_{10} (mg/m^3)	Number of samples
2005 (to June)	14.1	33	2.9	25

Table 15: Concentrations of PM_{10} measured at Kilburnie South January to June 2005

Year	Annual average PM_{10} (mg/m^3)	Maximum PM_{10} (mg/m^3)	Minimum PM_{10} (mg/m^3)	Number of samples
2005 (to June)	15.1	34.8	3.0	30

Table 16: Concentrations of PM_{10} measured at Moxey 2004 to June 2005

Year	Annual average PM_{10} (mg/m^3)	Maximum PM_{10} (mg/m^3)	Minimum PM_{10} (mg/m^3)	Number of samples
2003	31.5	337.5	2.1	51
2004	18.1	38.4	4.3	60
2005 (to June)	17.4	41.7	3.6	30

Table 17: Concentrations of PM_{10} measured at Oaklands January to June 2005

Year	Annual average PM_{10} (mg/m^3)	Maximum PM_{10} (mg/m^3)	Minimum PM_{10} (mg/m^3)	Number of samples
2005 (to June)	22.5	61.1	5.8	30

Table 18: Concentrations of PM_{10} measured at Wandewoi January to June 2005

Year	Annual average PM_{10} (mg/m^3)	Maximum PM_{10} (mg/m^3)	Minimum PM_{10} (mg/m^3)	Number of samples
2005 (to June)	17.7	38.1	2.9	30

Table 19: Concentrations of PM_{10} measured at Warkworth School 2004 to June 2005

Year	Annual average PM_{10} (mg/m^3)	Maximum PM_{10} (mg/m^3)	Minimum PM_{10} (mg/m^3)	Number of samples
2003	25.6	132	3.0	61
2004	27.1	78.7	6.7	54
2005 (to June)	26.2	65.5	10.8	30

In 2004 the annual average TSP concentrations at all monitoring sites, except Cheshunt, were in the range 39.2 µg/m^3 to 71.7 µg/m^3. In the first six months of 2005, the average TSP concentrations (except Cheshunt) ranged from 14.1 µg/m^3 to 52.3 µg/m^3. The concentrations are clearly influenced by emissions from mining but are below the 90 µg/m^3 annual criterion. The Cheshunt site is affected by dust emissions from nearby mining in the Cheshunt Pit and other mines which surround the site. This site would be within the pit and dump area of the Proposal.

Information on concentrations of PM_{10} are available from six sites, Moxey, Warkworth School, Jerry's Plains School, Kilburnie South, Oaklands and Wandewoi (see **Tables 15** to **21**). The data from 2003 were collected at the end of one of the most severe droughts in NSW over the past

100 years and were affected by smoke from bushfires associated with the dry period. In the period from January to June 2005 the average PM_{10} concentrations were within the DEC annual criterion of 30 µg/m^3. The 24-hour average PM_{10} concentrations were within the DEC criterion of 50 µg/m^3 except for two exceedances, both recorded on 8th February 2005, at Oaklands and Warkworth School.

4.2 Deposition

The locations of relevant dust deposition gauges operated by CNA are shown in **Figure 2**. Table 20 summarises the annual average deposition levels. The monthly average deposition levels are presented in **Appendix B**. Many of the gauges (see **Figure 2**) are located within the mining lease close to areas where active mining is taking place. The data from these gauges can be used to show the rate at which dust deposition levels decrease with distance from actively mined areas, but is not relevant for determining the background level.

Monitoring data from gauges D5, D103, D112, L14, L21, L22 and Knodlers Lane provide data that is representative of conditions near residential areas and is relevant for determining baseline data for assessment purposes.

Inspection of **Table 20** indicates that since the beginning of 2001:

- D5 has recorded annual average deposition levels of insoluble solids in the range 2.0 to 4.5 g/m^2/month;
- D103 has recorded annual average deposition levels of insoluble solids in the range 0.7 to 2.9 g/m^2/month;
- D112 has recorded annual average deposition levels of insoluble solids in the range 1.1 to 1.8 g/m^2/month;
- L14 has recorded annual average deposition levels of insoluble solids in the range 1.6 to 1.8 g/m^2/month (2.5 years of data);
- L21 has recorded annual average deposition levels of insoluble solids in the range 1.5 to 2.4 g/m^2/month (2.5 years of data);
- L22 has recorded annual average deposition levels of insoluble solids in the range 1.6 to 1.9 g/m^2/month, and;
- Knodlers has recorded annual average deposition levels of insoluble solids in the range 1.2 to 1.6 g/m^2/month (2.5 years of data).

Gauge D5 is located close to the Carrington Pit and Residence 6. This property is owned by CNA. Gauge L21 indicates that annual average deposition close to Residence 14 is above 2.0 g/m^2/month, but the surrounding gauges, L10, L14, L18 and L22 and Knodlers Lane all show levels below 2.0 g/m^2/month, which suggests that this gauges is affected by a very local source. It would be reasonable to infer that the rural residential areas that are not already substantially affected by mining operations could accommodate an increment of annual dust deposition of 2 g/m^2/month without causing the EPA's 4 g/m^2/month criterion to be exceeded.

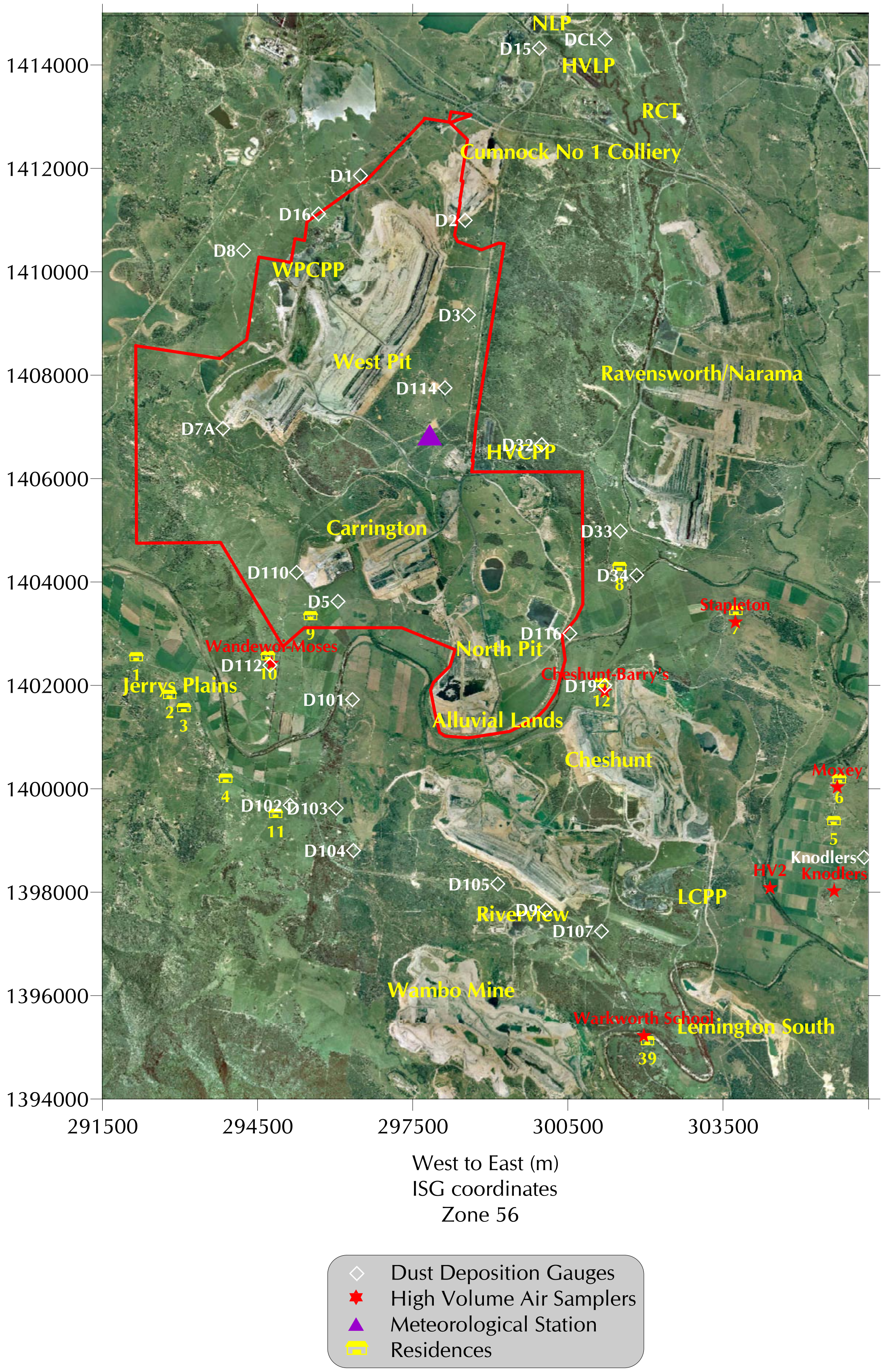
It should be noted that these data include the effect of existing mining operations and are unlikely to experience a significant change as a result of a similar level of dust emission from the continuation of mining at a similar level.

Table 20: Annual average dust deposition levels (g/m²/month)

Year	Annual average total insoluble matter (g/m²/mth)																			
Year	D1	D2	D2A	D3	D5	D7	D7A	D8	D9	D15	D16	D19	D30	D31	D32	D33	D34	D38	D39	D43
1998						4.2			1.9			2.7	2.7	2.9	2.2	2.8	2.2	1.7	2.0	1.4
1999						3.8			2.0			3.5	2.9	2.6	2.0	2.0	2.1	2.5	2.1	1.3
2000	4.6	2.2		8.6	6.5	5.3	5.3	4.9	2.3	5.3	4.1	3.8	3.2	3.3	2.1	23.7	2.9	2.0	3.7	1.4
2001	2.7	3.4		3.0	4.1	4.5	1.6	2.9	2.0	2.2	5.3	2.7	2.4		1.9	6.2	2.3	1.8	2.5	
2002	2.8	2.9		3.4	2.0		2.3	2.4	2.8	3.7	7.5	5.2			3.0	3.2	3.0			
2003	2.8	3.4	2.3	4.3	4.5		2.0	3.5	3.4	2.7	4.0	3.6			2.9	2.2	2.5			
2004	3.3		4.5	4.2	4.2		1.7	1.8	3.5	2.2	7.8	3.3			3.9	1.9	2.3			
2005 (to June)	2.4		6.5	4.5	4.5		2.4	4.4	3.9	2.2	3.5	2.5			3.6	2.3	1.8			

Year	D101	D102	D103	D104	D105	D107	D109	D110	D112	D113	D114	D115	D116	D117	DCL	DL1	DL2	DL4	DL10	DL14
1998	1.4	0.9	1.0	1.0	3.7	6.3	4.2	1.1	1.4	2.4	3.2	8.9	4.5							
1999	1.3	0.8	1.1	2.3	4.7	4.6	3.7	1.4	0.7	3.6	3.3	2.2	4.6							
2000	1.4	1.4	1.7	2.5	2.6	3.4	4.4	2.2	1.0	2.7	4.7	4.0	4.5							
2001	1.4	0.8	0.7	1.1	2.7	4.6	2.1	1.1	1.1		2.7		3.5		4.3					
2002	1.5	1.1	1.4	1.9	3.6	10.1		1.8	1.8		3.1		5.3		4.6					
2003	1.6	1.5	2.9	1.9	2.6	4.0		1.9	1.3		4.1		4.1	2.0	3.8	1.9	1.5	2.2	1.9	1.6
2004	1.2	1.7	2.8	2.4	2.1	7.8		1.7	1.1		3.6		3.8	1.3	3.8	3.4	1.5	2.3	1.7	1.7
2005 (to June)	2.3	1.5	2.9	2.4	2.8	5.3		2.2	1.1		2.9		3.2	2.2	3.3	2.8	2.4	3.4		

Year	DL17	DL21	DL22	DL23	DL30	DL43	DL44	DL45	Knoddlers Lane
1998									
1999									
2000									
2001									
2002									
2003	2.9	1.7	1.7	2.0	2.7	2.0	2.9	1.5	1.4
2004	2.6	2.4	1.6	1.7	6.5	2.2	2.1	2.0	1.2
2005 (to June)	2.8	1.5	1.9	3.1	4.0	2.3	2.6	2.0	1.6



Location of dust and meteorological monitoring sites and residences

Figure 2

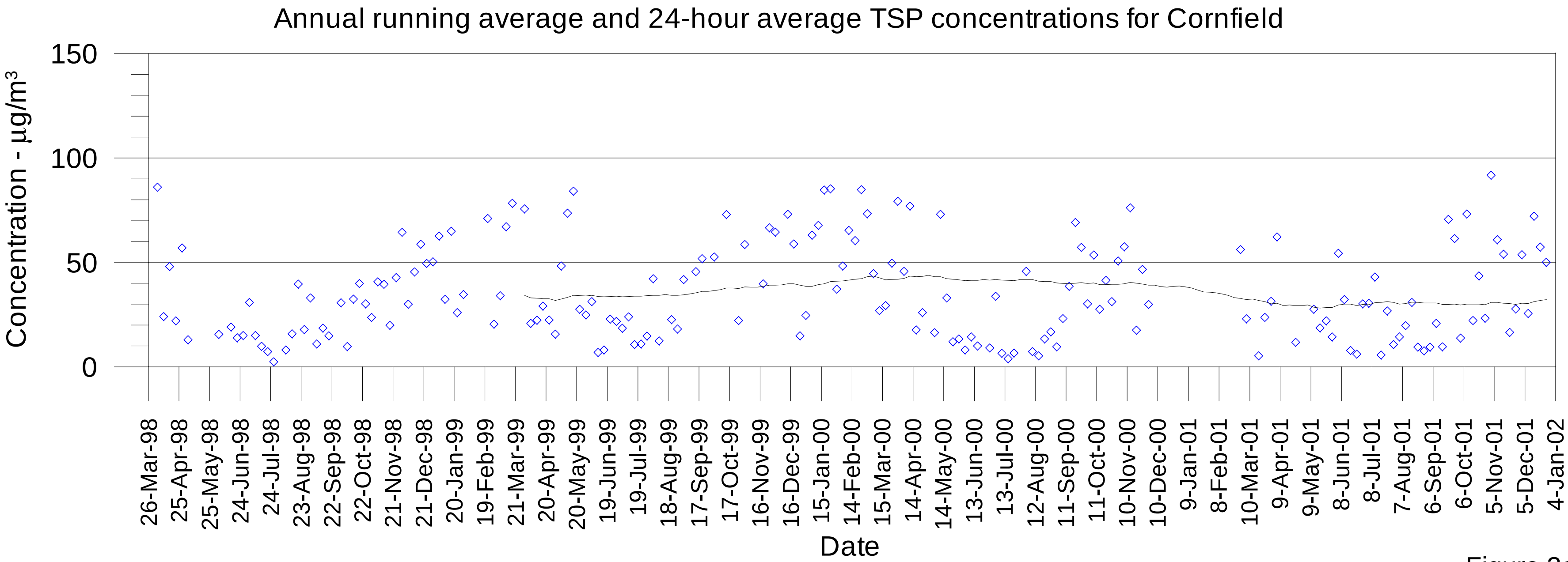


Figure 3a

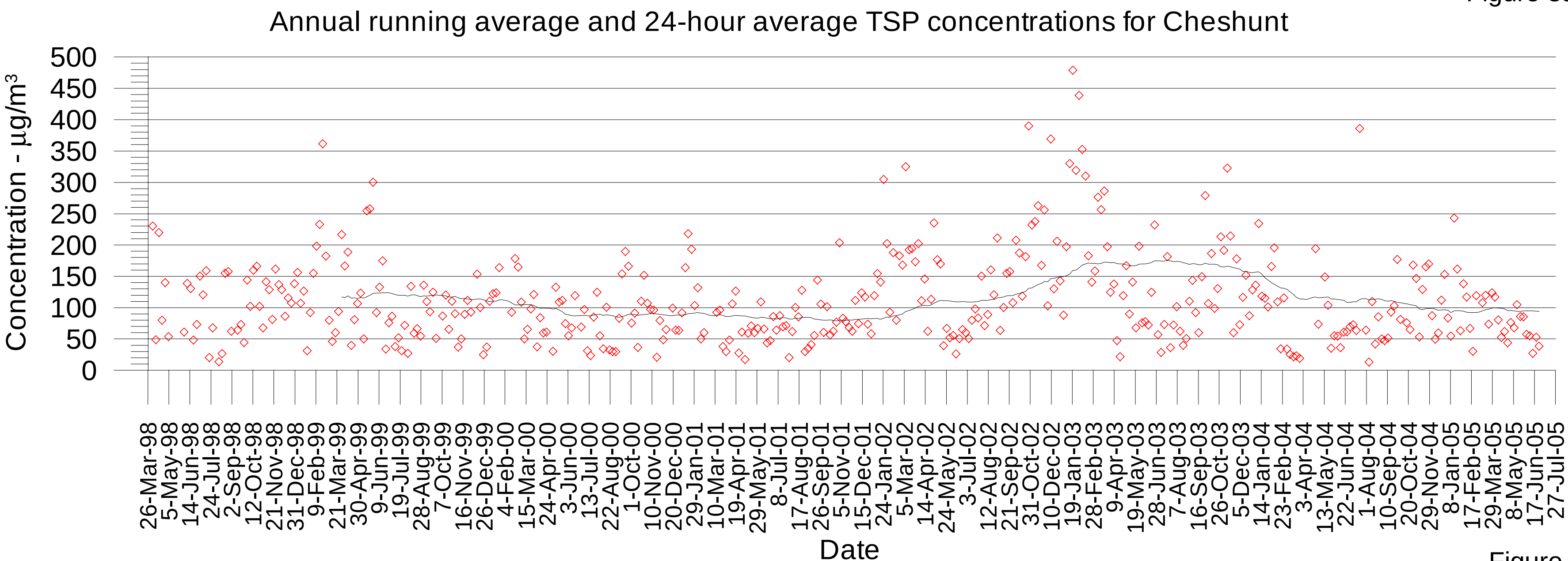


Figure 3b

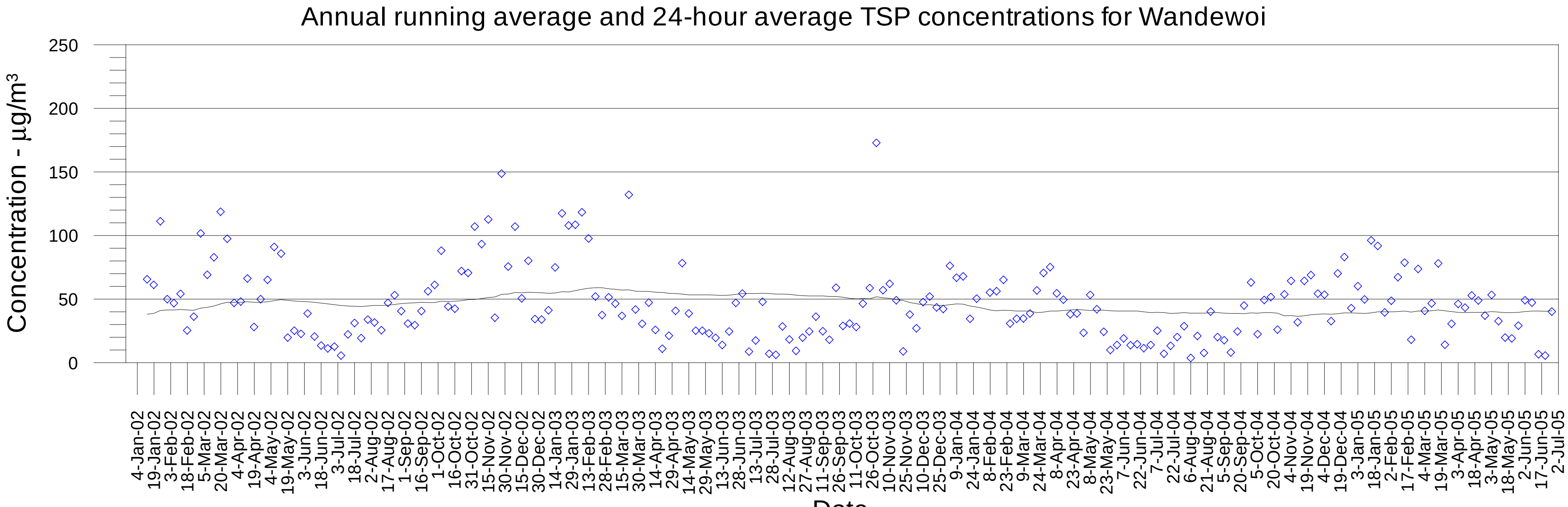


Figure 3c

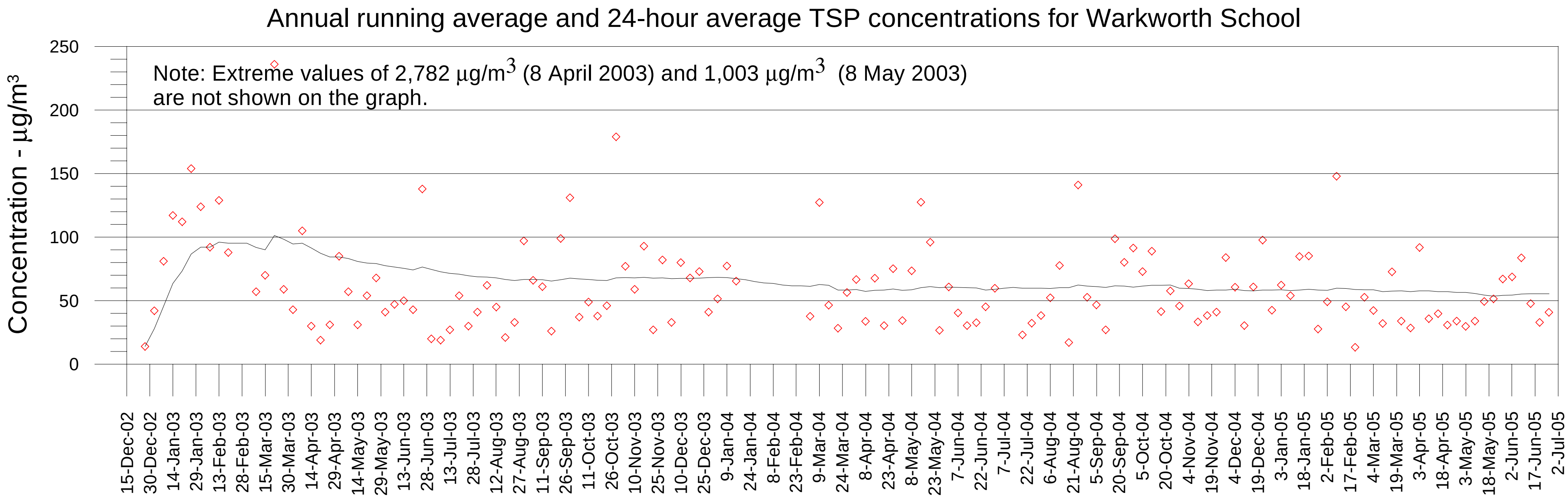


Figure 3d

5. CLIMATE AND METEOROLOGY

5.1 Dispersion Meteorology

The computer-based dispersion model Industrial Source Complex Short Term (Version 3) ISCST3 as been used in this study to assess the dispersion of particulate matter.

Meteorological data were available from the HVO meteorological station operated by CNA at the site shown in **Figure 2**. Data from this site for the year 2002 have been used for the current study. These same data were used in the air quality assessment included in HVO West Pit Extension and Minor Modifications EIS (**Holmes Air Sciences, 2003a**) and therefore provide a comparative assessment. A total of 8,736 hours of data were available for the 2002 period. This corresponds to 99.7% of the data potentially available in a year. The data provide hourly information on wind speed, wind direction, and other parameters required for dispersion modelling.

Figure 4 shows annual and seasonal wind roses prepared from the 2002 data. Data are also available for the year 2004 and as shown in **Figure 5**, the distribution of winds for the site for the year 2004 are consistent with the 2002 data. The data show a pattern of seasonal winds that is typical of central regions of the Hunter Valley where, over a year, winds are generally aligned along a northwest-southeast axis. The data were therefore considered to be representative of dispersion conditions at the site and in the area covered by the modelling.

Appendix C summarises the statistics of the meteorological data sets for 2002 and 2004. The mean annual wind speed in 2002 was 3.0 m/s and in 2004 it was 2.9 m/s.

5.2 Temperature and Humidity

Temperature and humidity data for the local area, Jerrys Plains, are presented in **Table 21**. These data were obtained from the Bureau of Meteorology's weather station operated at the Jerrys Plains Post Office, which has collected data since 1884 and thus provides a useful historical record over the longer term. January is the warmest month experiencing a mean monthly maximum temperature of 31.8 ^{o}C. July is the coolest month experiencing a mean monthly minimum temperature of 3.7 ^{o}C.

Annual average relative humidity at 9 am is 69%. Annual average 3 pm humidity is 47%.

5.3 Rainfall and Evaporation

Rainfall data are presented in **Table 21**. Mean annual rainfall has been 638.8 mm. January is the wettest month with an average rainfall of 78.2 mm and August is the month with lowest average rainfall (36.6 mm). Jerrys Plains records 86 rain days per year.

Evaporation data are available from the "Climatic Atlas of Australia" (**Bureau of Meteorology, 1988**). Evaporation rates for Singleton for January, April, July and October are approximately 225, 125, 75, and 175 mm respectively. Thus, evaporation is well above the expected rainfall amount for all the months of the year.

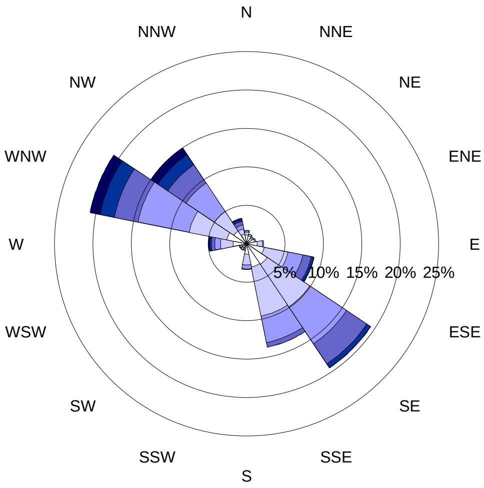
Table 21: Climate averages for Jerrys Plains Post Office

Station number: 061086 Commenced: 1884; Last record: 2004; Latitude (degS):-32.4983; Longitude (degE): 150.9083; State: NSW

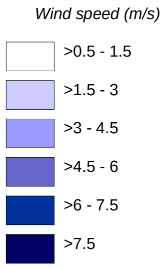
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%)													
Dry-bulb	23.3	22.7	21.3	17.9	13.5	10.5	9.2	11.3	15.2	18.9	21.1	23.1	17.3
Wet-bulb	19.2	19.3	17.9	14.9	11.5	8.9	7.6	8.9	11.7	14.4	16.2	18.1	14
Humidity	67	72	71	71	77	79	78	72	65	60	59	60	69
3 pm Mean Temperatures (C) and Mean Relative Humidity (%)													
Dry-bulb	29.6	28.9	27.1	24.2	20.0	17.1	16.3	18.2	21.1	23.9	26.8	29.0	23.5
Wet-bulb	21.0	21.1	19.6	17.1	14.5	12.2	11.1	12.0	13.9	16.1	17.8	19.6	16.3
Humidity	46	50	50	47	51	53	50	45	43	43	41	42	47
Daily Maximum Temperature (°C)													
Mean	31.8	30.9	29.0	25.3	21.2	17.9	17.3	19.4	22.8	26.2	29.3	31.4	25.2
Daily Minimum Temperature (°C)													
Mean	17.1	17.1	15.0	10.8	7.4	5.2	3.7	4.4	6.9	10.2	13.1	15.7	10.5
Rainfall (mm)													
Mean	78.2	71.7	58.2	44.7	41.3	45.3	44.3	36.6	41.3	51.9	58.2	67.3	638.8
Raindays (Number)													
Mean	7.9	7.3	7.3	6.3	6.6	7.3	7.0	7.0	6.6	7.5	7.6	7.5	86

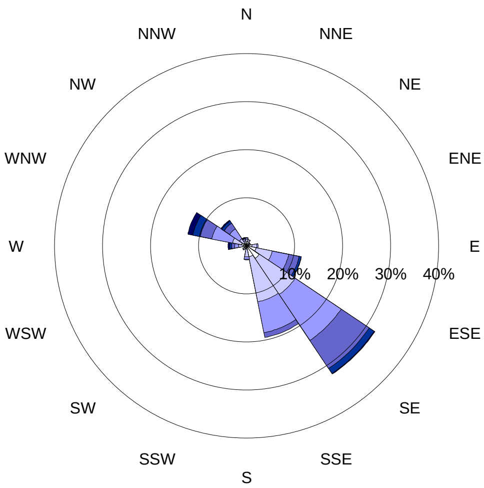
Source: ***Bureau of Meteorology (2005)***

Annual and Seasonal Windroses for HVO Meteorological Station (2002)

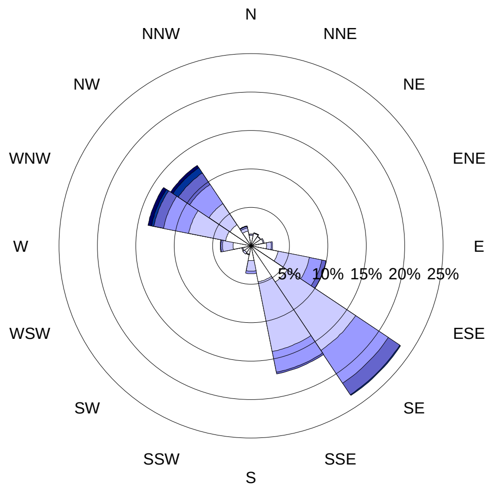


Annual

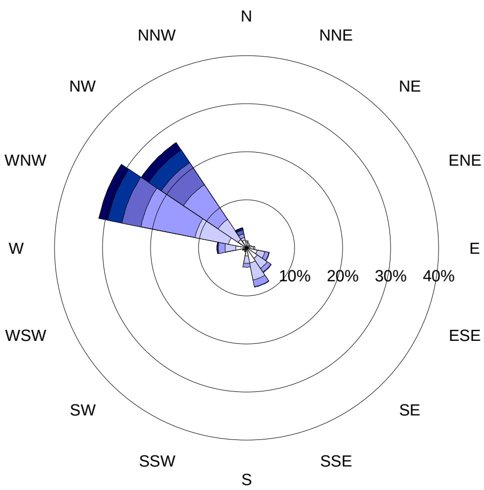




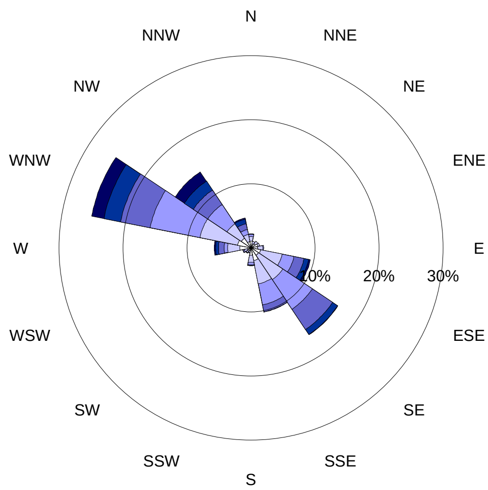
Summer



Autumn



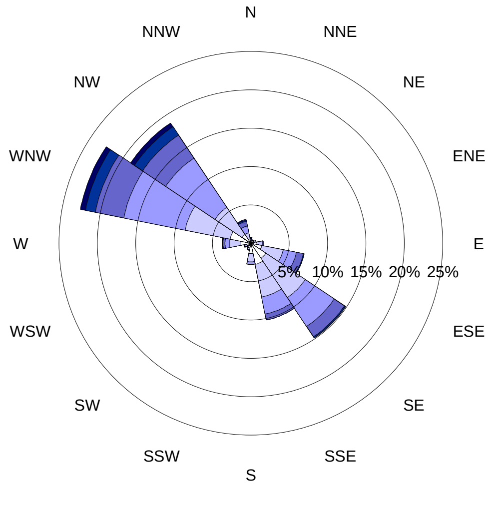
Winter



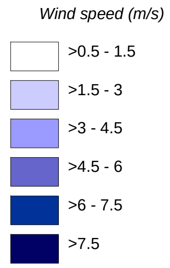
Spring

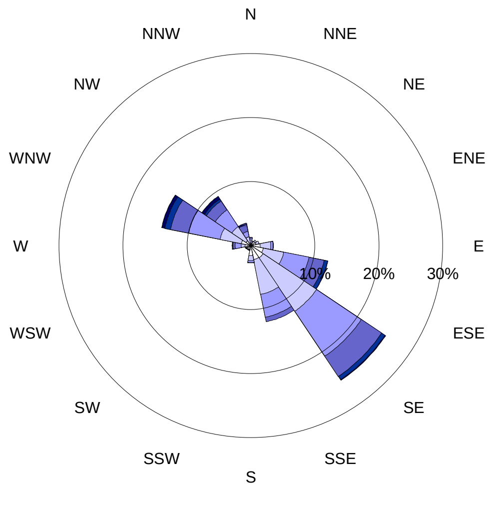
Figure 4

Annual and Seasonal Windroses for HVO Meteorological Station (2004)

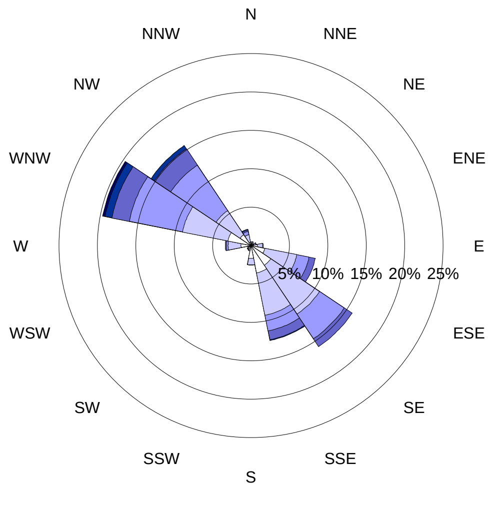


Annual

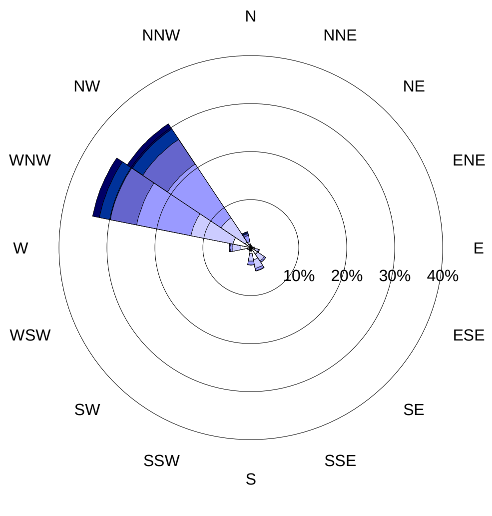




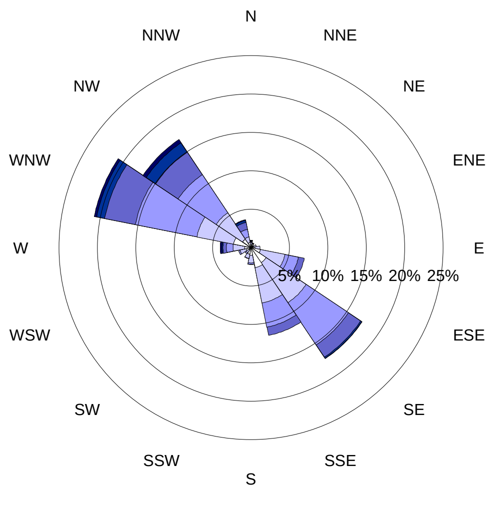
Summer



Autumn



Winter



Spring

Figure 5

5.4 Mixing-height and stability class

Information on hourly mixing height and stability class are required as input to the dispersion model. Intensive sonde[2] studies of the upper atmosphere around the Liddell Power Station have been undertaken on behalf of the previously named Electricity Commission of NSW by **Malfroy (1989)** and **Malfroy (1992)**. However, no long-term direct measurements on mixing height are available for the area and theoretically derived values have been used. The theoretical values in the day have been estimated by assuming that the maximum mixing height reached during the day was 1500 m, 1200 m, 1000 m and 1200 m for summer, autumn, winter and spring respectively. At night theoretical values based on wind speed and stability have been derived. These give mixing height values which are consistent with the values reported by Malfroy.

Stability class is used by dispersion models to determine the rate at which the plume grows by the process of turbulent mixing. Each stability class is associated with a dispersion curve, which is used by the model to calculate the plume dimension and dust concentration at points downwind of the source. In the model used here, the Pasquill-Gifford dispersion curves have been used.

The frequency of occurrence of particular stability classes in the 2002 HVO meteorological station data set, which was used in the dispersion model, is shown in Table 22.

Table 22: Frequency of occurrence of stability classes for HVO Meteorological Station data 2002

Stability	Frequency of occurrence
A	12.6%
B	8.1%
C	12.7%
D	40.9%
E	13.3%
F	12.3%

Note: the stability classes presented vary slightly from those reported in the noise study as F and G classes are combined for air quality studies.

[2] A sonde in this context is a package of instruments that are carried aloft by balloon and transmit information about temperature, humidity and pressure back to the ground.

6. ESTIMATED EMISSIONS OF PARTICULATE MATTER

6.1 Introduction

The mining plans for Carrington Pit have been analysed and detailed emissions inventories have been prepared for three operating years:

4. **2006**

   - 2006 Carrington Pit with data from the HVO West Pit Extension and Minor Modifications assessment for Year 3 (2006)

5. **2011**

   - 2011 Carrington Pit with data from the HVO West Pit Extension and Minor Modifications assessment for Year 8 (2011)

6. **2014**

   - 2011 Carrington Pit with data from the HVO West Pit Extension and Minor Modifications assessment for Year 14 (2017)[3]

The HVO West Pit Extension inventories include both estimated emissions from all other HVO north of the Hunter River and emissions from other nearby mines, namely Cumnock, Wambo, Ravensworth-Narama, Riverview and Cheshunt.

It is anticipated that operations at Carrington Pit will have ceased by 2011, however, to provide some flexibility in the operations, and to allow for market fluctuations, estimates of TSP emissions for 2014 have been made. In the 2014 scenario it has been assumed that operations at Carrington Pit are the same as in 2011 and that HVO operations are the same as assessed in the HVO West Pit Extension and Minor Modifications EIS (**Holmes Air Sciences, 2003a**) for Year 14. At this point rehabilitation operations at North Pit and the Alluvial Lands will have ceased operation.

Table 23 presents a summary of the activities that are included in each of the scenarios.

Table 23: Summary of modelling scenarios

Proposed Operating Year	Mining activities		Rehabilitation operations	
	Carrington Pit operations	Data from HVO West Pit Extension EIS	Alluvial Lands	North Pit
2006	2006	Year 3 (2006)	✓	✓
2011	2011	Year 8 (2011)	✓	✓
2014	2011	Year 14 (2017)	x	x

[3] Carrington Pit operations are due to be completed by 2011. This scenario represents a contingency to allow for changes in market forces. It assumes the mining activities occur in the same location as in 2011. For the rest of the activities, the data from the closest year to 2014 in the West Pit Extension and Minor Modifications assessment (that is, the year 2017) were used.

Appendix D provides details as to how dust emissions from each dust producing activity have been calculated including the effect of dust controls and the assumptions that have been made in estimating these emissions. **Table 24** summarises the estimated TSP emission rates.

Table 24: Summary of estimated TSP dust emissions (kg/y)

YEAR	2006	2011	2014
ACTIVITY	**TSP emissions (kg/year)**		
OTHER MINES			
Ravensworth/Narama ALL OPERATIONS	2,028,000	1,248,000	1,248,000
Wambo ALL OPERATIONS[(a)]	3,969,329	5,122,771	5,139,243
Cheshunt ALL OPERATIONS	2,600,000	2,600,000	2,600,000
Riverview ALL OPERATIONS	1,560,000	1,560,000	1,560,000
United Colliery ALL OPERATIONS	1,026,264	1,026,264	1,026,264
Cumnock ALL OPERATIONS	2,406,642	2,406,642	2,406,642
HVO north OPERATIONS			
WEST PIT			
OPERATIONS ON OVERBURDEN (O/B)			
Stripping top-soil - West Pit	17,920	17,920	17,920
Drilling O/B - West Pit	29,553	18,344	29,607
Blasting - West Pit	95,588	96,994	121,604
Shovel/Excavators/FELs Loading O/B - West Pit	108,623	110,318	151,277
Hauling O/B to West Pit	699,257	710,169	973,843
Hauling O/B from North Pit to Alluvial Lands	25,000	25,000	0
Hauling O/B from south of river to Alluvial Lands	25,000	25,000	0
Emplacing O/B at dumps at West Pit	108,623	110,318	151,277
Emplacing O/B at Alluvial Lands	7,767	7,767	0
Dozers on O/B - West Pit	273,058	275,268	358,098
Dragline - West Pit	868,599	892,533	911,865
OPERATIONS ON OPEN CUT COAL			
Drilling coal - West Pit	3,465	2,156	4,075
Blasting coal - West Pit	18,111	11,268	27,044
Dozers ripping coal - West Pit	326,154	328,794	427,730
Loading ROM Coal to trucks - West Pit	431,169	438,529	492,592
Hauling ROM coal to dump hopper - West Pit to HVCPP	179,422	183,053	284,363
Hauling ROM coal to dump hopper - West Pit to WPCPP	116,667	113,333	113,333
Hauling ROM coal to dump hopper - S of River to HVCPP	666,667	666,667	666,667
Sum West Pit	**4,000,642**	**4,033,431**	**4,731,295**
CARRINGTON PIT			
OPERATIONS ON OVERBURDEN (O/B)			
Dozers on O/B (inc stripping of topsoil) – Carrington Pit	379,818	103,357	103,357
Drilling O/B – Carrington Pit	21,020	191	191
Blasting – Carrington Pit	90,532	90,532	90,532
Shovel/Excavators/FELs Loading O/B – Carrington Pit	185,956	32,085	32,085
Hauling O/B to emplacement area – Carrington Pit	1,995,137	344,239	344,239
Emplacing O/B at dumps – Carrington Pit	185,956	32,085	32,085
Rehandle shovel/Excavators/FELs Loading O/B – Carrington Pit	2,041	5,147	5,147
OPERATIONS ON OPEN CUT COAL			
Dozers ripping coal – Carrington Pit	80,900	33,183	33,183
Loading ROM Coal to trucks – Carrington Pit	512,371	210,161	210,161
Hauling ROM coal to dump hopper – Carrington Pit to HVCPP	323,786	128,876	128,876
Hauling ROM coal to dump hopper – Carrington Pit to WPCPP	16,667	16,667	16,667
Sum CarringtonPit	**3,794,183**	**996,522**	**996,522**

[(a)] The data presented for Wambo were sourced from calculations made by Holmes Air Sciences in February 2003. In the final version of the EIS (**Holmes Air Sciences, 2003b**) these figures were revised downwards. To maintain a comparative assessment with the original EIS, the same data have been used in this assessment.

Table 24: Summary of estimated TSP dust emissions (kg/y) *continued*			
YEAR	2006	2011	2014
ACTIVITY	**TSP emissions (kg/year)**		
COMMON ACTIVITIES[(a)]			
Unloading ROM coal at hopper/stockpile - WPCPP	35,000	34,000	34,000
Unloading ROM coal at hopper/stockpile - HVCPP	313,826	214,916	245,309
Re-handle ROM at hoppers - WPCPP	1,750	1,750	1,750
Re-handle ROM at hoppers - HVCPP	5,383	5,492	8,531
Transport product coal to user/loadout point - WPCPP to NLP	59,674	54,181	54,181
Transport product coal to user/loadout point - HVCPP to HVLP (Belt Line Road)	7,200	7,200	7,200
Transport product coal to user/loadout point - HVLP to RCT	25,200	25,200	25,200
Transport product coal to user/loadout point - HVLP to NLP	17,400	17,400	17,400
Unloading coal from conveyors or trucks - Bayswater Power Station	25,000	25,000	25,000
Unloading coal from conveyors or trucks - HVLP	140,000	140,000	140,000
Unloading coal from conveyors or trucks - NLP	44,864	42,576	42,576
Loading trains - HVLP	4,272	4,272	4,272
Loading trains - NLP	1,369	1,299	1,299
Handling coal at CHPP - WPCPP	26,703	25,940	25,940
Handling coal at CHPP - HVCPP	239,432	163,969	187,157
Sum Common Activities	**947,073**	**763,195**	**819,815**
WIND EROSION			
West Pit pit	1,752,000	1,752,000	1,752,000
Alluvial Lands	175,200	175,200	0
West Pit pit O/B	1,752,000	1,752,000	1,752,000
Alluvial Lands O/B	175,200	175,200	0
Carrington Pit pit	211,992	211,992	211,992
Carrington Pit pit O/B	204,702	204,702	204,702
Sum Wind Erosion	**4,271,094**	**4,271,094**	**3,920,694**
GRADERS			
Grading all roads	61,547	61,547	61,547
SUM ALL HVO ACTIVITIES (EXCLUDING OTHER MINES)	**13,074,538**	**10,125,790**	**10,529,873**
SUM ALL ACTIVITIES (INCLUDING OTHER MINES)	**26,664,773**	**24,089,467**	**24,510,022**

(a) Common activities refer to activities and locations that process or handle coal from a number of pits.

6.2 Estimated emissions from other local mines not included in modelling

Other mines and other sources, in addition to those identified above, will contribute to $PM_{2.5}$, PM_{10}, TSP concentrations and to dust deposition. In the past, the annual average concentration of particulate matter contributed by these more distant sources has been set at 5 $\mu g/m^3$ for PM_{10}, 10 $\mu g/m^3$ for TSP and 0.5 g/m^2/month for deposited dust.

Some monitoring of $PM_{2.5}$ concentrations has been undertaken by the Australian Nuclear Science and Technology Organisation (ANSTO) on behalf of the Muswellbrook Council and as part of an (Australian Coal Association Research Program) ACARP funded study. The data suggest that long-term average $PM_{2.5}$ concentrations in the Muswellbrook area are approximately 7 $\mu g/m^3$. This level includes the effect of existing mining. At this stage there is insufficient experience with $PM_{2.5}$ concentrations in the Hunter Valley to provide a reliable estimate of background $PM_{2.5}$ concentrations in the area around the Proposal. No allowance for non-mining $PM_{2.5}$ background has been added to model predictions and predictions of concentrations of $PM_{2.5}$ are provided for information rather than as a key component of the assessment (**Appendix A**).

In the cumulative modelling work each neighbouring mine has been treated as a number of volume sources. These have been located at the apparent points of major emission as estimated from the known locations of the pits and/or major dust sources on the mine or facility.

Sources have been considered in three classes:

1. Wind erosion sources where emissions vary with the hourly average wind speed according to the cube of the wind speed;
2. Loading and dumping operations where emissions vary as wind speed raised to the power 1.3; and
3. All other sources where emissions are assumed to be independent of wind speed.

For neighbouring mines the proportions of emissions in each of these categories has been assumed to be the same as applies at the Proposal, namely:

- 0.732 for emissions independent of wind speed;
- 0.135 for emissions that depend on wind speed (such as loading and dumping); and
- 0.133 for wind erosion sources.

7. ASSESSMENT METHODOLOGY

7.1 Modelling approach

The short-term industrial source complex model (ISC3ST - Version 02035) has been used in this study. The model is an advanced Gaussian dispersion model approved by the US EPA for use in regulatory assessments undertaken within the US. It has been one of the most widely used regulatory models in the world. The model is accepted by the NSW DEC for assessing the dispersion of dust. A complete description of the model is provided in US EPA publications (**US EPA 1995a** and **1995b**). These two volumes provide user instructions (Volume 1) and a comprehensive technical description of the algorithms used in the model (Volume 2). For convenience, a very brief description of the model is provided below.

The model uses the Gaussian dispersion equation to simulate the dispersion of a plume from either point area or volume sources. The model takes account of dry and wet deposition, includes algorithms to account for retention of dust within an open pit, and includes mechanisms for determining the effect of terrain on plume dispersion. The model works on an hourly time step. This means that it requires a meteorological file that provides wind speed, wind direction and other dispersion parameters on an hourly basis. For each hour the dispersion of plumes is determined using the conventional Gaussian model assumptions. These model assumptions have some limitations and it is worth noting some of these at this point.

One of the most significant limitations of the Gaussian model is that it assumes that a steady state dispersion condition is reached instantaneously. That is, if one were to imagine the situation that the plume is simulating for a particular hour, one would see each source of dust producing a plume that extends indefinitely in the downwind direction to the edge of the prediction grid. In reality, under very light wind conditions, this is an inappropriate assumption.

Consider for example a condition where the wind speed is 0.5 m/s. At the end of one hour any emission that occurred at the beginning of the hour will have travelled approximately 1.8 km from the source (0.5 m/s x 3,600 s). Thus, under these light wind conditions, the dust will have travelled 1.8 km from the source. The model assumes the dust will have travelled to the edge of the prediction grid that in this case may be up to 10 km from the source. In the next hour the meteorological conditions may remain the same or, more likely, the wind direction will change and the light wind condition may persist. The model then assumes that a new equilibrium is established instantaneously and the plume travels in the new downwind direction at the new wind speed.

Because for surface sources the worst-case dispersion conditions are associated with light winds, the model has the potential to significantly overstate impacts at long distances downwind from the source, especially under light-wind conditions. Since this problem leads to an overstatement of impacts rather than an understatement of impacts, this does not create a significant problem for environmental impact assessment. However, it should be borne in mind that there is a potential to overstate impacts at more distant receptors.

7.2 Assessing worst-case 24-hour PM_{10} and $PM_{2.5}$ concentrations

The ISC model also has the capacity to take into account emissions that vary in time, or with meteorological conditions. This has proved particularly useful for simulating emissions on mining operations where wind speed is an important factor in determining the rate at which dust is generated.

The mine was represented by a series of between 77 and 79 volume sources for each of the three years assessed. **Figure 6** shows the location of these sources for each year. Each volume source was a combination of all dust emissions from activities in the general area. Estimates of emissions for each volume were developed on an hourly time step. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of mining activity and the wind speed. It is important to do this in the ISC model to ensure that long-term average emission rates are not combined with worst-case dispersion conditions which are associated with light winds. Light winds in a mining area correspond with periods of low dust generation (because wind erosion and other wind dependent emissions rates will be low) and also correspond with periods of poor dispersion. If these measures are not taken into account then the model has the potential to significantly overstate impacts.

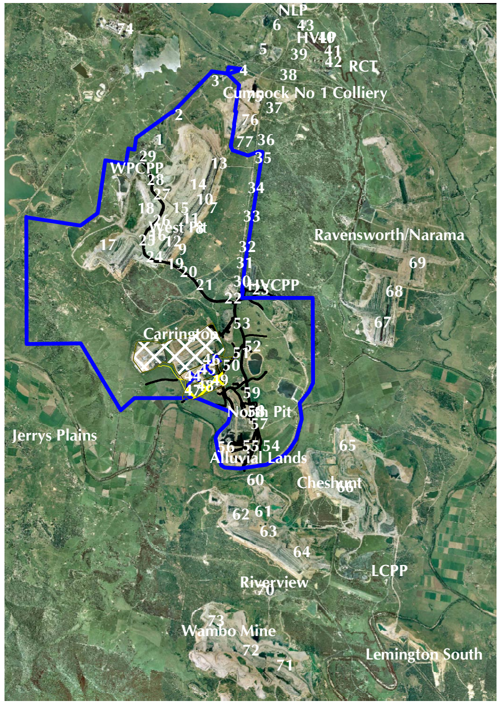
A calibration study was undertaken as part of the Warkworth EIS (**Holmes Air Sciences, 2002**). This was done by comparing the predicted maximum 24-hour average PM_{10} concentrations in the period 1 November 2000 to 31 October 2001 at the Warkworth Mine monitors at HV1 and HV2 and at the Mount Thorley Operations monitors at Lot 543 and Bulga. The maximum measured PM_{10} concentration at the Bulga monitoring site and the maximum measured TSP concentrations at all four sites over the same period were then determined by inspection of the monitoring data records. (Note, PM_{10} concentrations are only measured at the Bulga monitoring site, the other sites measure TSP only). The TSP concentrations have been converted to equivalent PM_{10} concentrations assuming that PM_{10} constitutes 40% of the TSP in this area. The results are shown in **Table 25**.

Table 25: Comparison of maximum measured (or inferred) and maximum predicted 24-hour PM_{10} concentrations (1 Nov 2000 to 31 Oct 2001) - Warkworth

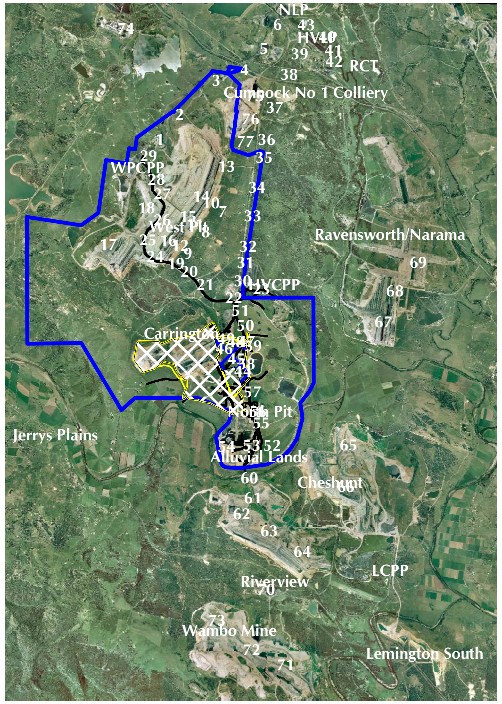
Site	Maximum predicted 24-hour PM_{10} ($\mu g/m^3$)	Maximum measured or inferred 24-hour PM_{10} ($\mu g/m^3$)	Ratio of predicted to measured concentration
HV1	100	170 x 0.4 = 68	1.5
HV2	140	140 x 0.4 = 56	2.5
Bulga PM_{10}	160	44 (direct measurement)	3.6
Bulga TSP	160	102 x 0.4 = 41	3.9
Lot 543	95	138 x 0.4 = 55	1.7
		Average	***2.6***

The average extent of over prediction was a factor of 2.6, that is, unadjusted model predictions appear to over predict 24-hour PM_{10} concentrations by 260%. This factor was used to adjust the model predictions for the Warkworth EIS downwards to obtain a calibrated prediction of the worst-case 24-hour PM_{10} concentrations. This same factor has been used for the current assessment.

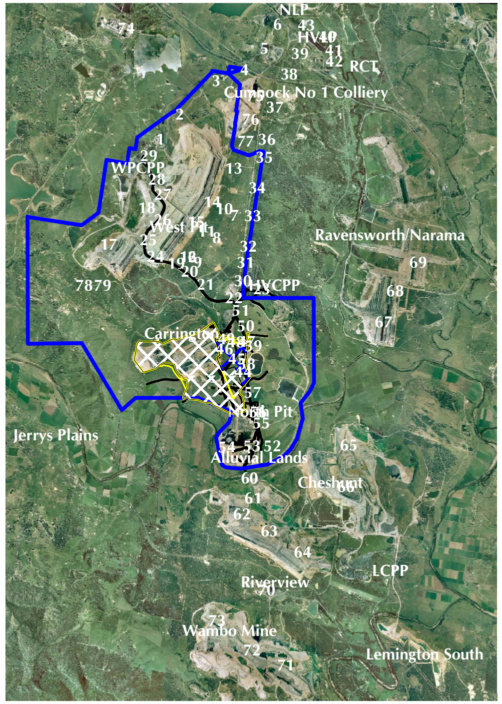
Additional work undertaken using data as part of the original West Pit environmental studies (**Holmes Air Sciences, 2003c**) found calibration factors in the range 3.7 to 4.1 for the Cheshunt monitor. Pending further investigations into the best way of modelling short-term PM_{10} and $PM_{2.5}$ concentrations, the 2.6 factor has been used as a conservative estimate.



Year 2006



Year 2011



Year 2014

Assumed source locations

Figure 6

8. ASSESSMENT OF IMPACTS – PARTICULATE MATTER

8.1 Introduction

Dispersion model simulations have been undertaken for the Years 2006, 2011 and 2014. This section provides an interpretation of the predicted contours of dust concentration (PM_{10}, and TSP) and dust deposition produced by these simulations.

Contours have been provided showing the predicted effects of the Proposal considered in isolation and the predicted effects of the Proposal considered with other neighbouring mines (including an allowance for remote mines and non-mining sources of dust). The Proposal is taken to be all HVO operations north of the Hunter River including the proposed Carrington Extension. For each of the three scenario years, isopleth diagrams have been produced showing the following:

1. The predicted maximum 24-hour average PM_{10} concentration for the Proposal alone;
2. The predicted maximum 24-hour average PM_{10} concentration for the Proposal with other sources of PM;
3. The predicted annual average PM_{10} concentration for the Proposal;
4. The predicted annual average PM_{10} concentration for the Proposal with other sources of PM;
5. The predicted annual average TSP concentration for the Proposal;
6. The predicted annual average TSP concentration for the Proposal with other sources of PM;
7. The predicted annual average dust deposition for the Proposal, and;
8. The predicted annual average dust deposition for the Proposal with other sources of PM.

Similar predictions for 24-hour and annual average $PM_{2.5}$ concentrations for the Proposal by itself and the Proposal considered with the effects of other mines are provided in **Appendix A**.

8.2 Assessment locations

Rather than provide a detailed discussion of each isopleth figure, the results have been summarised in tabular form for each year. The nearby residences are listed with those that are predicted to experience particulate matter deposition or concentration levels above the NSW DEC's assessment criteria highlighted.

The contour plots of dust concentrations and deposition levels show the areas of land that are affected by dust at different levels. However, concentration and deposition levels at residences are of particular interest. The locations of neighbouring residences are shown in **Figure 2**.

When considering the isopleths it is useful to bear in mind, that because of the prevailing winds, the main areas where impacts would be expected are to the southeast and northwest, which are generally associated with the active mining areas. In most cases impacts are the consequence of several sources of dust including other mines and non-mining sources, but in most cases one source can be seen to be responsible for the majority of the effect.

It is important to note that there are additional mining activities in the region that are outside the scope of this assessment. In particular, mines to the north-west of the RCT will have an impact on air quality in that area and therefore the predicted concentrations in the north-west of the contour maps are likely to be higher than shown. However, the contribution that the Proposal makes to these concentrations is small.

Table 26 identifies those residences that are currently within an existing zone of affectation or under a negotiated agreement concerning environmental impacts.

Table 26: Locations of neighbouring residences and other reference sites

Residence ID (see Figure 1)	ISG Easting (m)	ISG Northing (m)	Zone of Affectation or negotiated agreements
1	292153	1402554	
2	292801	1401825	
3	293074	1401571	
4	293884	1400207	
5	305645	1399385	
6	305748	1400194	
7	303750	1403450	Agreement with Xstrata
8	301500	1404300	Ravensworth West Zone of Affectation & agreement with CNA
9	295525	1403350	Acquired by CNA
10	294700	1402575	HVO Zone of Affectation
11	294850	1399525	Acquired by Wambo mine
12	301150	1402050	Acquired by CNA
13	305727	1399565	
14	305590	1399330	
39	302041	1395132	

8.3 Assessment criteria

The air quality criteria used for deciding which properties are likely to experience air quality impacts are those specified in the NSW DEC's modelling guidelines as interpreted by recent conditions of consent for mines in the Hunter Valley (see **Section 3** and the discussion below). The criteria are:

- 50 $\mu g/m^3$ for 24-hour average PM_{10} for the Proposal considered alone;
- 150 $\mu g/m^3$ for 24-hour average PM_{10} for the Proposal considered with the contributions of other sources;
- 30 $\mu g/m^3$ for annual average PM_{10} due to the Proposal and other sources;
- 90 $\mu g/m^3$ for annual average TSP concentrations due to the Proposal and other sources;
- 2 g/m^2/month for annual average deposition (insoluble solids) due to the Proposal considered alone; and
- 4 g/m^2/month for annual average predicted cumulative deposition (insoluble solids) due to the Proposal and other source levels.

Following practice established in recent conditions of consent, with the exception of the 2 g/m^2/month goal and the 24-hour PM_{10}, the assessment criteria are interpreted to be cumulative assessment criteria.

The 24-hour PM_{10} criterion of 50 µg/m^3 is interpreted as being applicable to the Proposal when considered in isolation and the US EPA 24-hour PM_{10} standard of 150 µg/m^3 has been taken to be the cumulative criterion.

8.4 2006 impacts

Figures 7 to **14** show the predicted model results for 2006. This includes the cumulative effect including the emissions from HVO north of the Hunter River, Cumnock, Riverview, Cheshunt, Wambo, United, Ravensworth-Narama and an allowance for remote mines and non-mining sources. For convenience, **Table 27** summarises the results highlighting those residences that are predicted to experience exceedances of any of the assessment criteria.

The table shows that no residences are predicted to experience exceedances of the NSW DEC's criterion due to emissions from HVO north of the Hunter River, including the proposed Carrington Extension.

With the Proposal and other sources, Residence 12 is predicted to experience 24-hour average PM_{10} concentrations above the US EPA's 24-hour PM_{10} standard of 150 µg/m³ and is also predicted to experience annual average PM_{10} concentrations above the NSW DEC's assessment criterion of 30 µg/m³. In addition, Residence 12 is predicted to experience exceedances of NSW DEC's assessment criteria for annual average TSP and dust deposition. This residence is already within an existing zone of affectation and has an agreement with the CNA. The contribution that HVO north of the Hunter River makes to these exceedances is small.

Table 27: Summary of affected residences for 2006

	Proposal in isolation in 2006				Proposal with other sources in 2006			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
ID	µg/m³	µg/m³	µg/m³	g/m²/month	µg/m³	µg/m³	µg/m³	g/m²/month
Goal	*50*	*30*	*90*	*2*	*150*[a]	*30*	*90*	*4*
1	12.3	2.0	2.2	0.02	17.4	13.5	19.5	0.67
2	15.2	2.1	2.2	0.02	29.1	14.6	20.7	0.70
3	19.3	2.2	2.3	0.02	35.2	15.0	21.2	0.71
4	15.0	1.7	1.8	0.02	27.7	16.7	23.1	0.77
5	17.4	7.7	9.3	0.44	43.5	24.0	32.6	1.47
6	20.0	8.0	9.6	0.42	37.9	22.6	30.8	1.27
7(b)	35.3	11.0	13.2	0.63	49.5	23.8	31.8	1.28
8(b)	39.5	12.5	15.7	0.90	57.0	28.6	37.7	1.58
9(c)	34.2	8.7	9.5	0.13	39.5	27.0	34.0	0.89
10(d)	28.1	5.0	5.3	0.04	32.8	23.3	29.8	0.82
11(d)	18.0	2.2	2.3	0.02	37.3	19.9	26.8	0.87
12(c)	45.4	23.2	29.2	1.63	**180.4**	**103.0**	**136.0**	**5.79**
13	16.6	7.8	9.3	0.43	36.9	24.0	32.5	1.43
14	17.9	7.7	9.3	0.44	44.2	24.2	32.8	1.50
39	9.1	1.8	2.1	0.06	41.4	22.9	31.6	1.35

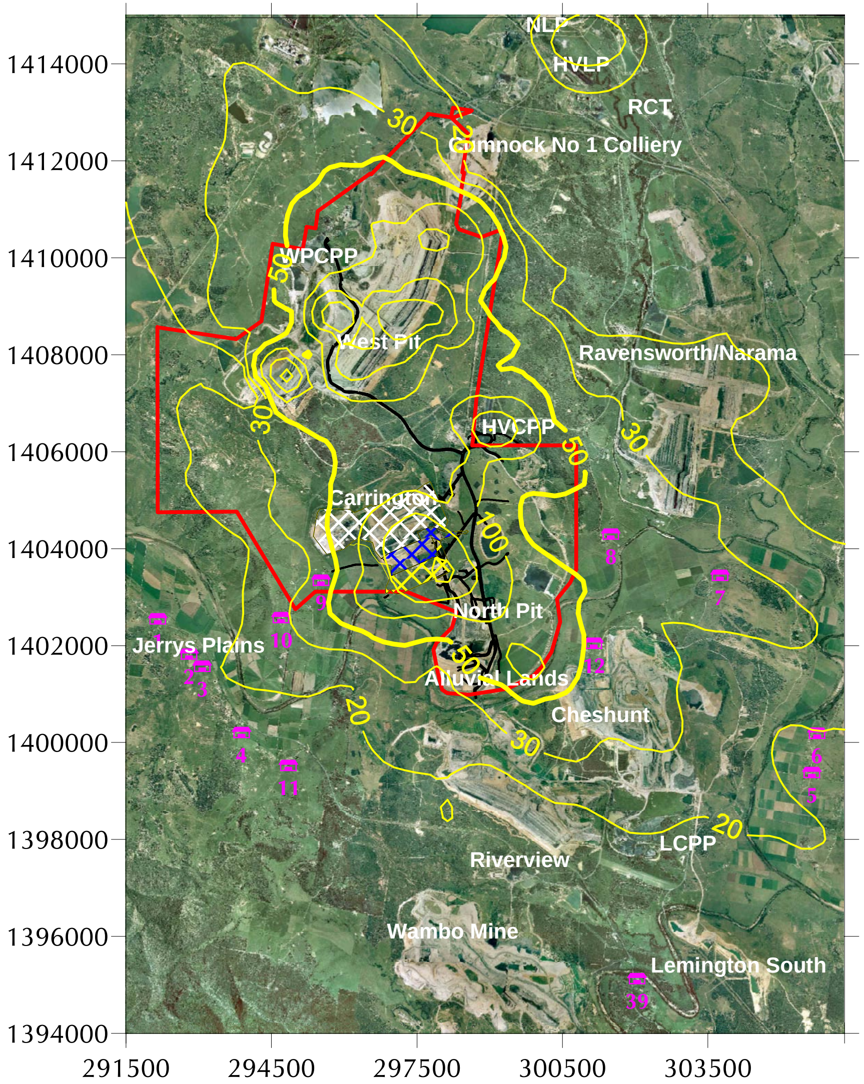
(a) US EPA 24-h ambient air quality standard (99th percentile over 3 years)

(b) These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement with HVO

(c) These properties are owned by Coal and Allied

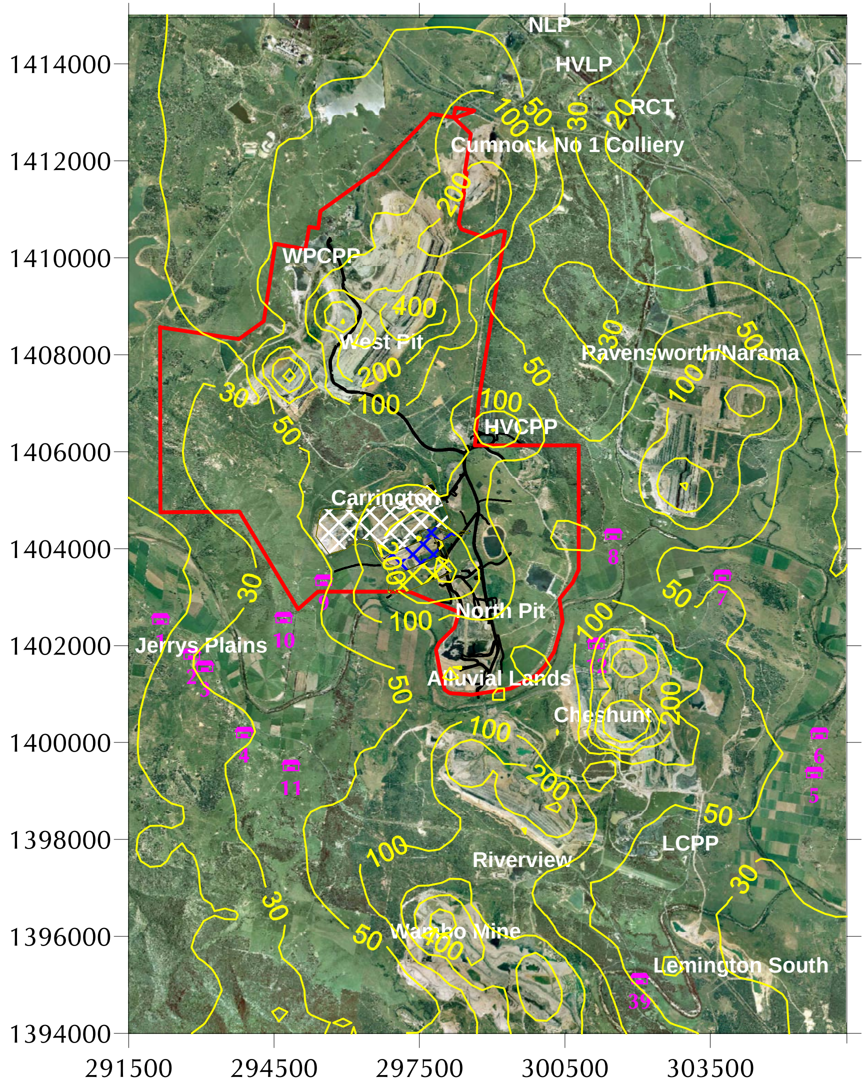
(d) These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO

Bold font indicates predicted exceedance of goal



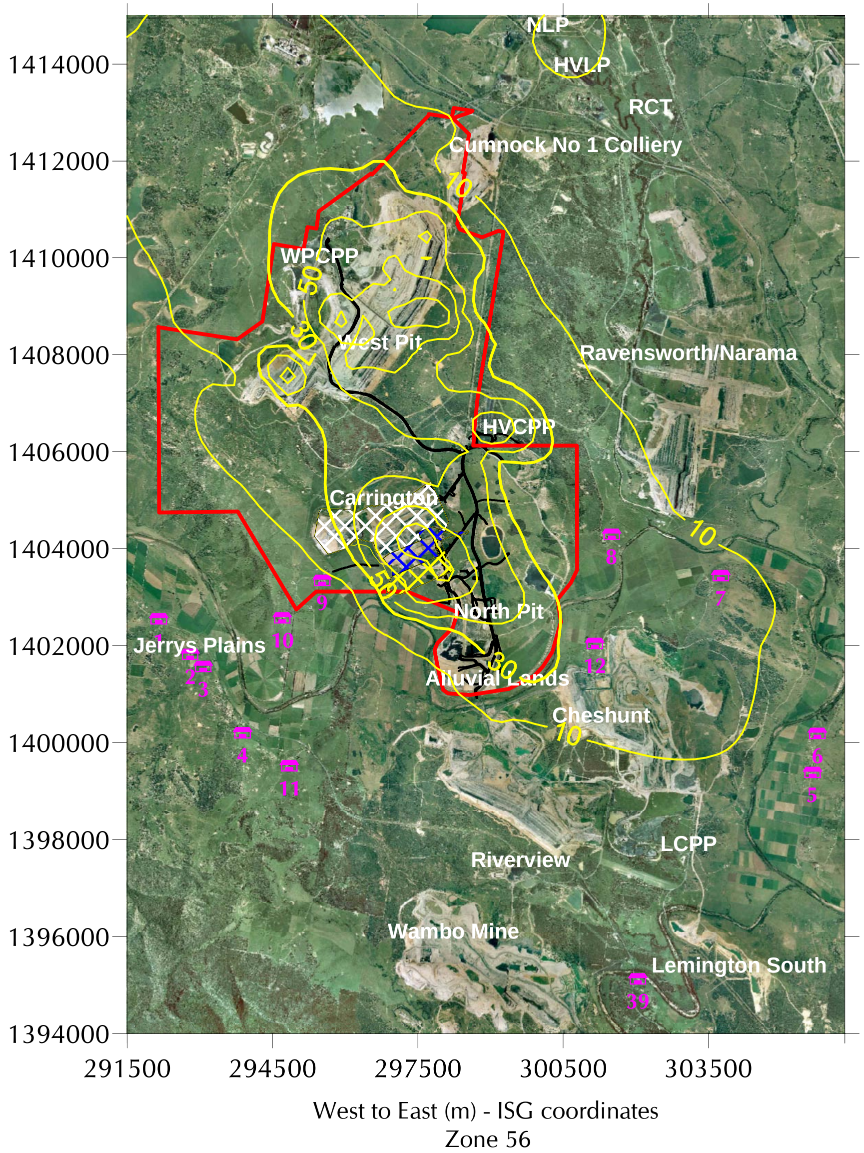
Predicted maximum 24-hour average PM_{10} concentration due to emissions from the Proposal in 2006 ($\mu g/m^3$)

Figure 7



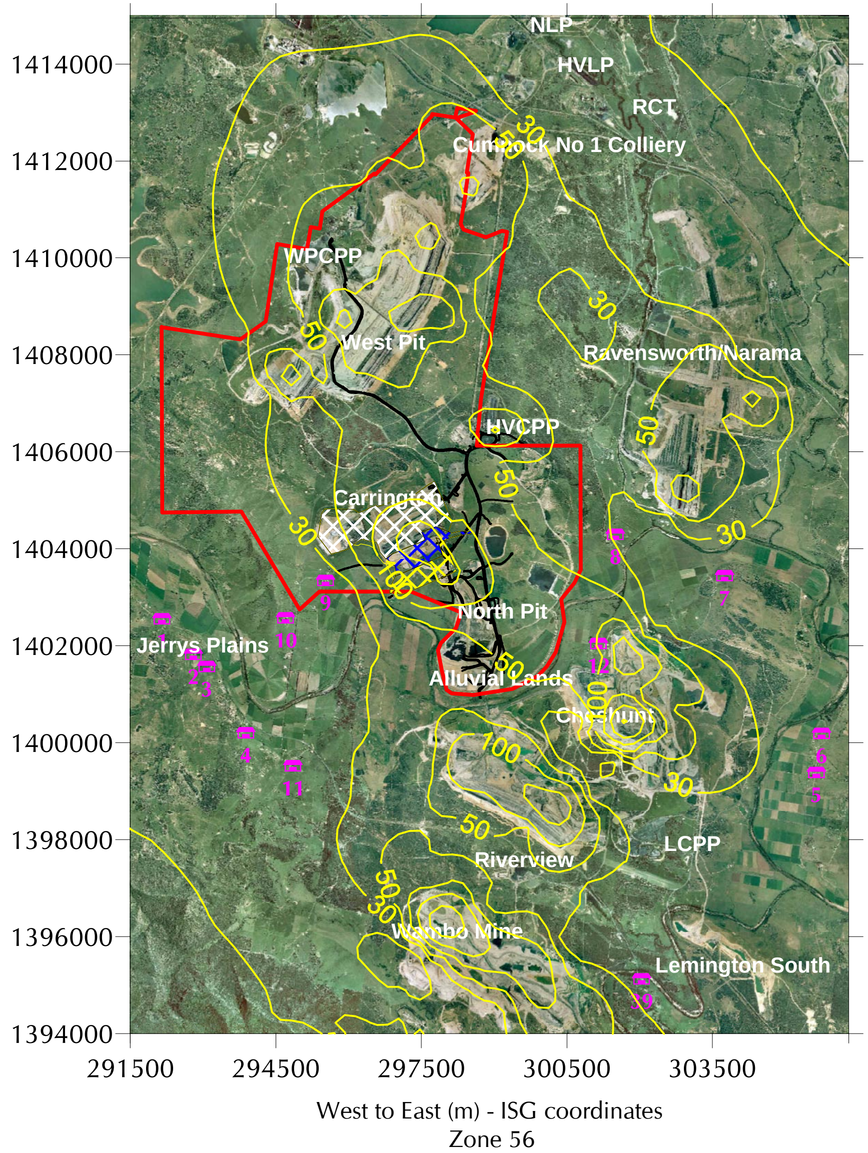
Predicted maximum 24-hour average PM_{10} concentration due to emissions from the Proposal and other sources in 2006 ($\mu g/m^3$)

Figure 8



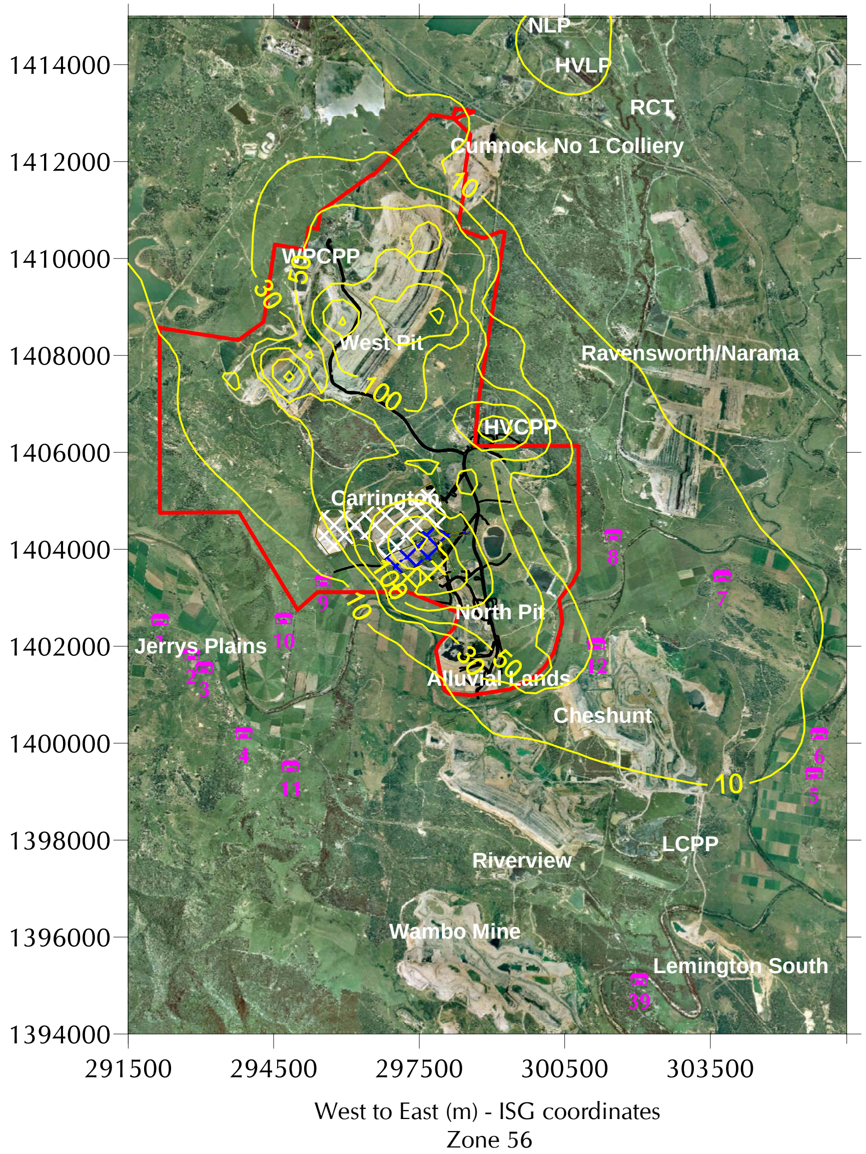
Predicted annual average PM_{10} concentration
due to emissions from the Proposal in 2006 (μg/m^3)

Figure 9



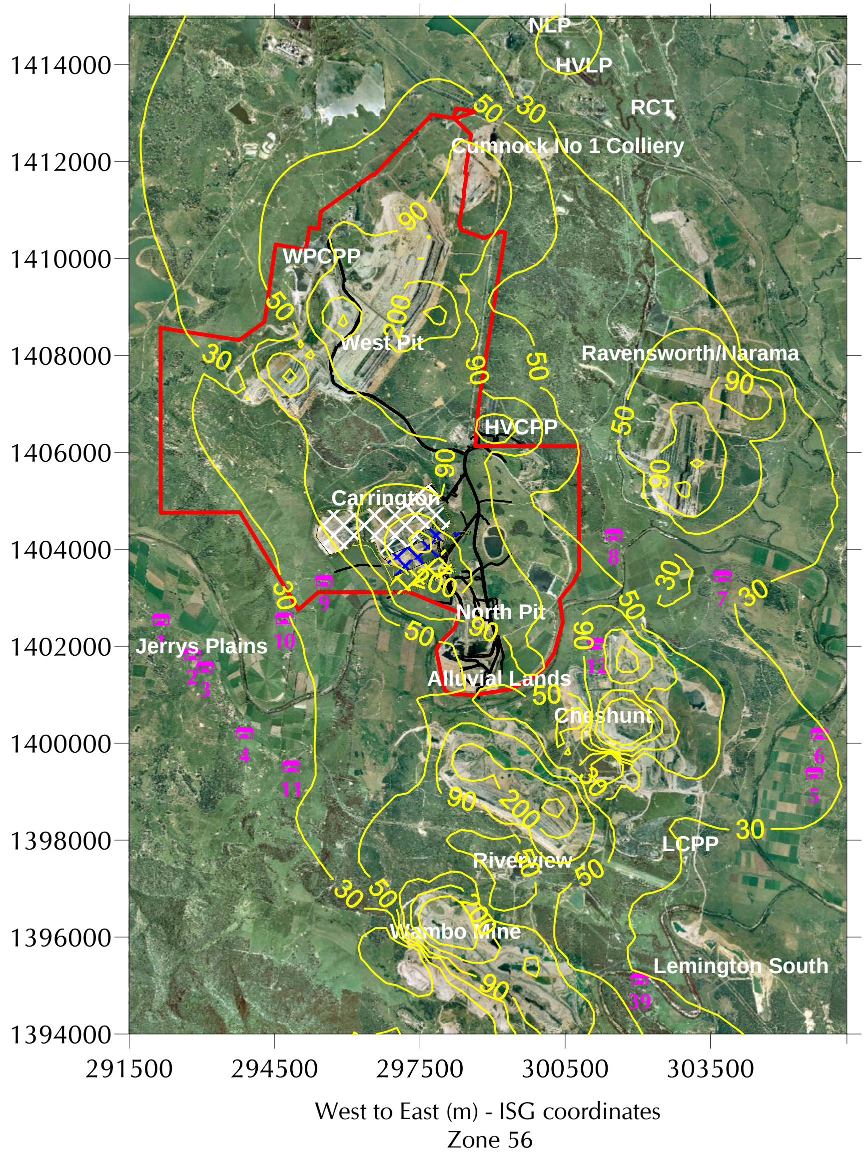
Predicted annual average PM_{10} concentration
due to emissions from the Proposal and other sources in 2006 (μg/m^3)

Figure 10



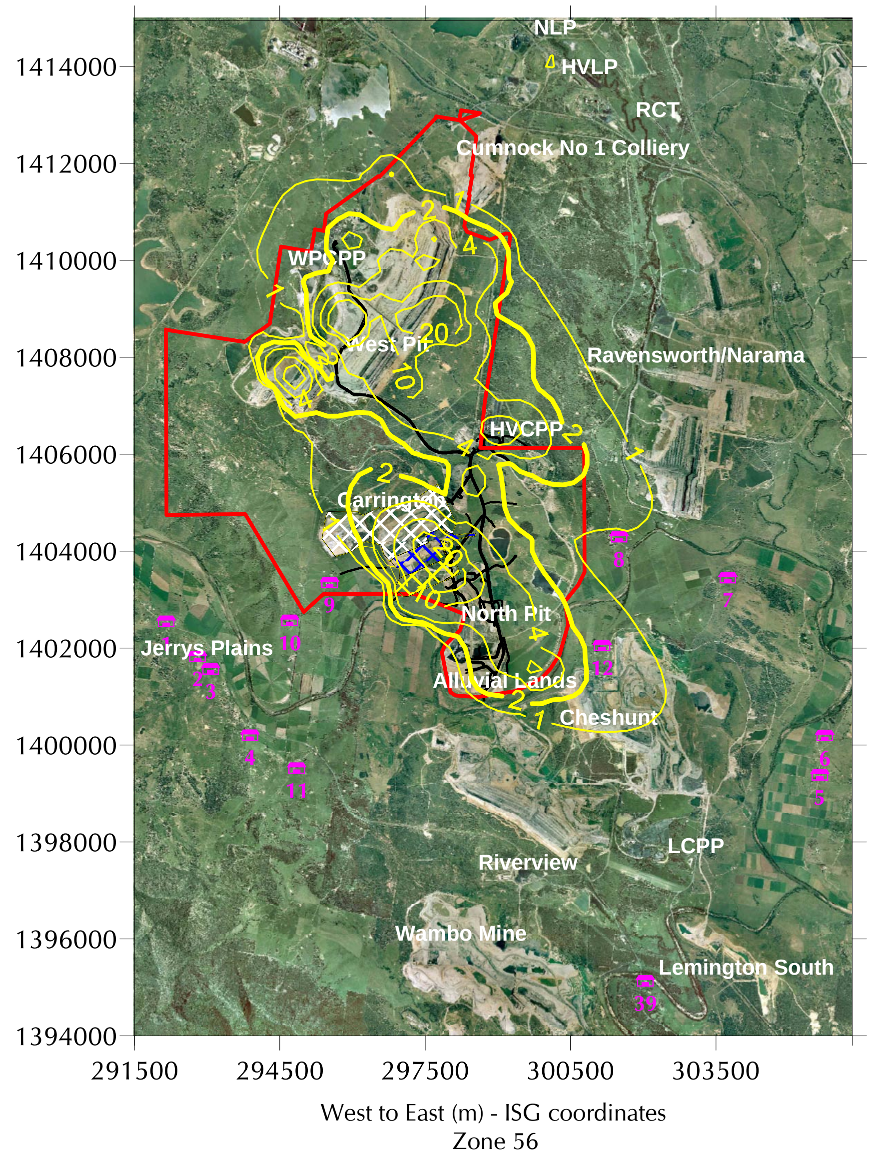
Predicted annual average TSP concentration
due to emissions from the Proposal in 2006 (μg/m³)

Figure 11



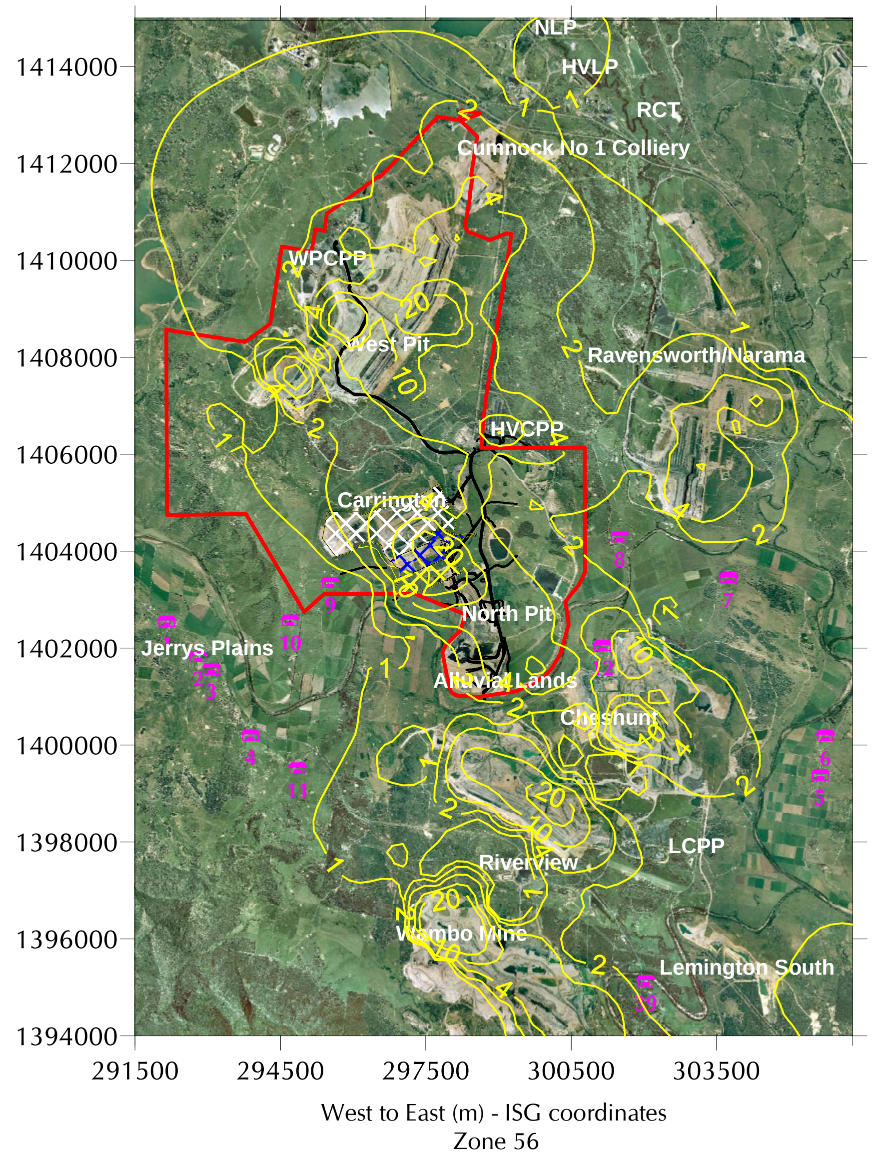
Predicted annual average TSP concentration
due to emissions from the Proposal and other sources in 2006 (μg/m^3)

Figure 12



Predicted annual average dust deposition
due to emissions from the Proposal in 2006 (g/m²/month)

Figure 13



Predicted annual average dust deposition
due to emissions from the Proposal and other sources in 2006 (g/m²/month)

Figure 14

8.5 2011 impacts

Figures 15 to **22** show the predicted model results for 2011.

Table 28 summarises the results. No residences are predicted to experience exceedances of any of the NSW DEC's assessment criterion due to emissions from HVO north of the Hunter River, including the proposed Carrington Extension.

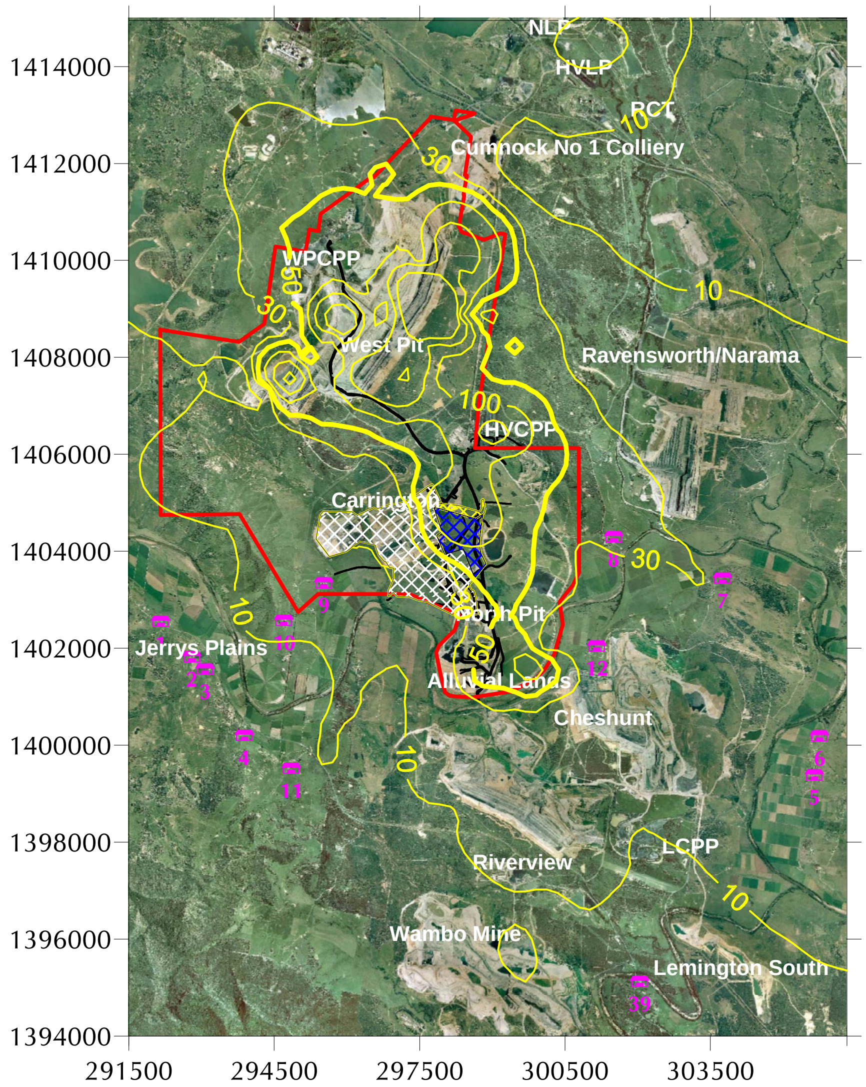
With the Proposal and other sources, Residence 12 is predicted to experience 24-hour average PM_{10} concentrations above the US EPA's 24-hour PM_{10} standard of 150 $\mu g/m^3$. Residences 8, 12 and 39 are predicted to experience annual average PM_{10} concentrations above the NSW DEC's assessment criterion of 30 $\mu g/m^3$. In addition, Residence 12 is predicted to experience exceedances of NSW DEC's assessment criteria for annual average TSP and dust deposition. Residences 8 and 12 are already within an existing zones of affectation and have a agreements with CNA or another mine. Emissions from HVO north of the Hunter River make little contribution to the exceedances at Residences 8, 12 and 39.

Table 28: Summary of affected residences for 2011

ID	Proposal in isolation in 2011				Proposal with other sources in 2011			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$g/m^2/month$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$g/m^2/month$
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	4.6	1.0	1.1	0.01	19.1	18.4	9.5	0.69
2	8.0	1.2	1.3	0.01	27.8	19.8	11.0	0.72
3	9.4	1.2	1.3	0.01	29.0	20.2	11.4	0.73
4	5.2	1.1	1.2	0.01	29.1	22.8	14.4	0.82
5	14.6	4.3	5.3	0.26	33.4	25.4	18.4	1.30
6	16.9	5.0	6.1	0.30	29.3	24.3	17.0	1.15
7[(b)]	29.5	9.3	11.5	0.61	41.3	25.5	18.2	1.21
8[(b)]	35.0	12.2	15.9	0.99	55.6	**33.1**	27.5	1.66
9[(c)]	12.3	3.5	3.9	0.08	27.6	28.2	19.9	0.86
10[(d)]	12.9	2.8	2.9	0.03	35.2	27.6	19.2	0.83
11[(d)]	7.4	1.3	1.3	0.01	40.4	26.5	18.8	0.95
12[(c)]	22.8	8.3	10.6	0.66	**196.4**	**96.4**	**113.2**	**5.29**
13	15.3	4.5	5.4	0.27	30.9	25.4	18.2	1.26
14	14.2	4.2	5.2	0.26	34.2	25.5	18.6	1.31
39	7.6	1.1	1.3	0.03	49.3	**30.1**	24.4	1.50

(a) US EPA 24-h ambient air quality standard (99th percentile over 3 years)
(b) These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement with HVO
(c) These properties are owned by Coal and Allied
(d) These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO

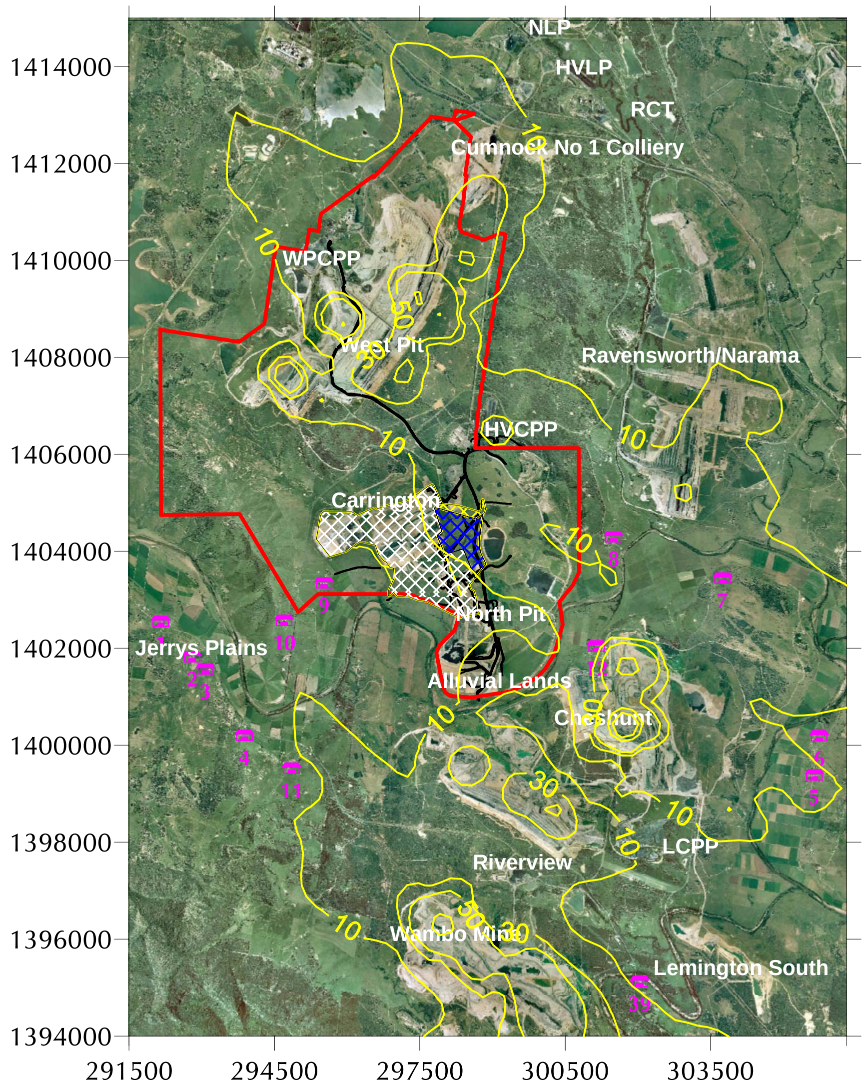
Bold font indicates predicted exceedance of goal



West to East (m) - ISG coordinates
Zone 56

Predicted 24-hour average PM_{10} concentration
due to emissions from the Proposal in 2011 ($\mu g/m^3$)

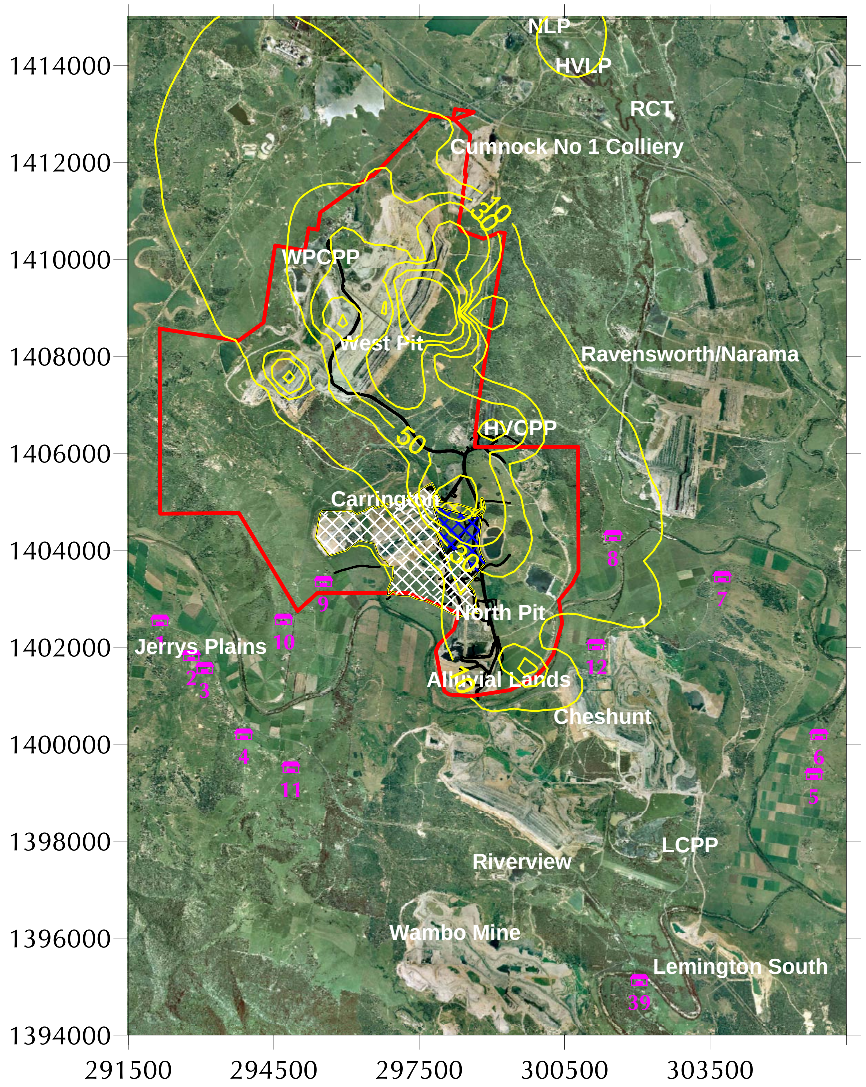
Figure 15



West to East (m) - ISG coordinates
Zone 56

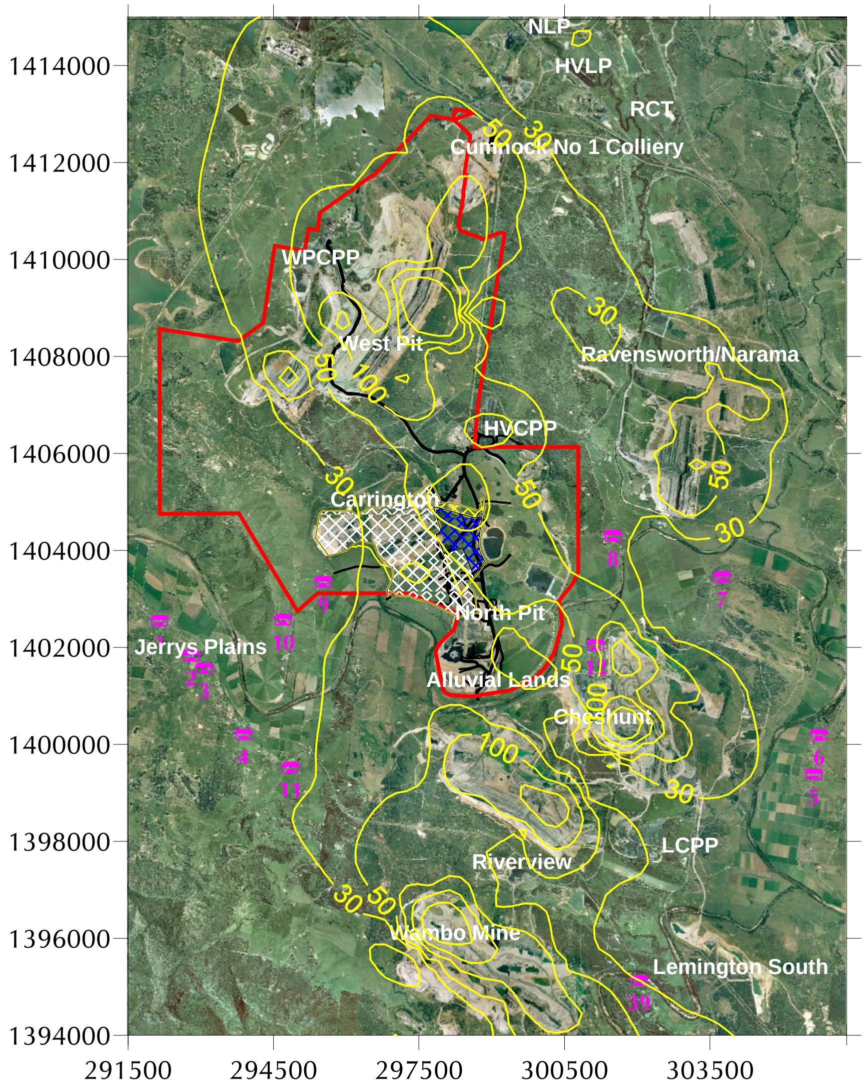
Predicted 24-hour average PM_{10} concentration
due to emissions from the Proposal and other sources in 2011 ($\mu g/m^3$)

Figure 16



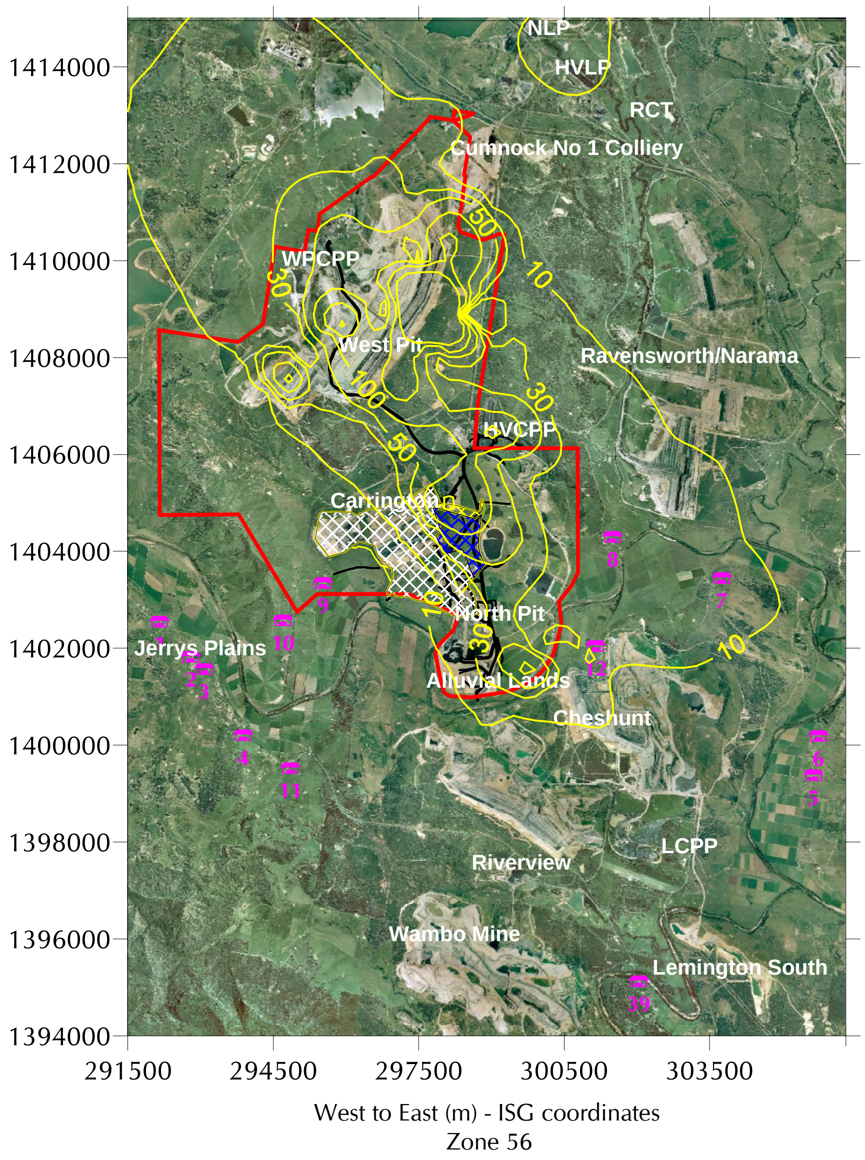
Predicted annual average PM_{10} concentration
due to emissions from the Proposal in 2011 ($\mu g/m^3$)

Figure 17



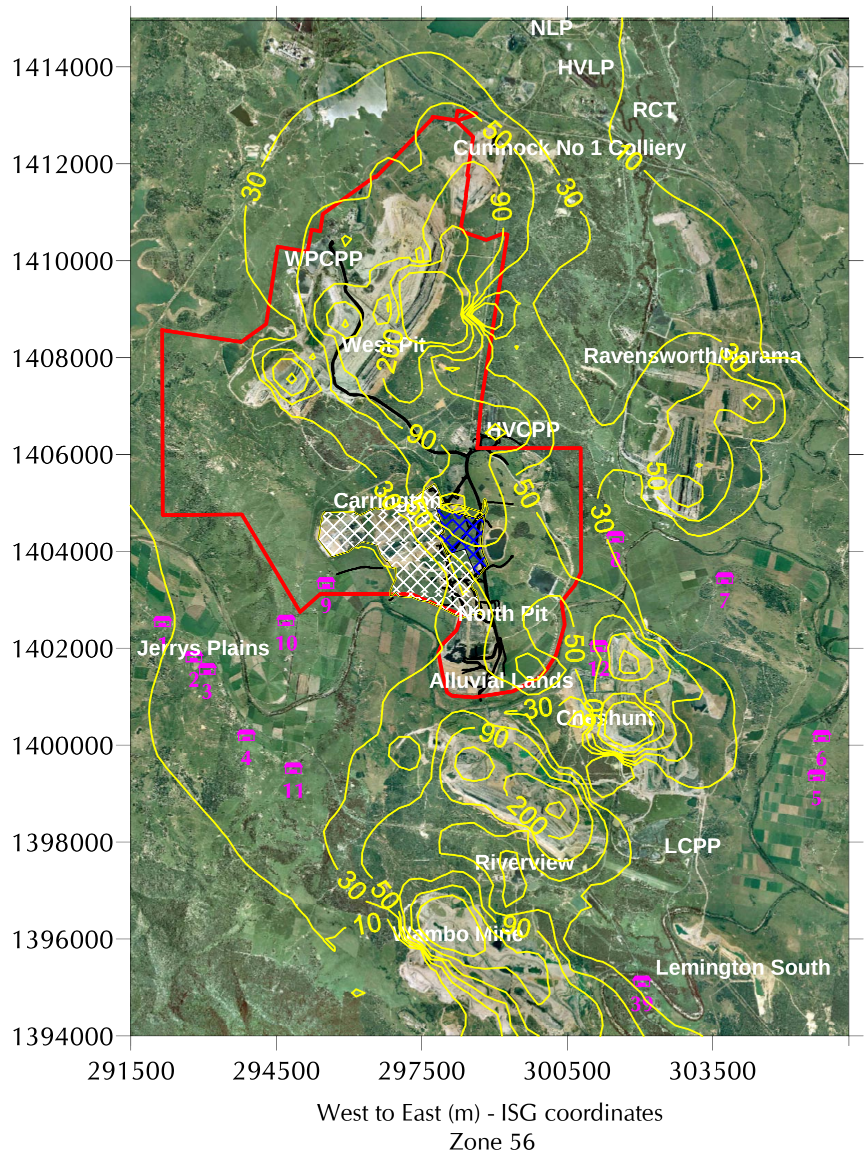
Predicted annual average PM_{10} concentration
due to emissions from the Proposal and other sources in 2011 ($\mu g/m^3$)

Figure 18



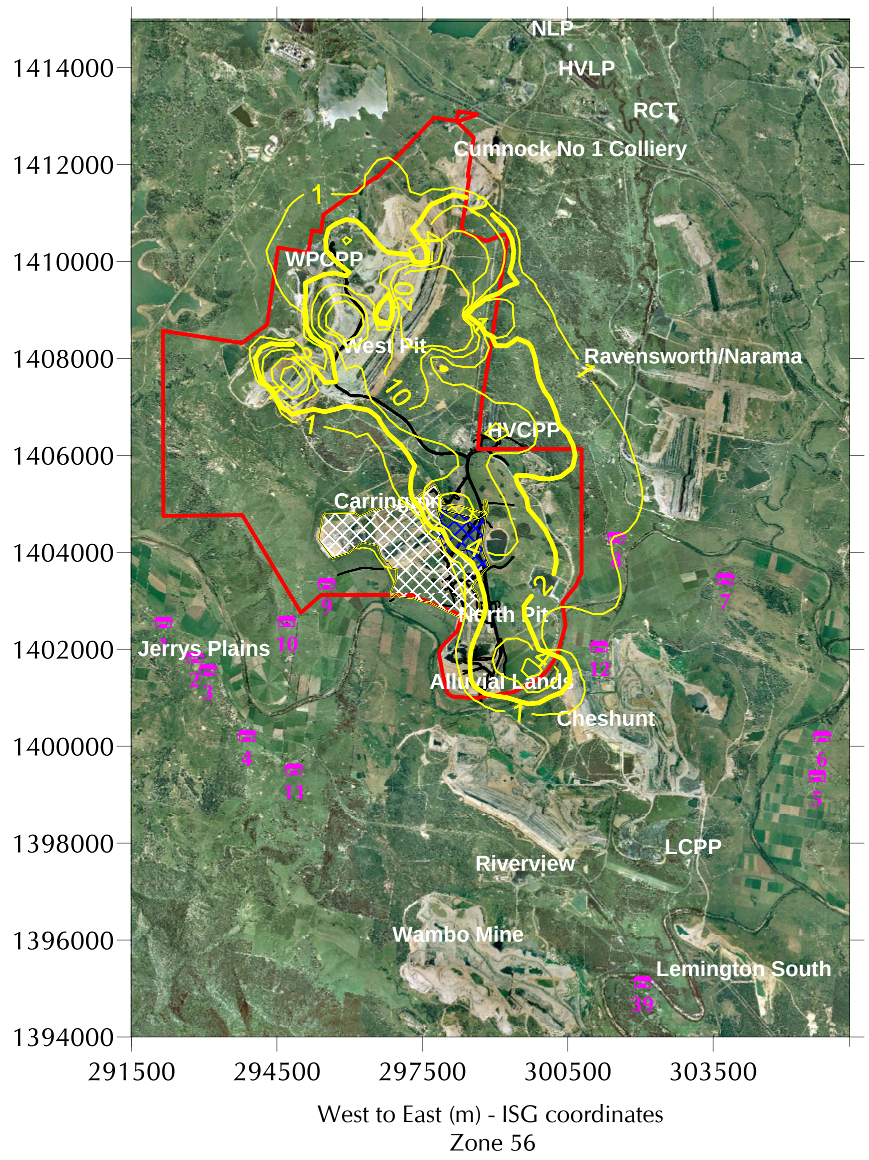
Predicted annual average TSP concentration
due to emissions from the Proposal in 2011 (μg/m^3)

Figure 19



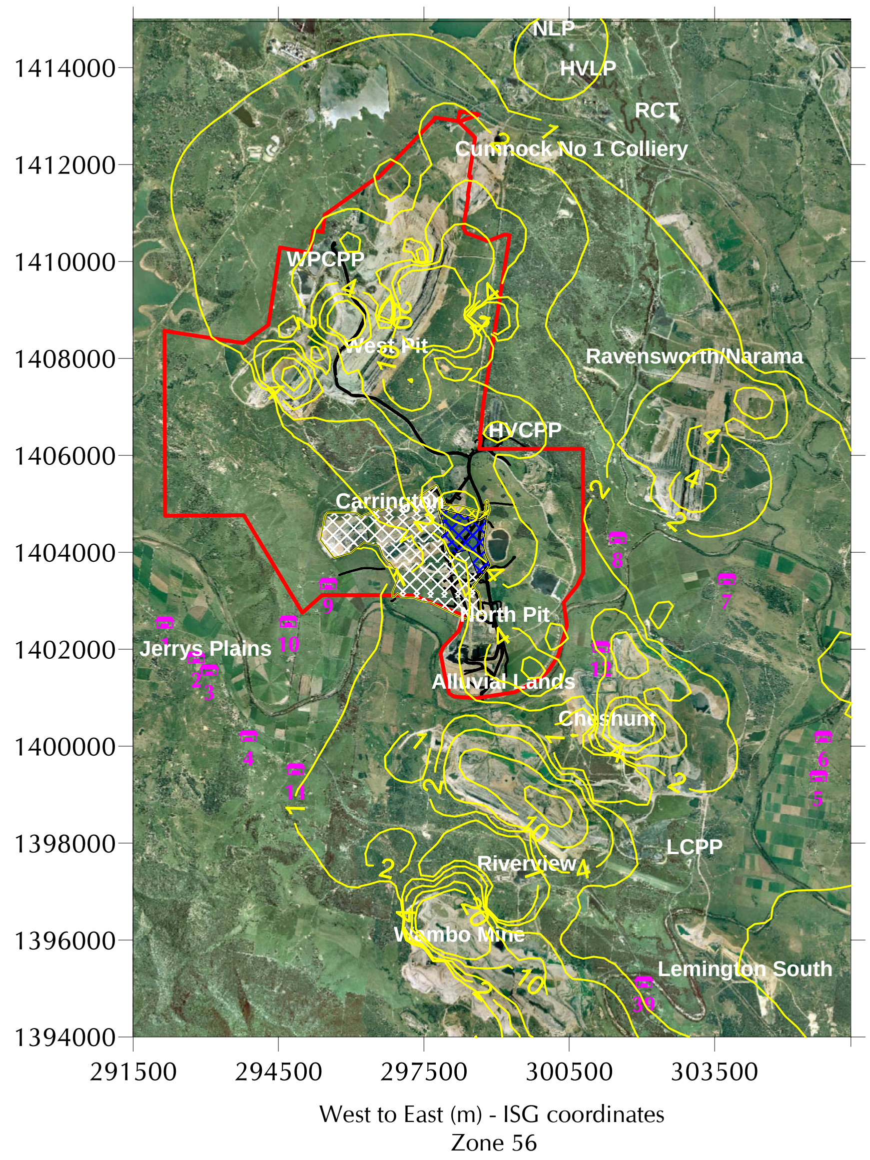
Predicted annual average TSP concentration
due to emissions from the Proposal and other sources in 2011 (μg/m^3)

Figure 20



Predicted annual average dust deposition
due to emissions from the Proposal in 2011 (g/m²/month)

Figure 21



Predicted annual average dust deposition
due to emissions from the Proposal and other sources in 2011 (g/m²/month)

Figure 22

8.6 2014 impacts

Figures 23 to **30** show the predicted model results for 2014.

Table 29 summarises the results. No residences are predicted to experience exceedances of any of the NSW DEC's assessment criterion due to emissions from HVO north of the Hunter River, including the proposed extension of Carrington Pit.

As before, with the Proposal and other sources, Residence 12 is predicted to experience 24-hour average PM_{10} concentrations above the US EPA's assessment criterion of 150 $\mu g/m^3$. Residences 8 and 12 are predicted to experience annual average PM_{10} and dust deposition concentrations above the NSW DEC's assessment criterion of 30 $\mu g/m^3$ and 4 g/m^2/month, respectively. In addition, Residence 12 is predicted to experience exceedances of NSW DEC's assessment criteria for annual average TSP. These residences are already within an existing zone of affectation and have an agreement with CNA. Emissions from HVO north of the Hunter River make little contribution to these exceedances.

Table 29: Summary of affected residences for 2014

ID	Proposal in isolation in 2014				Proposal with other sources in 2014			
	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year	PM_{10} 1-day	PM_{10} 1-year	TSP 1-year	Deposition 1-year
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	g/m^2/month
Goal	*50*	*30*	*90*	*2*	*150*[(a)]	*30*	*90*	*4*
1	7.8	1.2	1.3	0.01	27.3	15.1	21.3	0.71
2	9.1	1.3	1.4	0.01	27.3	16.9	23.2	0.74
3	11.2	1.4	1.5	0.01	30.9	17.0	23.3	0.75
4	7.7	1.3	1.4	0.01	31.1	19.4	26.2	0.83
5	15.0	4.4	5.3	0.25	41.5	23.4	31.8	1.40
6	18.2	5.4	6.5	0.31	32.9	22.7	30.9	1.28
7[(b)]	32.6	11.2	13.7	0.72	46.8	25.9	34.5	1.44
8[(b)]	38.6	15.1	19.5	1.21	60.2	**35.6**	46.6	2.06
9[(c)]	15.8	3.5	3.8	0.04	47.4	28.0	35.4	1.02
10[(d)]	20.3	3.0	3.2	0.03	43.0	27.5	34.3	0.88
11[(d)]	7.3	1.5	1.5	0.01	40.6	23.5	30.9	0.97
12[(c)]	24.7	8.7	11.1	0.67	**196.6**	**97.8**	**130.7**	**5.63**
13	15.9	4.6	5.6	0.26	38.7	23.4	31.7	1.37
14	14.8	4.3	5.2	0.25	42.1	23.5	31.9	1.42
39	8.6	1.2	1.3	0.03	50.8	25.9	35.4	1.53

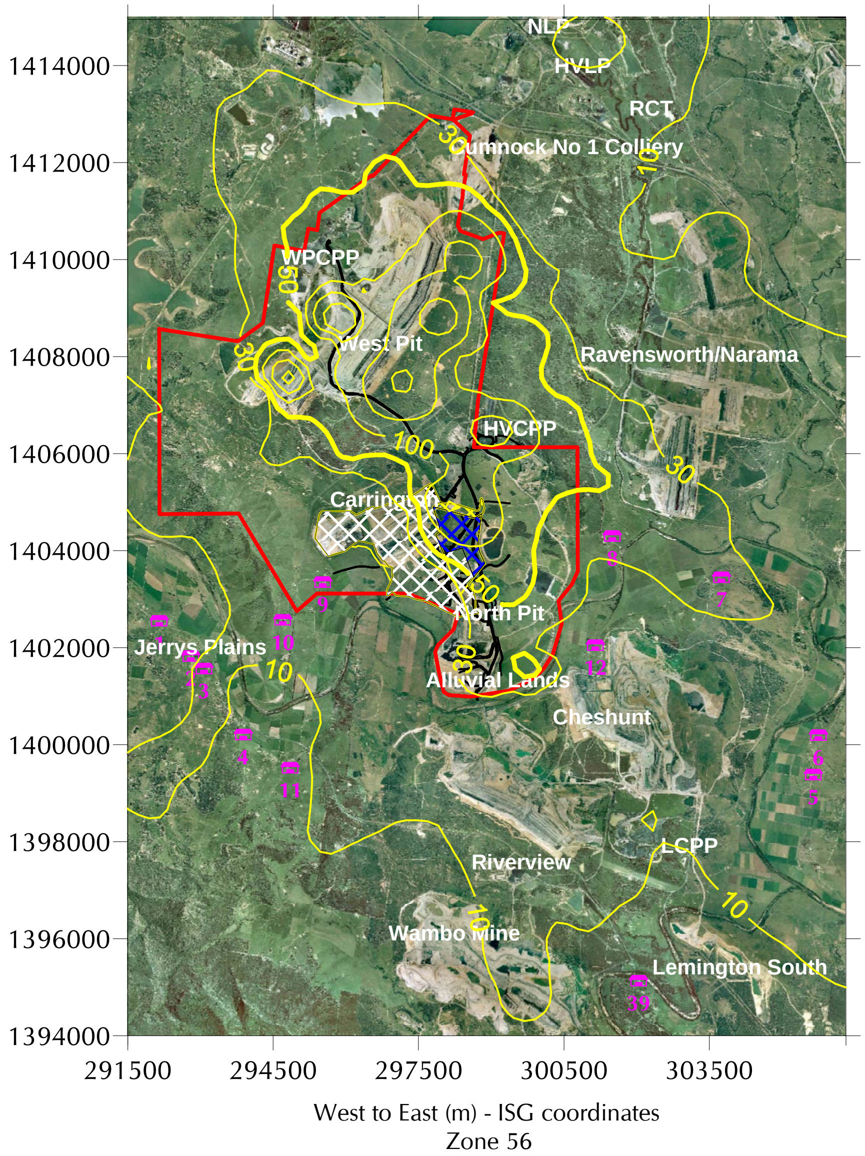
(a) US EPA 24-h ambient air quality standard (99th percentile over 3 years)

(b) These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement with HVO

(c) These properties are owned by Coal and Allied

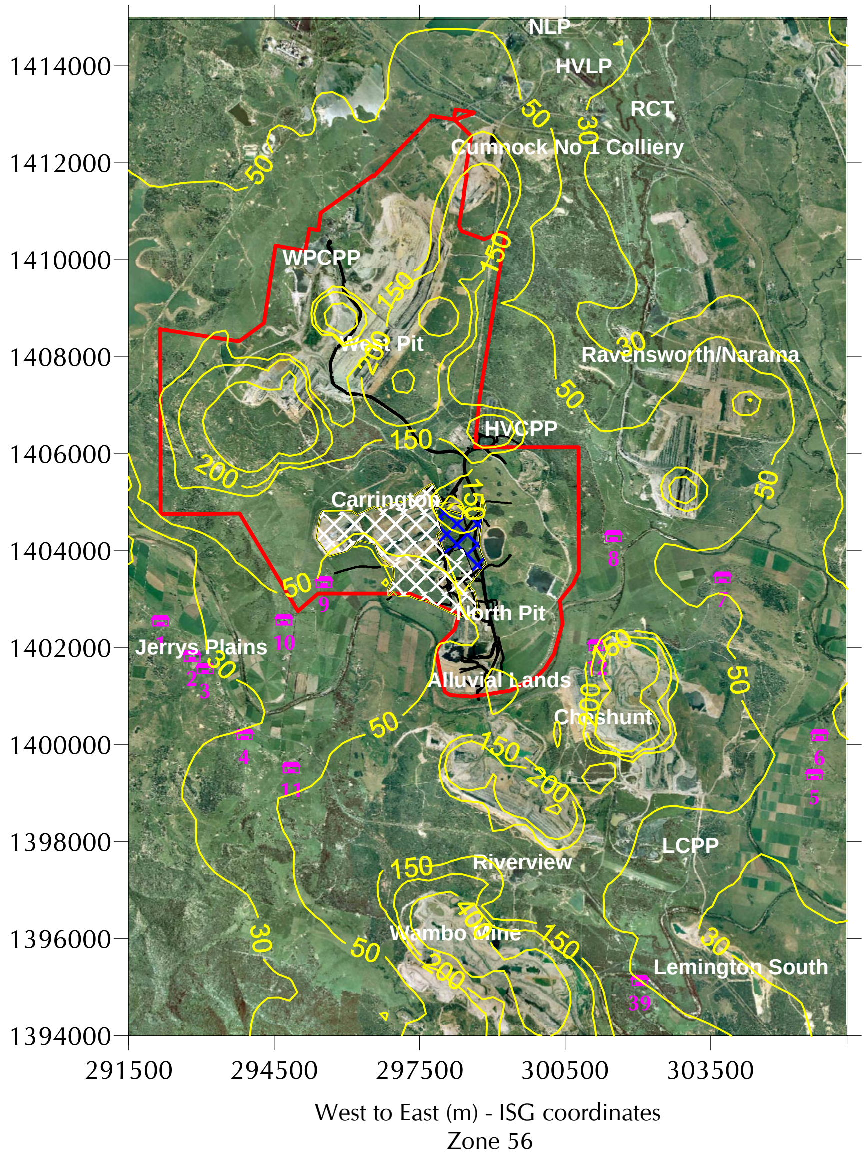
(d) These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO

Bold font indicates predicted exceedance of goal



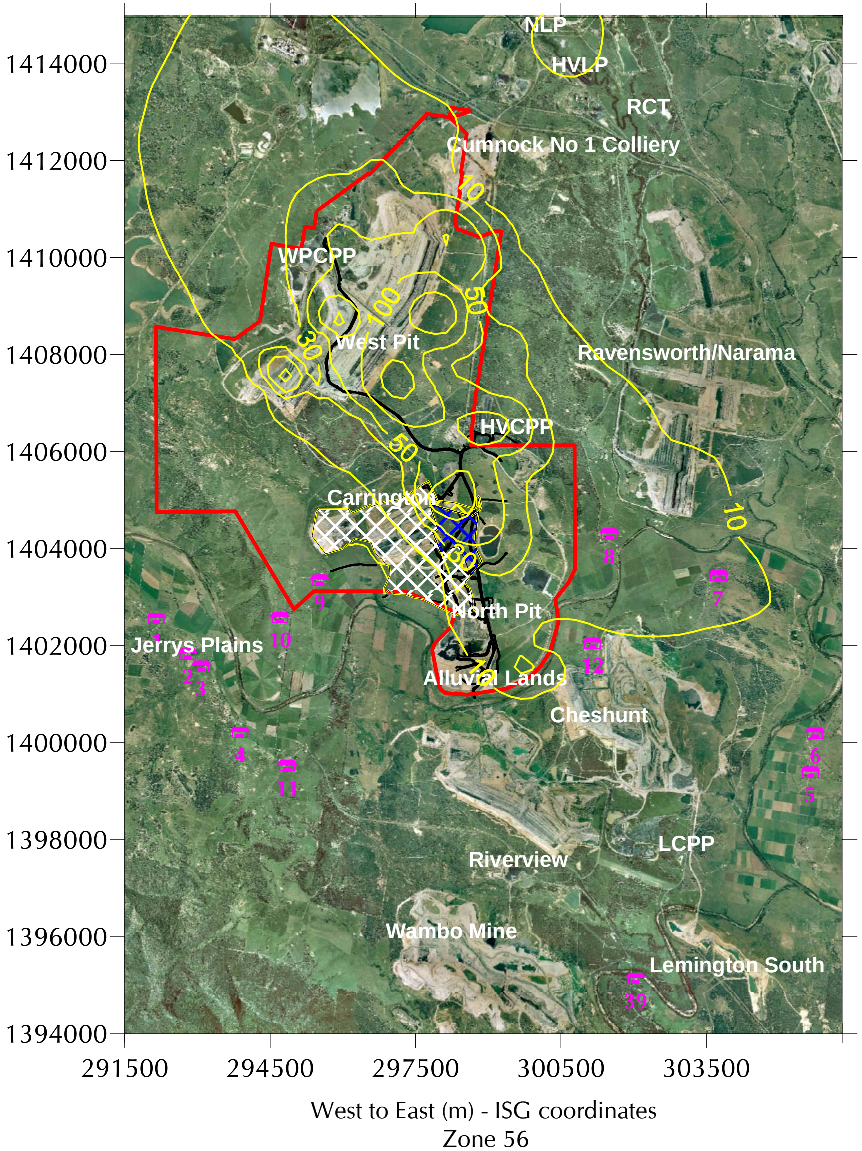
Predicted 24-hour average PM_{10} concentration
due to emissions from the Proposal in 2014 ($\mu g/m^3$)

Figure 23



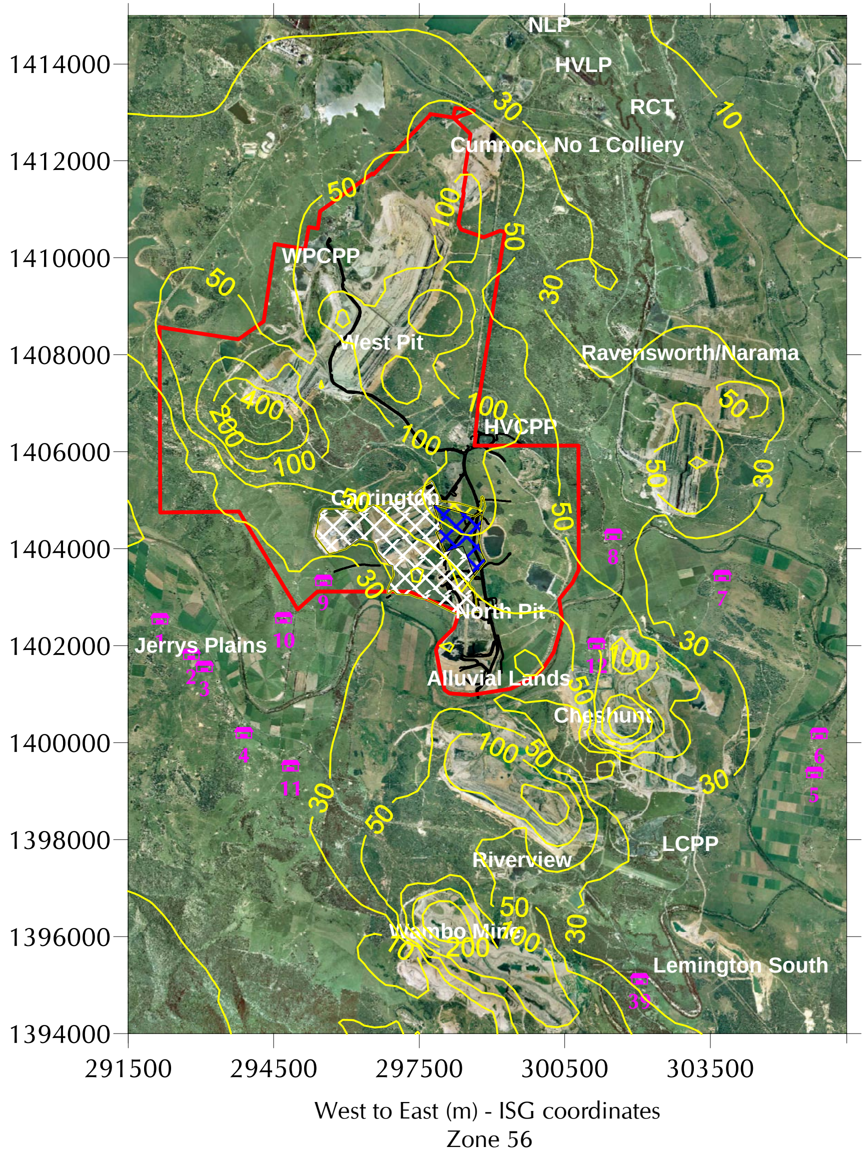
Predicted 24-hour average PM_{10} concentration
due to emissions from the Proposal and other sources in 2014 ($\mu g/m^3$)

Figure 24



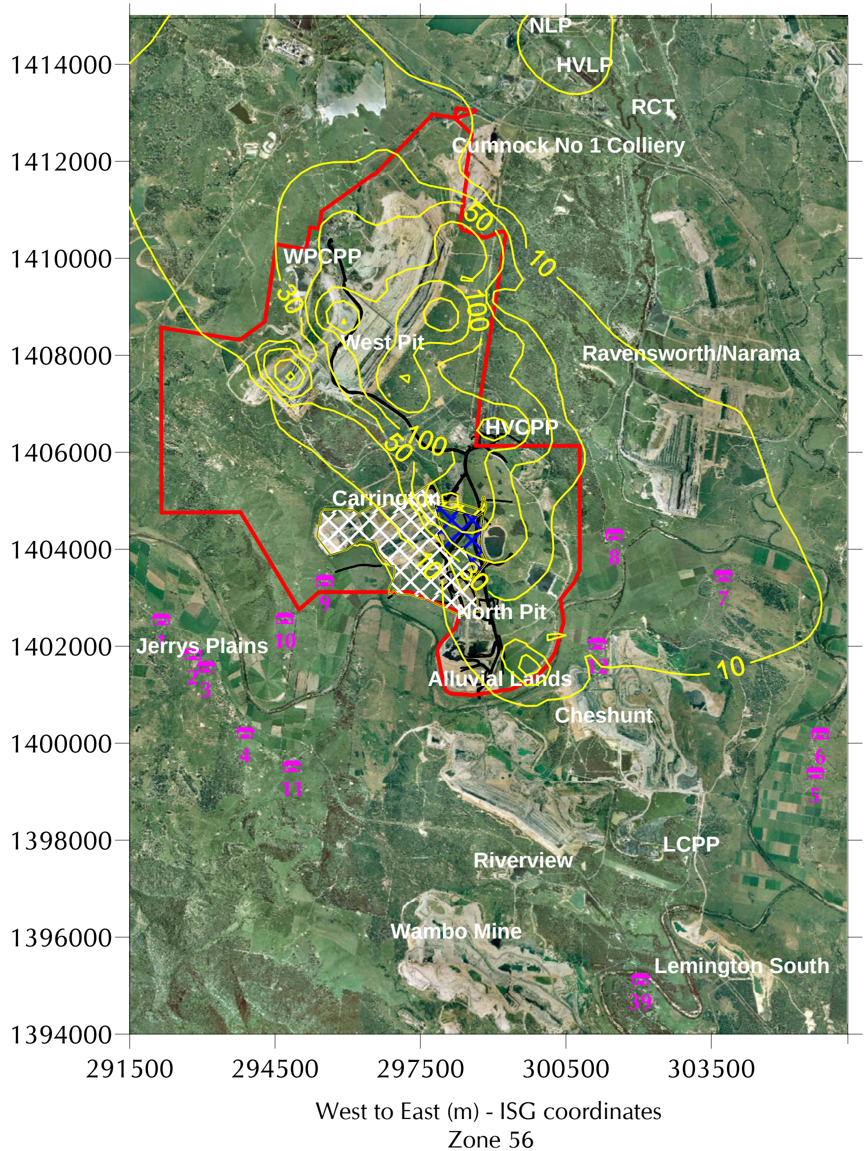
Predicted annual average PM_{10} concentration due to emissions from the Proposal in 2014 ($\mu g/m^3$)

Figure 25



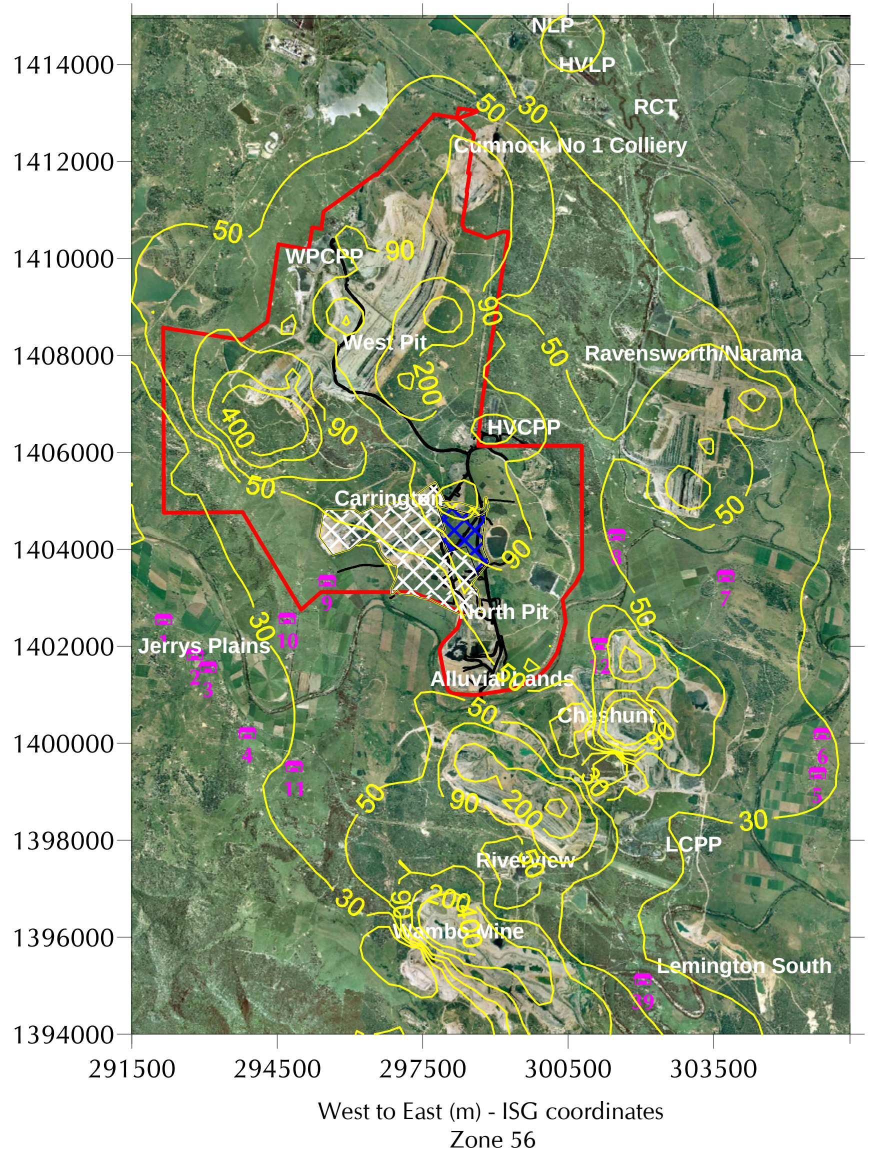
Predicted annual average PM_{10} concentration due to emissions from the Proposal and other sources in 2014 ($\mu g/m^3$)

Figure 26



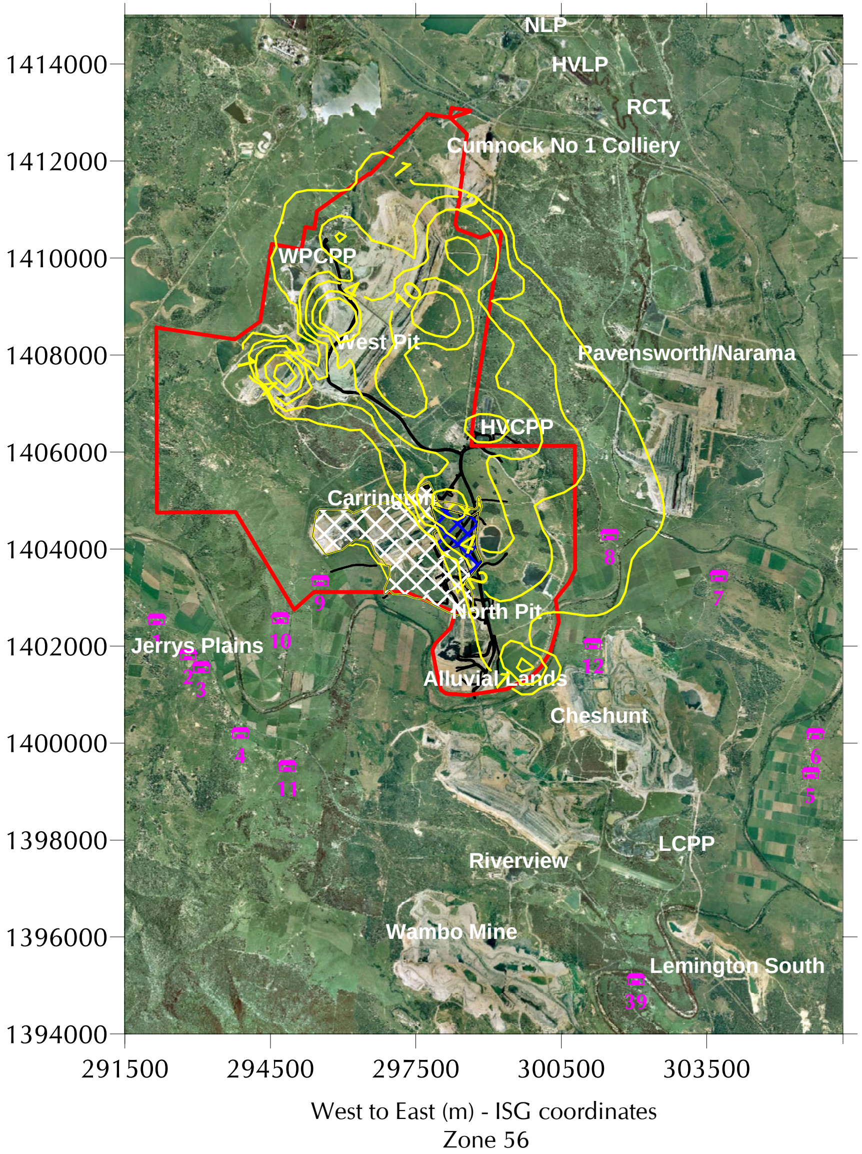
Predicted annual average TSP concentration
due to emissions from the Proposal in 2014 ($\mu g/m^3$)

Figure 27



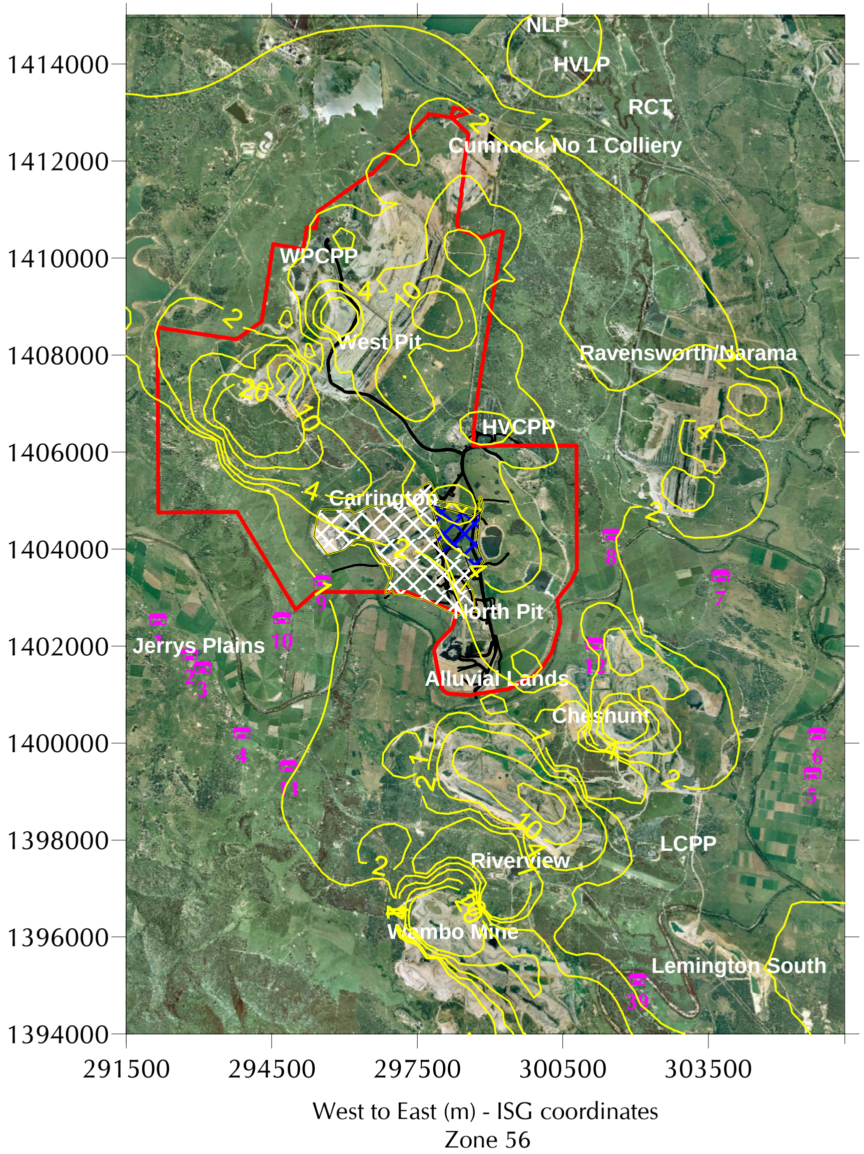
Predicted annual average TSP concentration
due to emissions from the Proposal and other sources in 2014 ($\mu g/m^3$)

Figure 28



Predicted annual average dust deposition
due to emissions from the Proposal in 2014 (g/m²/month)

Figure 29



Predicted annual average dust deposition
due to emissions from the Proposal and other sources in 2014 (g/m²/month)

Figure 30

Comparison of results with HVO West Pit Extension and Minor Modifications EIS
There are a number of differences between the modelling results presented in the original West Pit EIS (**Holmes Air Sciences, 2003a**) and the current study. These are discussed in **Appendix E**.

9. MITIGATION

9.1 Introduction

The modelling results presented above are based on the assumption that the project applies control measures to minimise dust emissions. Because of the scale of mining operations in the Hunter Valley and the need to manage cumulative impacts, it will be necessary to ensure that dust emissions are kept to the minimum practicable level. This section outlines procedures proposed for the management and control of dust emissions.

9.2 Dust management and control procedures

Management measures as outlined in CNA EMS Procedure 8 - Air Quality Management, will continue to be implemented to minimse potential impacts from dust.
Dust can be generated from two primary sources, these being:

i) wind blown dust from exposed areas, and
ii) dust generated by mining activities.

Table 30 and **Table 31** list the different sources of wind blown and mining generated dust respectively, and the defined controls.

Table 30: Control procedures for wind blown dust

Source	Control Procedures
Areas Disturbed by Mining	Disturb only the minimum area necessary for mining. Reshape, topsoil and rehabilitate completed overburden emplacement areas as soon as practicable after the completion of overburden tipping.
Coal Handling Areas	Maintain coal-handling areas in a moist condition using water carts to minimise wind blown and traffic generated dust.
Coal Product Stockpiles	Maintain water sprays on product coal stockpiles and use sprays to reduce the dust emissions as required.

Table 31: Mine generated dust and controls	
Source	**Control procedures**
Haul Road Dust	All roads and trafficked areas will be regularly watered using water carts to minimise the generation of dust. All haul roads will have edges clearly defined with marker posts or equivalent to control their locations, especially when crossing large overburden emplacement areas. Obsolete roads will be ripped and re-vegetated.
Minor Roads	Development of minor roads will be limited and the locations of these will be clearly defined. Minor roads used regularly for access etc will be watered. Obsolete roads will be ripped and re-vegetated.
Topsoil Stripping	Access tracks used by topsoil stripping equipment during their loading and unloading cycle will be watered.
Topsoil Stockpiling	Long term topsoil stockpiles, not used for over 6 months will be re-vegetated.
Drilling	Dust aprons will be lowered during drilling. Drills will be equipped with dust extraction cyclones, or water injection systems. Water injection or dust suppression sprays will be used when high levels of dust are being generated.
Blasting	Adequate stemming will be used at all times.
Raw Coal Bins	Automatic sprays, or other dust control mechanisms will be used when tipping raw coal that generates excessive dust quantities.
Coal Preparation Plant	All spillage of material will be cleaned up to prevent dust. Water sprays are/will be fitted at all transfer points.
Conveyors	Conveyors will be covered on the top and wherever practicable on the upwind side. All spillages from conveyors will be cleaned up as soon as practicable.

The monitoring program in place to verify environmental performance incorporates the following.

- One meteorological station.
- Three high volume PM_{10} monitors.
- A network of deposition gauges to monitor dust fallout.
- Real time monitoring of wind speed and wind direction is undertaken at the meteorological station to allow real-time dust monitoring data to be interpreted and assist in the implementation of best practice management to reduce the effects of dust emissions.

The proposed Carrington Extension will be incorporated into the existing monitoring program to manage dust generating activities across HVO.

10. GREENHOUSE ISSUES

10.1 Introduction

Coal mining results in the emission of carbon dioxide (CO_2) during the combustion of diesel fuel (used in diesel-powered equipment and in blasting), and indirectly in the use of electricity to power mining equipment and operate the coal preparation plants. In addition, methane is released as coal is mined.

To estimate emissions from these sources, the electrical and fuel requirements for existing mining operations have been used to determine the energy required to mine each tonne of coal from the existing mine. These estimates have then been used to estimate CO_2 emissions rates for future years.

Emissions of greenhouse gases have been calculated for the West Pit and Carrington operations (including the proposed extension) for the three years of operation modelled.

10.2 HVO North Greenhouse Emissions

Data were provided by CNA for HVO operations in 2004. These data showed that HVO used 57,015 kL of diesel and 127,035,923 kWh of electrical energy to produce 17,200,000 tonne of ROM coal.

To estimate CO_2-e (CO_2 equivalent) emissions it has been assumed that each kWh of electrical energy used results in the release of 0.973 kg of CO_2 (**Australian Greenhouse Office, 2004)**[4]. Each litre of diesel fuel burnt (either in mobile plant or explosives) is assumed to result in the release of 2.7 kg of CO_2 (**Australian Greenhouse Office, 2004**)[5]. In addition, it has been assumed that each tonne of ROM coal mined results in the release of 2.17 kg of methane (**Australian Greenhouse Office, 2004**)[6] and that methane has a greenhouse warming potential of 21. (This means that each kilogram of methane, because of its lifetime in the atmosphere and its spectral absorption characteristics, is equivalent to 21 kg of CO_2).

Table 32 summarises the estimated CO_2 emissions from West Pit and Carrington for each year using the above emissions factors for the HVCPP, WPCPP and open cut pits. Emissions from mines south of the river are not included in this estimate.

Table 32: Summary of estimated CO_2 emissions from mining of coal at West Pit and Carrington Pit

Year	WPCPP ROM coal	HVCPP ROM coal	Electricity used by WPCPP	Electricity used by HVCPP	Diesel used in transport and blasting	CH_4 released during mining	Total CO_2-e from mining
	t	t	kWh	kWh	kilolitres	t	t
2006	3,700,000	15,096,223	13,117,198	53,518,959	64,077	40,788	1,099,785
2011	3,600,000	9,357,891	12,762,679	33,175,489	44,174	28,119	758,179
2014	3,600,000	12,397,171	12,762,679	43,950,309	54,535	34,714	936,010
Total	**10,900,000**	**36,851,286**	**38,642,555**	**130,644,756**	**162,785**	**103,620**	**2,793,974**

For each tonne of ROM coal mined, approximately 59 t of CO_2-e emissions are produced.

[4] Table 5 – excluding transmission losses

[5] Table 3

[6] Table 6

The mine will also produce CO_2 when the coal is used by the ultimate customers. This is not included in the above estimates. **Table 33** presents a summary of the ROM coal that will be mined in each year and the approximate yield of product coal (based on 70% recovery). On combustion, this will produce approximately 2.65 t of CO_2-e per tonne of coal burnt (**Australian Greenhouse Office, 2004**)[7]. **Table 33** compares the total tonnes CO_2-e emissions resulting from the combustion of coal from West Pit and Carrington Pit with the tonnes of CO_2-e emission per year for mining and processing of the coal.

Table 33: Summary of estimated CO_2 emissions from combustion of coal from West Pit and Carrington Pit

	Total ROM coal	Product coal	CO_2-e released when coal burnt	CO_2-e released during mining
Year	t/y	t/y	t CO_2-e/y	t CO_2-e/y
2006	18,796,223	13,157,356	34,866,995	1,099,785
2011	12,957,891	9,070,524	24,036,888	758,179
2014	15,997,171	11,198,020	29,674,752	936,010

11. CONCLUSIONS

This report has developed emissions inventories for the proposed Carrington Extension, which is part of HVO north of the Hunter River for three representative periods. These emissions inventories have been used with local meteorological data and the US EPA's ISCST3 model to predict the maximum 24-hour PM_{10}, annual average PM_{10}, annual average TSP and annual average dust deposition (insoluble solids) over an area extending approximately 14 km (east-west) and 21 km (north-south). The modelling has been undertaken to show both the effects of mining in HVO north of the Hunter River and the cumulative effects of these operations with neighbouring mines and other sources of dust.

It is concluded that a maximum of three residences (Residences 8, 12 and 39) will be impacted by dust levels exceeding the NSW DEC assessment criteria. Residences 8 and 12 are already within an existing zones of affectation and have agreements with CNA or another mine. Overall, it should be noted that emissions from HVO north of the Hunter River make little contribution to the exceedances.

[7] Table 1

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Appendix A - Predicted $PM_{2.5}$ Concentrations from Mining Sources

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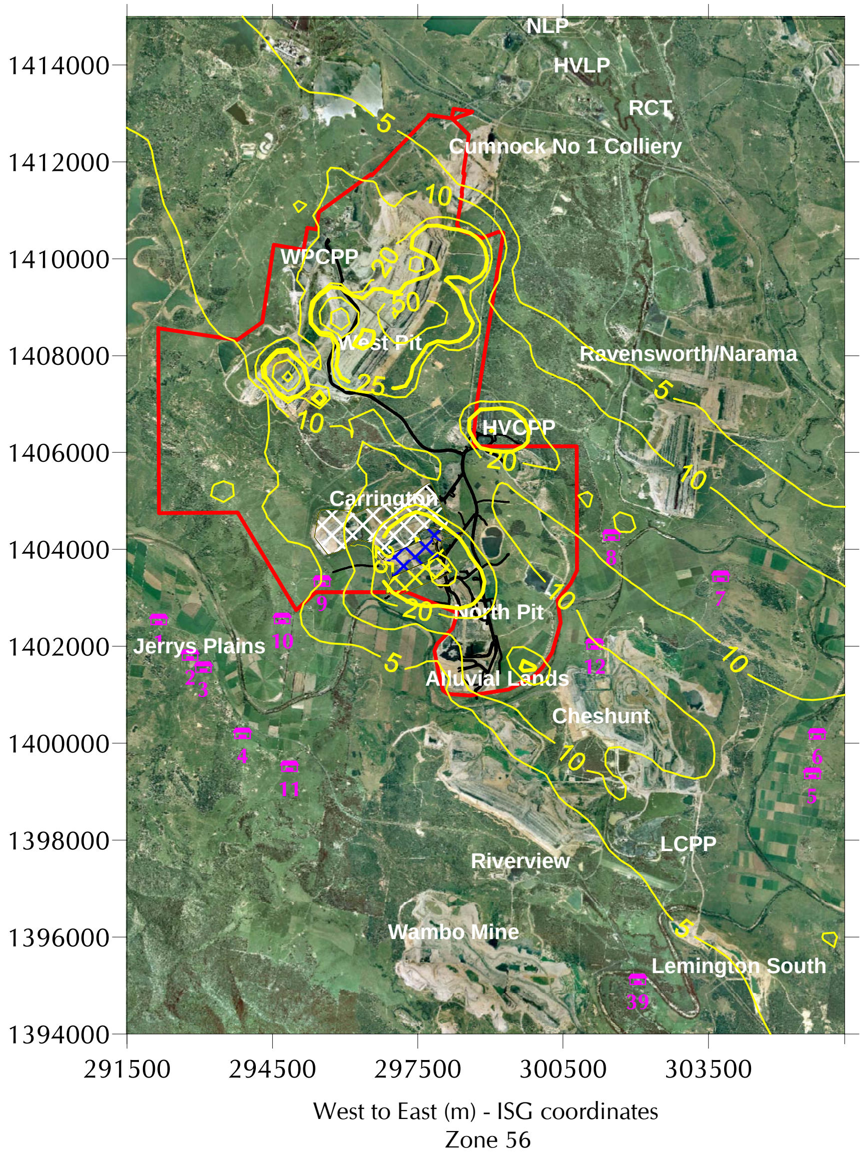
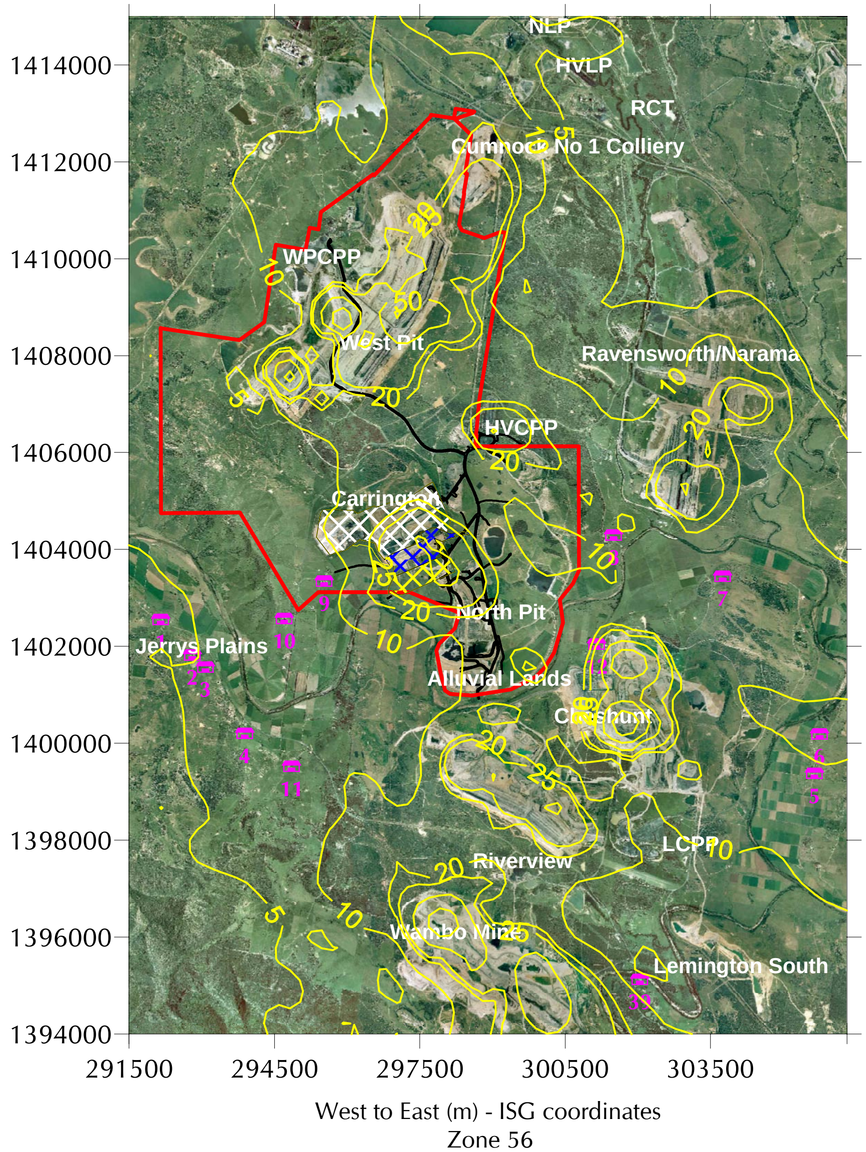


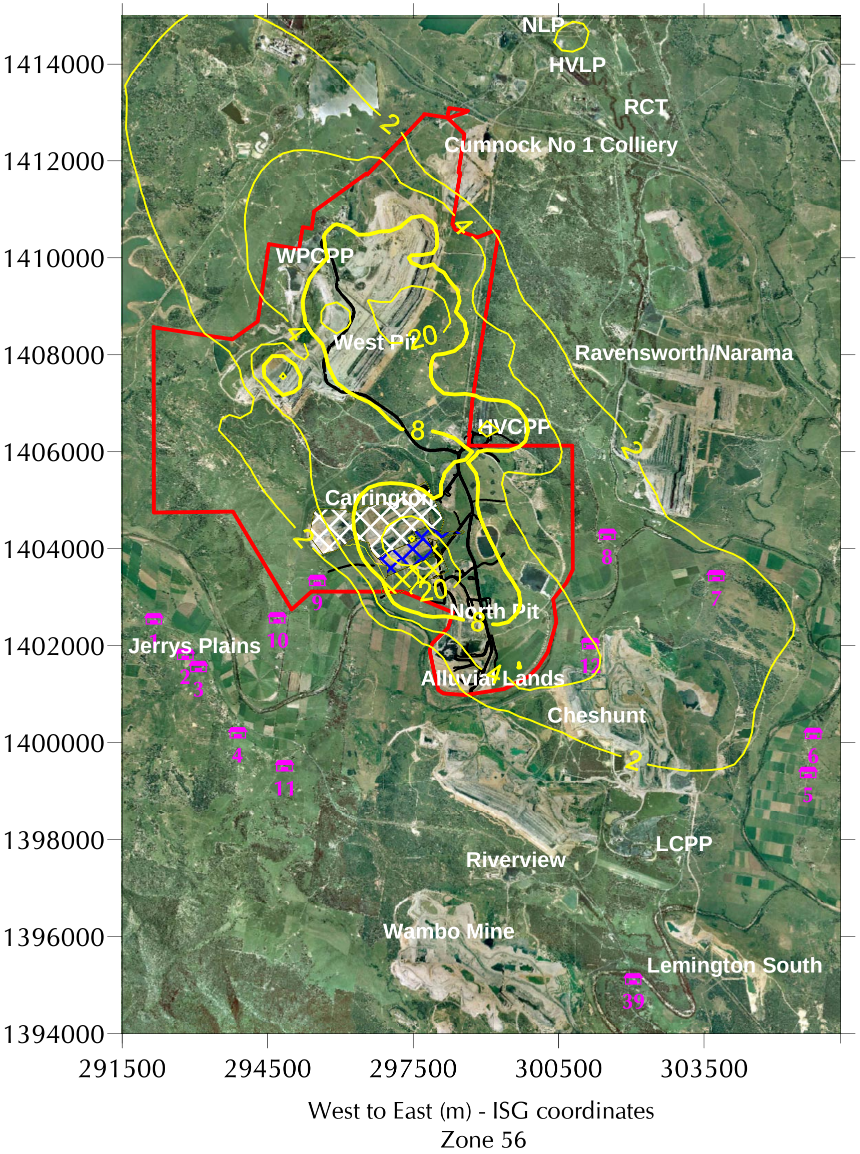
Predicted maximum 24-hour average $PM_{2.5}$ concentration due to emissions from the Proposal in 2006 ($\mu g/m^3$)

Figure A1



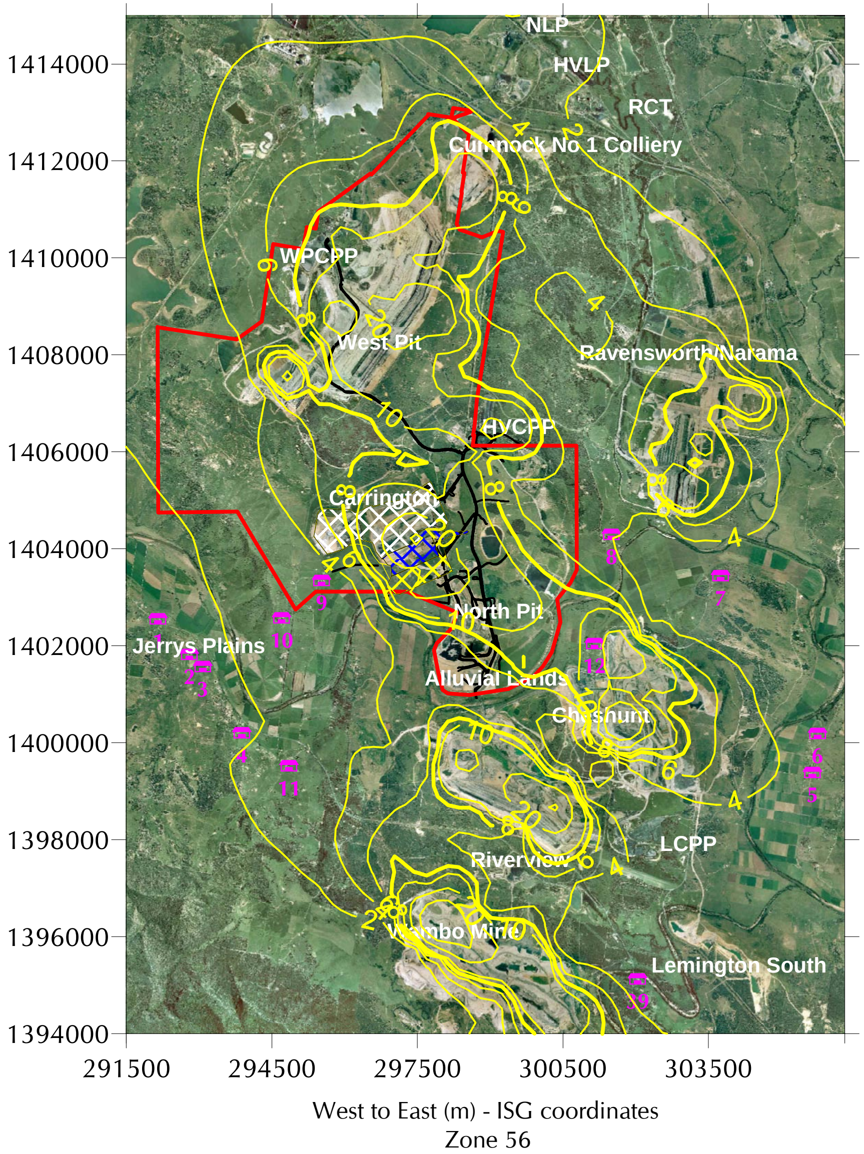
Predicted maximum 24-hour average $PM_{2.5}$ concentration due to emissions from the Proposal and other sources in 2006 ($\mu g/m^3$)

Figure A2



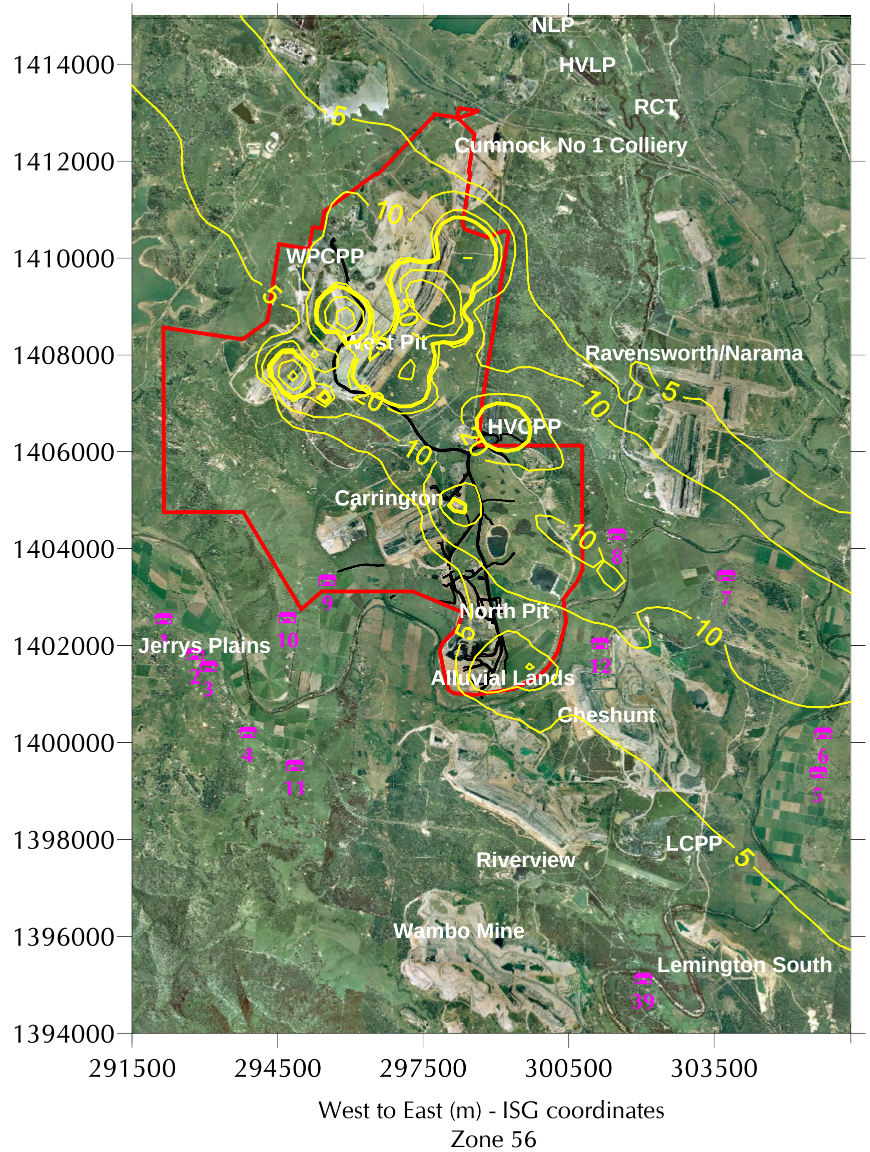
Predicted annual average $PM_{2.5}$ concentration
due to emissions from the Proposal in 2006 (μg/m^3)

Figure A3



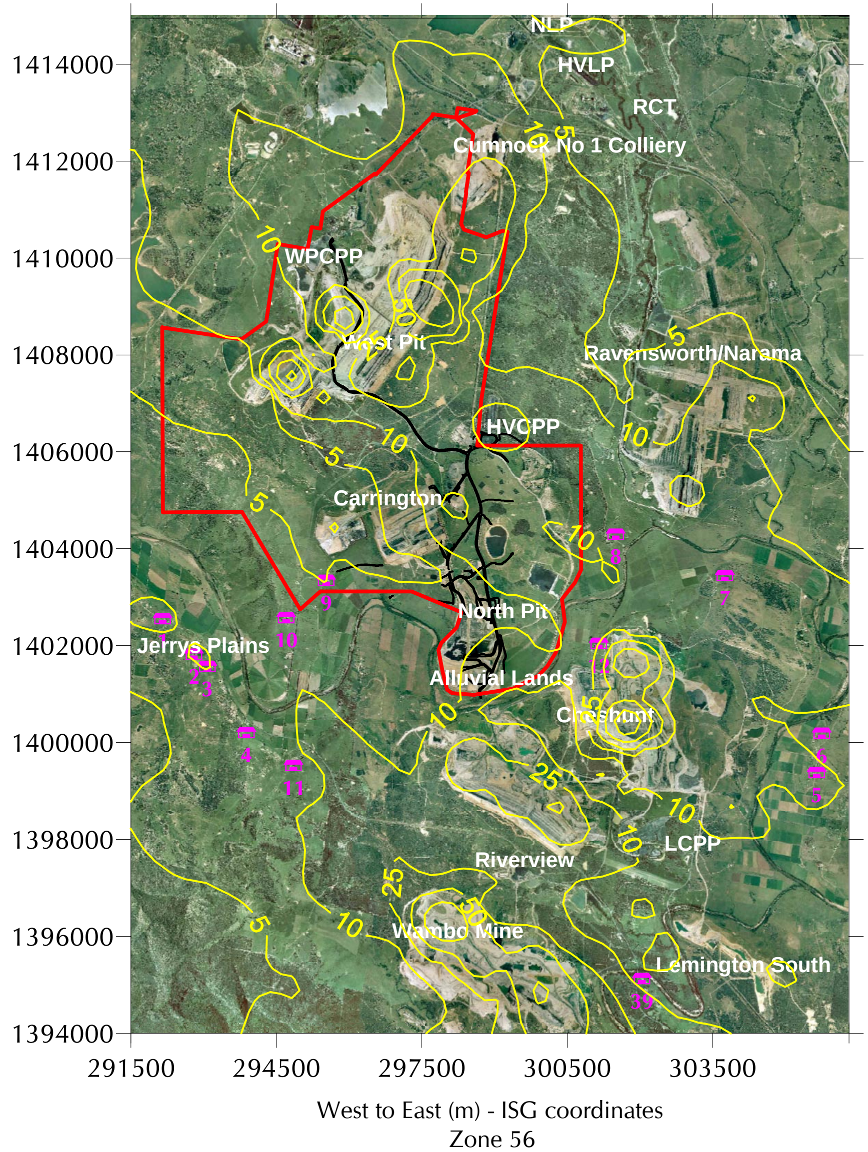
Predicted annual average $PM_{2.5}$ concentration
due to emissions from the Proposal and other sources in 2006 (μg/m^3)

Figure A4



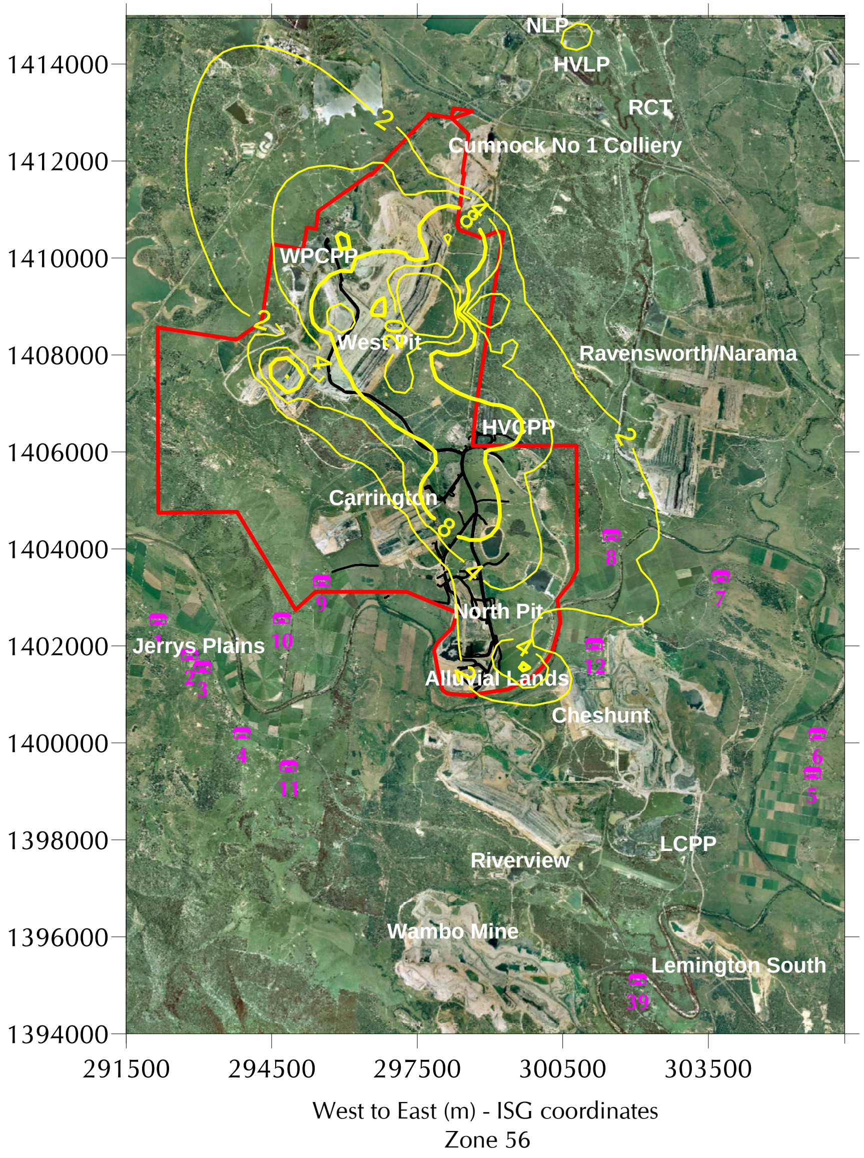
Predicted maximum 24-hour average $PM_{2.5}$ concentration due to emissions from the Proposal in 2011 ($\mu g/m^3$)

Figure A5



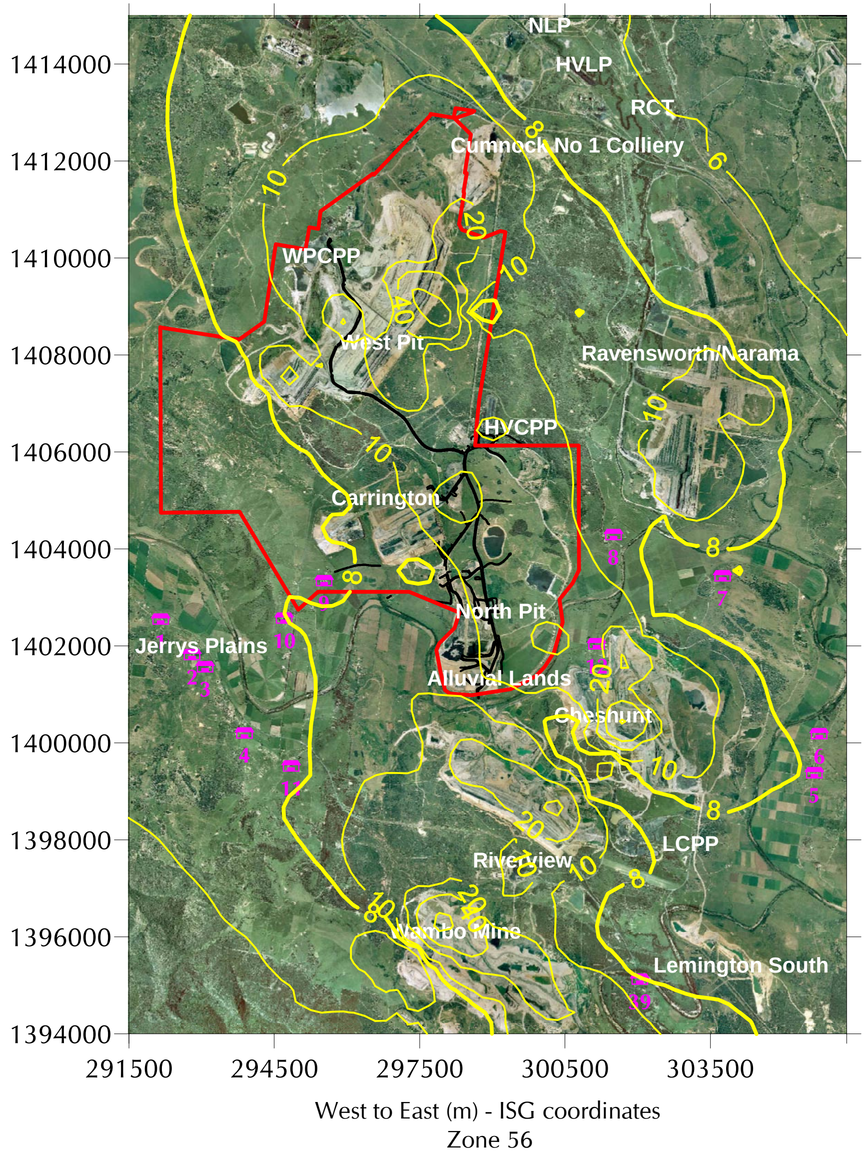
Predicted maximum 24-hour average $PM_{2.5}$ concentration due to emissions from the Proposal and other sources in 2011 ($\mu g/m^3$)

Figure A6



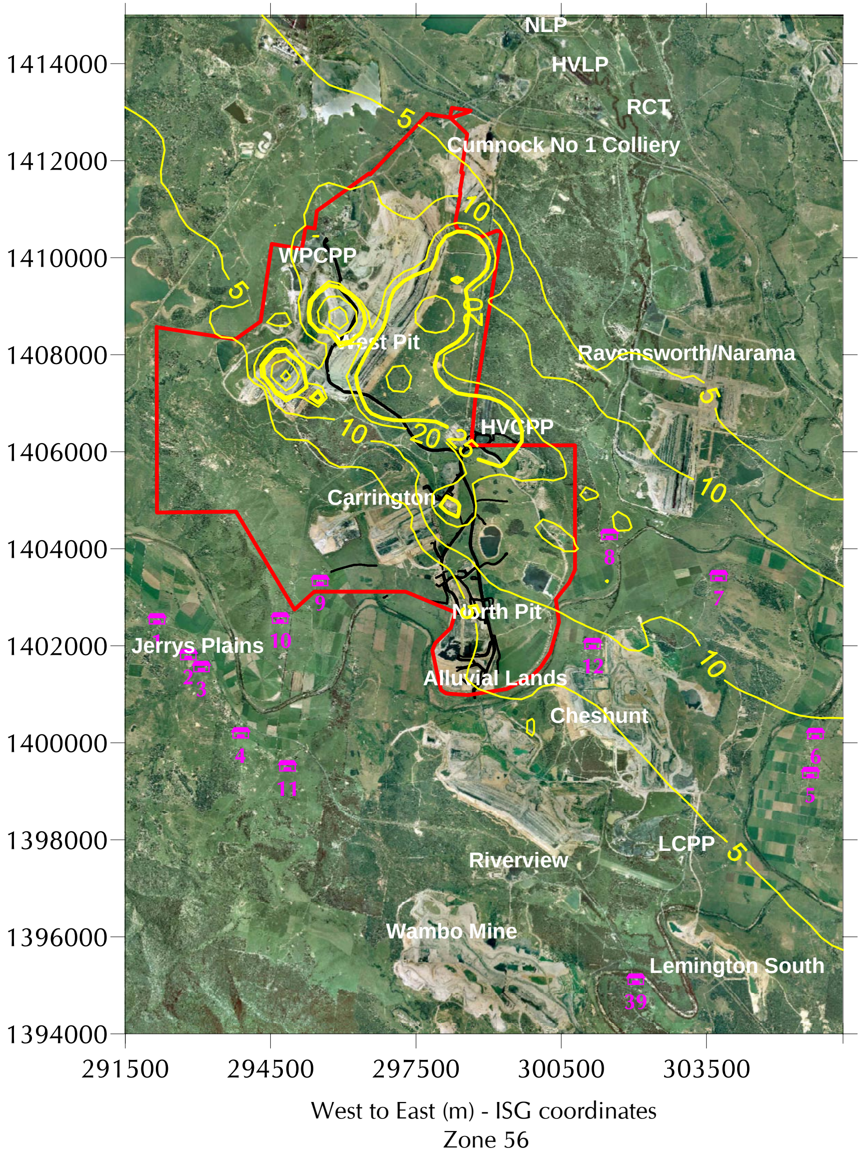
Predicted annual average $PM_{2.5}$ concentration
due to emissions from the Proposal in 2011 ($\mu g/m^3$)

Figure A7



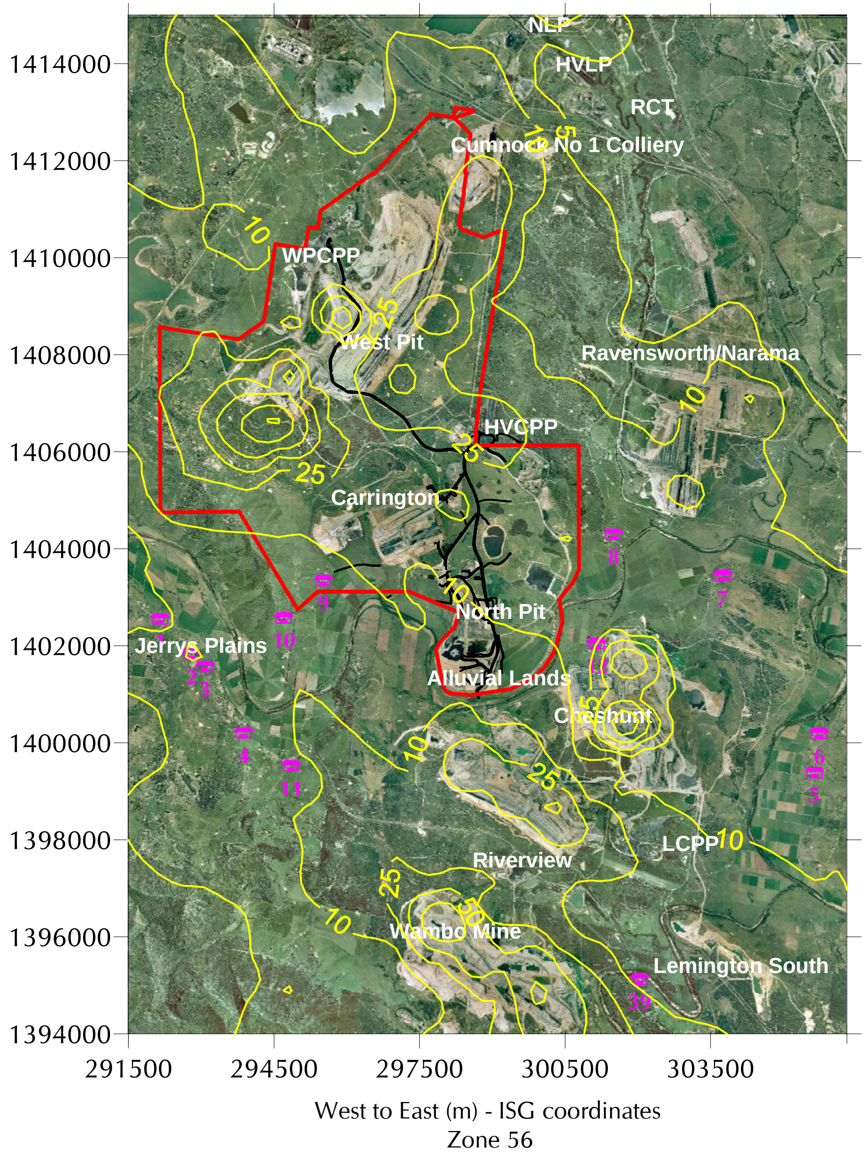
Predicted annual average $PM_{2.5}$ concentration
due to emissions from the Proposal and other sources in 2011 ($\mu g/m^3$)

Figure A8



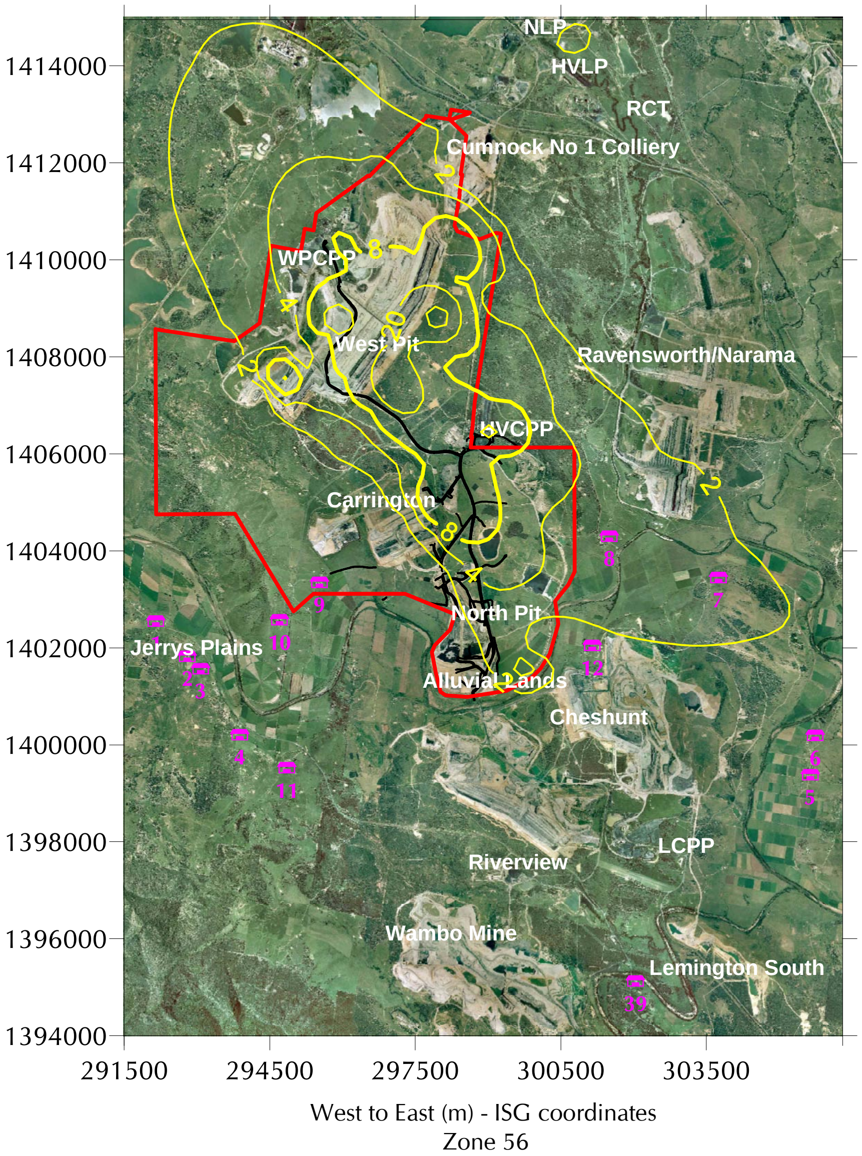
Predicted maximum 24-hour average $PM_{2.5}$ concentration
due to emissions from the Proposal in 2014 ($\mu g/m^3$)

Figure A9



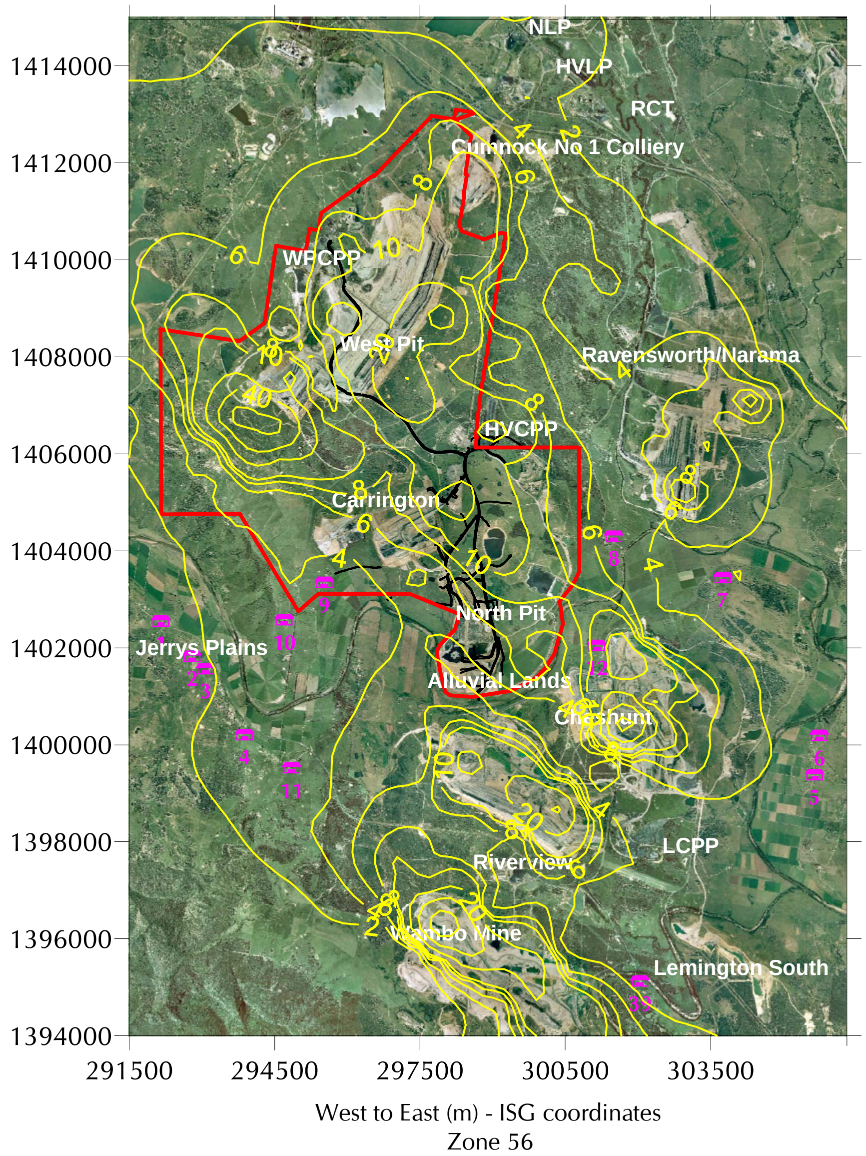
Predicted maximum 24-hour average $PM_{2.5}$ concentration
due to emissions from the Proposal and other sources in 2014 ($\mu g/m^3$)

Figure A10



Predicted annual average $PM_{2.5}$ concentration
due to emissions from the Proposal in 2014 (μg/m^3)

Figure A11



Predicted annual average $PM_{2.5}$ concentration
due to emissions from the Proposal and other sources in 2014 (μg/m^3)

Figure A12

Appendix B – Monthly dust deposition data

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Sample Date	D1	D2	D2A	D3	D5	D7	D7A	D8	D9	D15	D16	D19	D30	D31	D32	D33	D34	D38	D39	D43
									Total Insoluble Matter g/m2/mth											
May-98						3.5			1.9			3.8	2.5	2.2	3.15	4.55	2.5	1.6	2.8	2
Jun-98						2.1			3.3			2.9	3.2	3.2	1	1.8	3.1	1.6	1.1	1.3
Jul-98						2.1			2.5			2.8	1.4	1.3	2.1	1.2	1.5	0.8	1.2	0.6
Aug-98						0.7			1.4			0.7	2	1	1.4	Ns	1.9	0.9	2.7	0.4
Sep-98						13			1.8			2.9	2.3	2.6	2.2	2.9	2.6	1.9	1.7	1
Oct-98						4.3			0.7			3.4	3.7	2.3	2.6	2.9	1.5	1.4	1.1	1
Nov-98						3.6			1.8			4.2	3.3	4	2.8	2.4	2	2.8	1.6	2
Dec-98						4.4			1.6			0.9	3.3	6.3	2.7	4.1	2.7	2.6	4	2.9
Average 1998						**4.2**			**1.9**			**2.7**	**2.7**	**2.9**	**2.2**	**2.8**	**2.2**	**1.7**	**2.0**	**1.4**
Jan-99						1.2			1.2			1.8	5	1.9	1.2	0.9	1.1	0.9	1.1	2.7
Feb-99						3.2			2.2			5.5	2.3	5.3	1.5	1	1.1	2	1.5	1.8
Mar-99						3.3			1.3			2.7	2.6	2.6	2.1	2.3	2.6	8.3	2.4	1.7
Apr-99						3.1			0.7			3.1	2.1	2.6	2.3	1.7	1.9	1.5	1.8	0.9
May-99						3.9			0.6			3.1	2.9	2.8	2.2	2.1	2.5	2.3	2.5	0.7
Jun-99						5.1			7.7			4.4	4.3	2.8	3.3	4.6	4	1.7	4	0.6
Jul-99						4.3			3.1			3.8	2	1.2	0.9	1.4	1.3	3.3	1.3	0.5
Aug-99						5.4			2			3.4	3	2.7	2.5	1.8	1.9	1.8	2.3	0.9
Sep-99						4.2			2.3			3	2.8	2.4	2.2	1.9	2.4	1.6	2.1	1.2
Oct-99						2.3			1.1			2.4	3.1	2.9	2.9	1.3	2.2	2.8	2.5	2.6
Nov-99						5.3			1.4			4.8	1.9	1.2	1.4	3.2	1.6	0.9	1.7	1.2
Dec-99																				
Average 1999						**3.8**			**2.0**			**3.5**	**2.9**	**2.6**	**2.0**	**2.0**	**2.1**	**2.5**	**2.1**	**1.3**
Jan-00						5			2.7			3.3	2.8	2.4	1.5	1.1	3.7	1.8	4.1	2.9
Feb-00						11			1.2			9.5	2.8	2.8	2.1	3.2	1.1	2	2.6	2.7
Mar-00						16			4.3			5.3	9.8	13	1.3	6.2	4.7	0.6	9	2.7
Apr-00						3.1			1.2			2	2.4	2.4	2.8	2.8	4.7	1.6	2.3	1.8
May-00						1.6			3.2			3.2	1.3	2.2	1.6	5.2	1.5	1.2	1.3	0.5
Jun-00						4.6			2.3			4.1	0.9	2.2	2.1	249	2.1	2	3.1	0.6
Jul-00						4.5			2.3			3	1.3	1.9	2.5	4.3	2.2	2	3.8	0.6
Aug-00						3.9			2.3			2.4	1.8	2	2.2	2.5	2.1	1.8	2.9	0.7
Sep-00						3.4			1.8			3.4	2.7	1.9	2.2	1.6	1.7	1.6	1	0.9
Oct-00						4			1.3			3.5	2.4	2.3	1.5	2.9	3.6	1.9	2.7	1.1
Nov-00	4.5	1.2		7.3	7.3	2.5	6.1	5.9	1.8	5.3	3.5	2.4	2.3		2.8	3.1	3.3	4.7	2.9	0.9
Dec-00	4.7	3.1		9.9	5.7	4.6	4.4	3.9	4.6	5.2	4.6	3.5	7.3		3	3	4.5	3.3	9	1.2
Average 2000	**4.6**	2.2		**8.6**	**6.5**	**5.3**	**5.3**	**4.9**	**2.3**	**5.3**	**4.1**	**3.8**	**3.2**	**3.3**	**2.1**	**23.7**	**2.9**	**2.0**	**3.7**	**1.4**
Jan-01	4.8	1.6		1.5	2.3	4.5	0.9		0.8	1.4	1.6	1.1	1.8		2	0.5	1.3	3.3	3.3	
Feb-01	3.4	6.9		2.7	3.5		2.7	2.2	1.5	1.7	3.3	3.2	3.7		1	2.1	2	1.9	3.7	
Mar-01	3.7	3.3		1.1	1.1		0.8	3.5	1.4	3.2	1.6	3.5	1.7		0.2	4.1	3.3	0.3	0.4	
Apr-01	2.6	2.2		1.5	6.3		1.5	1.5	2	1.5	4.5	2.1			1	3.6	2			
May-01	1.7	1.8		1.9	15.7		1.6	2.4	0.7	1.4	3.1	1.3			1.3	2.9	1.8			
Jun-01	2.3	1.9		4.2	4.9		1	2.9	2	2.9	2.2	1.9			2.2	4	1.6			
Jul-01	1.0	4.1		4.7	1.9		1.1	2.2	1	2.1	2.5	2			1.9	3.5	2			
Aug-01	2.6	4.5		2.4	2.6		2.2	1.4	0.9	4.5	10.8	5.2			3.1	7.4	1.9			
Sep-01	1.4	2.5		2.4	1.6		1	1.6	1.8	2.1	2.8	3.2			1.9	4.2	3.6			
Oct-01	4.0	2.4		4.4	2.2		2	4	1.3	2.2	19.1	2.6			2.4	3.8	2.3			
Nov-01	1.0	5.2		4.3	3.2		1.5	4.3	3.7	1.9	8.1	2.4			3	7.7	2.6			
Dec-01	4.0	4.4		5	4		2.3	3.6	3.3	1.8	4.2	4.2			3.2	30.5	3.2			
Average 2001	**2.7**	**3.4**		**3.0**	**4.1**	**4.5**	**1.6**	**2.9**	**2.0**	**2.2**	**5.3**	**2.7**	**2.4**		**1.9**	**6.2**	**2.3**	**1.8**	**2.5**	
Jan-02	2.6	3.8		4.5	1.9		3.7	1.2	1.7	2.7	1.9	3.4			2.6	1.7	2			
Feb-02	5.1	1.8		2.2	3.3		2.7	5.8	1.7	2.9	4	6.8			4.2	7.4	2.3			
Mar-02	3.0	1.8		1.9	1.4		3.5	3	2.6	1.8	8	6.1			1.1	8.1	2.5			
Apr-02	2.2	1.3		2.5	1.4		1.7	2.1	1.6	2.3	9.5	5			1.6	1.4	1.1			
May-02	2.3	3		3.2	1.3		2.1	1.3	1.9	2.1	34.4	5.4			2.9	2.1	2.5			
Jun-02	1.4	2.2		3.4	1.5		1.1	1	2.2	2.5	5.2	3.4			2	1.3	2.4			
Jul-02	1.1	1.1		2.3	0.7		0.8	1.1	2.6	1.5	1.5	3.9			5.2	2.1	3.1			
Aug-02	1.9	2.9		4.8	3.1		1.5	1.1	4.6	7.4	5.4	4.3			3.9	3.7	3.3			
Sep-02	1.8	2.3		4	1.9		1.6	2.1	3.4	10.8	3.5	3.5			2.6	2.4	6.4			
Oct-02	2.7	5.7		3.1	4.6		2.3	1.5	3.2	2.2	1.3	4.1			2.7	2.5	3.2			
Nov-02	4.4	4.9		3.7	0.3		3.3	2.7	4.7	3.7	10.6	4.4			3.5	2.1	2.8			
Dec-02	5.4	4.5		5.6	2.6		3.7	5.3	3.3	4.4	4.5	12			3.5	3.8	4			
Average 2002	**2.8**	**2.9**		**3.4**	2		**2.3**	**2.4**	**2.8**	**3.7**	**7.5**	**5.2**			**3.0**	**3.2**	**3.0**			
Jan-03	3.6	2.5		3.8	5		3.2	2.3	3.2	1.9	5.9	4.4			3.1	1.4	5.3			
Feb-03	4.8	4.3		3.9	3.7		1.7	3.1	2.7	2.9	3.7	4			1.5	2.1	1.3			
Mar-03	4.2			4.3	5.6		2.1	3.1	3.4	2.4	4.1	5.5			3.3	2.1	4			
Apr-03	1.8			2.1	7.2		1.8	15.4	4.1	1.9	4.3	3.5			3.6	2.6	2			
May-03	2.6			3.7	2		1.7	2.5	2.2	2.6	4.5	3.1			3.2		1.7			
Jun-03	1.9			6.4	2.2		0.8	3.6	2.7	3	4.7	3.2				3.1	2.6			
Jul-03	1.3		1.9	3.8	0.8		1	0.8	1.7		4.4	2.2			1.6	1.5	1.4			
Aug-03	1.3		0.9	2.3			1.6	1.1	4	2.3		2.7			3	1.6	2.4			
Sep-03	1.4			7.7	14.4		2.4	0.7	6.6		1	2.7			3.5	1.9	2.3			
Oct-03	2.7		2.2	3.9	2.5		2.5		4.7	2.6	3.1	4.2			3		2.4			
Nov-03	3.9		1.2	6.7	5		3.3	2.7	3.8	4.4	4.7	5			3.4	3.7	3			
Dec-03	4.6		5.5	3.2	1.1		2.3	2.7	2.1	2.6		2.3			2.6	2.1	1.3			
Average 2003	**2.8**	**3.4**	**2.3**	**4.3**	**4.5**		**2.0**	**3.5**	**3.4**	**2.7**	**4.0**	**3.6**			**2.9**	**2.2**	**2.5**			
Jan-04	4		6.3	6.8	2.5		2.2	3.6	1.5	7	17.6	4.3			6.8	2.2	2.9			
Feb-04	3.1		6.5		1.5		3.1	2.6	2.8	4.2	14.9	4.4			3.7	2.9	1.9			
Mar-04	11		2.4				1.3	2.7	1.5	0.7	12.7	3.5			1.5	1.2	1.7			
Apr-04	7.7		2.9	4.9	3		3.8	1.7	3.3	2.6	4.3	3.1			3.5	1.7	5			
May-04	1.8		2.3	3.5	2.8		0.8	1.3	3.7	2.4	2.9	3.4			2.6	2.1	1.8			
Jun-04	1.6		2.9	6	5		0.3	0.7	4.7	1	2.8	2.1			4.5	1.4	1.8			
Jul-04	1.5		4.5	5.6	4.1		0.7	0.7	3.3	1.1	1.7	2.9			5.6	1.9	3.3			
Aug-04	1.1		6.3	4	6.5		0.9	1.5	4.3	1.6	3.3	2.5			2.8	1.4	1.9			
Sep-04	0.5		5.1	2.7	8.5		0.8	1.4	4.3	0.9	11.7	1.9			2.1	1.2	1.3			
Oct-04	2.1		3.6	2.3	2.6		1.6	1.2	2.8	1.2	5	4.3			2.4	1.2	2.1			
Nov-04	3.6		5.1	4.2			2.9	2.6	5.1	2.4	8.9	3.3			4.9	4.4	2.4			
Dec-04	2		5.6	2	5.1		1.5	1.1	4.2	1	7.8	4.1			6.1	1	1.2			
Average 2004	**3.3**		**4.5**	**4.2**	**4.2**		**1.7**	**1.8**	**3.5**	**2.2**	**7.8**	**3.3**			**3.9**	**1.9**	**2.3**			
Jan-05	1.6		9.8	1.5	2		2	11.7	3	1.5	4.3	3.4			2.3	1.8	1.1			
Feb-05	2.6		8.8	6.4	5.3		3.6	3.7	3.3	2	5.4	2.7			5.6	2.1	2.9			
Mar-05	3.1		5.5	3.2	4.7		2.4	1.7	2	1.8	3.8	2.5			2.3	2.9	1.3			
Apr-05	2.1		3.3	6	6.9		2.7	3	2.1	3.6	2.8	1			1.5	2.6	1.8			
May-05	2.5		5.8	4.7	2		1.6	2.9	5.1	1.6	2.1	2.8			1.2	1.9	1.4			
Jun-05	2.4		5.7	5.3	6.3		1.8	3.2	8	2.8	2.3	2.8			8.5	2.6	2.4			
Average to June	2.4		6.5	4.5	4.5		2.4	4.4	3.9	2.2	3.5	2.5			3.6	2.3	1.8			

Sample Date	Total Insoluble Matter g/m2/mth														
	D101	D102	D103	D104	D105	D107	D109	D110	D112	D113	D114	D115	D116	D117	DCL
May-98	2	2	2	2	2	2	2	2	2	2	2	2	2		
Jun-98	1.3	0.9	0.7	0.8	7.1	4.5	15	0.6	2.5	0.7	2.7	54.8	4		
Jul-98	0.6	0.3	0.3	0.5	1.4	4.2	2.6	0.4	1.8	0.6	3	2.7	4.2		
Aug-98	0.4	0.3	0.3	0.5	9	0.9	0.9	0.4	0.3	1.4	2.6	1.4	4.1		
Sep-98	1	1	0.8	1.3	3.7	1	2.3	0.8	0.9	6.5	6	2.9	4.3		
Oct-98	1	0.9	2	1.1	1.3	2.5	3.7	2.1	1.2	1.1	4.6	2.4	7.1		
Nov-98	2	0.7	0.7	0.7	1.2	11.5	3.4	0.6	1	2.7	2.1	1.9	3.6		
Dec-98	2.9	0.9	1.5	1.1	3.7	23.9	3.7	1.8	1.4	4.1	2.2	3.1	6.5		
Average 1998	**1.4**	**0.9**	**1.0**	**1.0**	**3.7**	**6.3**	**4.2**	**1.1**	**1.4**	**2.4**	**3.2**	**8.9**	**4.5**		
Jan-99	2.7	1.3	1.2	3.8	3	4.9	2.4	0.2	0.5	0.2	1.1	1	3.2		
Feb-99	1.8	0.5	1.7	2	18.6	1.7	3.6	1	0.4	1.6	1.5	4.8	4.7		
Mar-99	1.7	0.5	-	3.1	8.7	2.1	4.4	1.8	0.8	7.3	4.2	3.2	5.6		
Apr-99	0.9	0.6	0.8	2	3	1.4	2.4	1.4	1.2	2	2.7	4.6	4.4		
May-99	0.7	0.5	0.9	1.7	4.1	0.9		0.7	0.3	2.1	2.5	1.4	6.1		
Jun-99	0.6	0.3	0.2	0.7	2	5.1	11.1	0.7	0.5	1.5	3.6	1.1	7.1		
Jul-99	0.5	0.4	0.5	0.4	2.7	2.1	2.7	0.9	0.3	0.7	4	0.7	2.5		
Aug-99	0.9	0.5	0.5	0.9	2.9	4.3	3.2	0.9	0.4	1.3	5.6	1.1	4.2		
Sep-99	1.2	0.9	1.3	8.3	3.2	3.6	2.8	1.6	1.1	15.7	5.4	1.1	6.5		
Oct-99	2.6	2.2	2.3	1.9	1.3	19	2.6	3.3	1.3	5.1	3.1	2.2	3.9		
Nov-99	1.2	0.8	1.1	0.9	2	5.4	2	2.4	0.6	1.9	2.1	3.4	2.4		
Dec-99															
Average 1999	**1.3**	**0.8**	**1.1**	**2.3**	**4.7**	**4.6**	**3.7**	**1.4**	**0.7**	**3.6**	**3.3**	**2.2**	**4.6**		
Jan-00	2.9	1	5.4	1.4	1.4	4.7	2.2	5.1	0.9	1.6	9.3	3	3		
Feb-00	2.7	0.6	0.6	1.1	2.4	4.7	3.5	0.8	0.9	2.8	5.8	1.4	2.7		
Mar-00	2.7	2.4	1.2	14.1	3.7	4.2	0.7	9.3	2.3	8.1	11.7	18.6	10.7		
Apr-00	1.8	2.9	1.2	2.4	6	1.2	3.7	0.9	0.5	2.2	4.9	1.5	2.3		
May-00	0.5	0.8	0.6	0.6	2.2	1.6	13.8	0.4	0.8	2	2.9	1	2.7		
Jun-00	0.6	1	0.4	0.6	1.6	2.5	2.2	0.4	0.7	1.3	1.6	1	3.5		
Jul-00	0.6	0.6	0.5	0.5	1.2	3.1	1.7	0.2	0.3	1.5	1.7	6.5	3.8		
Aug-00	0.7	2.1	1	0.4	3.7	6.5	2.6	0.6	1	1.1	4.3	2.2	7.9		
Sep-00	0.9	0.9	1.4	2.1	0.8	2.7	3.2	0.7	0.8	1.5	3.1	2.5	3.3		
Oct-00	1.1	0.9	6	0.7	1.9	4.5	3	2.5	1.1	4.6	3	2.4	6.4		
Nov-00	0.9	0.8	0.7	1	2.6	1.4	6.4	2.3	1		4.9		4.2		
Dec-00	1.2	2.8	1.2	4.8	3.1	3.7	9.7	3.3	1.4		3.1		3.1		
Average 2000	**1.4**	**1.4**	**1.7**	**2.5**	**2.6**	**3.4**	**4.4**	**2.2**	**1.0**	**2.7**	**4.7**	**4.0**	**4.5**		
Jan-01	2.3	0.5	0.2	1.8	2.1	1.4	1.6	1.2	0.6		1.4		1.9		
Feb-01	0.5	0.3	0.5	1.1	2.3	2.4	1.1	0.8	2.5		2.6		3.7		
Mar-01	0.7	0.9	0.9	1.2	3.2	4.4	1.4	0.3	1.7		3.2		3.1		
Apr-01	1.7	0.5	0.9	0.7	4.2	11.7		1.5			3.2		3.6		6
May-01	0.6	0.2	0.5	0.4	2.4	5.7	**1.4**	0.6	0.2		2		1.8		3.1
Jun-01	0.7	1.3	0.4	0.3	2	10.5		0.5	0.5		2.6		4.6		3.1
Jul-01	0.5	0.7	0.5	0.4	1.8	1.7		0.3	0.3		2.8		3.7		3.2
Aug-01	0.8	1.1	0.5	0.6	2.5	3.7		0.8	0.6		2.4		2.8		4.8
Sep-01	3.9	0.6	0.6	0.5	2.8	2.5		2.1	1.1		3.2		5.7		1.7
Oct-01	1.2	0.9	1.1	1.9	1.3	2		1.1	1		3.9		4.9		3.1
Nov-01	1.4	1	0.8	0.7	2.8	2.6		1.3	1.3		2.6		4.1		8
Dec-01	2	1.1	1.6	3.3	5.2	6.3		2.3	1.9		3		2.3		6.1
Average 2001	**1.4**	**0.8**	**0.7**	**1.1**	**2.7**	**4.6**	**2.1**	**1.1**	**1.1**		**2.7**		**3.5**		**4.3**
Jan-02	1.2	0.9	0.4	3.9	2.5	7.6		2	2		3.3		4.9		8.9
Feb-02	3	1.6	1.8	3.7	7.8	2.2		1.7	1.9		3		6.2		8.5
Mar-02	1.2	0.8	1.4	2.6	9.9	1.8		1.3	0.8		3.5		6.5		1.2
Apr-02	0.7	0.6	1.2	0.5	1.6	1.5		1.4	1.5		1.6		3.6		3.6
May-02	1.4	0.9	1.4	0.8	2.5	8.2		1.2	0.6		3.3		2.9		2.9
Jun-02	0.7	1.1	0.7	0.4	2.1	11.6		0.8	0.6				3		3.7
Jul-02	1	0.6	0.8	0.9	1.2	7.4		0.4	0.4		2.4		5.3		1
Aug-02	1.4	1.1	1.2	1.2	5.2	9.5		1.2	3.9		2.5		4.2		4.6
Sep-02	1.5	1	1.6	1.9	3.2	8.4		1.4	1.6		2.5		9.7		2
Oct-02	1.3	1.6	2.3	2.5	1.8	11.6		2.9	1.1		2.5		3.3		4.1
Nov-02	3.3	2.4	2.6	3.5	4.2	13.2		4.3	4.1		6		7.6		12
Dec-02	0.7	0.9	1	1.1	1.6	38.1		3.5	2.5		3.7		6		2.5
Average 2002	**1.5**	**1.1**	**1.4**	**1.9**	**3.6**	**10.1**		**1.8**	**1.8**		**3.1**		**5.3**		**4.6**
Jan-03	4.1	1.6	2.2	2.9	3.7	3.8		2	2		2.4		4		3.6
Feb-03	1	0.8	1.1	1.4	2.6	2.4		2.9	1.9		2.4		5.6		4.5
Mar-03	2.8	1.1	3	3.7	3.8	2.4		2.2	1.8		4		5.5		1.7
Apr-03	2.7	0.7	1.1	2.6	2.8	3		1	0.8		2.9		3.3		8.7
May-03	1	0.4	2.1	0.8	2.6			1.4	0.6		4		3.7		6.7
Jun-03	0.8	2.7	3.8	0.9	3.3	6.3		1.1	1		4		3.9		
Jul-03	0.5	1	3.6	0.4	0.8	7.2		0.6	0.6				2.4		2.8
Aug-03	1.4	1.2	4.3	1.5	2			1.7	1.3		3.7		3.6		1.9
Sep-03	0.6	0.4	1.7	0.8	2.1			1	0.3		9.5		3	0.4	1.2
Oct-03	1.5	1	1.9	2.2	2.2	5.2		3	1.8		3.8		4.4	1.5	2.1
Nov-03	1.3	1.1	3.1	1.8	2.8			3.4	1.8		3.5		6	2.9	3.5
Dec-03	1.8	5.7	6.8	3.5	2.1	1.3		2.3	1.4		5.3			3.2	4.7
Average 2003	**1.6**	**1.5**	**2.9**	**1.9**	**2.6**	**4.0**		**1.9**	**1.3**		**4.1**		**4.1**	**2.0**	**3.8**
Jan-04	4.9	4.1	2.1	2.8	3.2	2.9		2.3	1.7		2.8		3.5	1.8	3.2
Feb-04	0.7	2.2	1.3	3.7	1.9	1.6		1.6	2.2				4.7	1.5	11
Mar-04	1.8	1	1.1	1.5		3.5		1.6	0.8		8.1		3.5	1.6	3.3
Apr-04	1	0.8	4.1	1.6	2.1	7.2		1.8	0.9		4.5		3.1	1.8	3.9
May-04	0.7	1.6	2.9	1.1	2.4	13.4		1.6	1.8		2.6		4.5	1.1	7.8
Jun-04	0.3	0.3	1.5	0.6	1.3	8.8		1.5	0.3		1.8		2	0.3	6.1
Jul-04	0.4	2.7	2.1	0.4	1	8.5		0.4	0.2		3		10	0.6	1.9
Aug-04	0.9	1	3.8	2.6	1.6	6.4		1.1	0.6		2.9		2.6	1.4	1.8
Sep-04	0.7	0.9	1.9	1.2	3.2	10.2		3	0.6		2.7		1.8	1.6	1.1
Oct-04	0.8	1.1	2.4	0.9	2.6	6.2		1.7	1		1.5		3.1	0.9	1.6
Nov-04	1.6	2.2	7.7	9.4	3.1	21.2		2.1	1.4		3.5		4.8	2.1	2.1
Dec-04	1	2.2	2.1	3.4	1.1	3.4		1.5	1.3		6.2		1.8	1.3	1.7
Average 2004	**1.2**	**1.7**	**2.8**	**2.4**	**2.1**	**7.8**		**1.7**	**1.1**		**3.6**		**3.8**	**1.3**	**3.8**
Jan-05	3.3	1.4	2.4	2.2	1.6	4.1		2.1	0.6		5.3		2.8	2.6	2.5
Feb-05	5.2	2.5	2.3	3.3	1.9	3.2		3	2.2					1.8	4.4
Mar-05	2.0	1.3	2.8	2.7	2.4	2.2		4.5	0.9		1.9		3.4	1.9	3
Apr-05	1.1	1.3	5.4	2	5.8	3.9		1.4	1.4		2		4.6	2.3	3.3
May-05	1.0	1.6	2.3	2.6	3	6.5		1.1	1		2.2		2.4	3.1	3.7
Jun-05	1.1	0.8	1.9	1.3	1.8	11.6		1.1	0.6		3.1		3	1.2	2.9

	Total Insoluble Matter g/m2/mth														
	DCL	DL1	DL2	DL4	DL10	DL14	DL17	DL21	DL22	DL23	DL30	DL43	DL44	DL45	Knoddlers Lane
May-98															
Jun-98															
Jul-98															
Aug-98															
Sep-98															
Oct-98															
Nov-98															
Dec-98															
Average 1998															
Jan-99															
Feb-99															
Mar-99															
Apr-99															
May-99															
Jun-99															
Jul-99															
Aug-99															
Sep-99															
Oct-99															
Nov-99															
Dec-99															
Average 1999															
Jan-00															
Feb-00															
Mar-00															
Apr-00															
May-00															
Jun-00															
Jul-00															
Aug-00															
Sep-00															
Oct-00															
Nov-00															
Dec-00															
Average 2000															
Jan-01															
Feb-01															
Mar-01															
Apr-01	6														
May-01	3.1														
Jun-01	3.1														
Jul-01	3.2														
Aug-01	4.8														
Sep-01	1.7														
Oct-01	3.1														
Nov-01	8														
Dec-01	6.1														
Average 2001	**4.3**														
Jan-02	8.9														
Feb-02	8.5														
Mar-02	1.2														
Apr-02	3.6														
May-02	2.9														
Jun-02	3.7														
Jul-02	1														
Aug-02	4.6														
Sep-02	2														
Oct-02	4.1														
Nov-02	12														
Dec-02	2.5														
Average 2002	**4.6**														
Jan-03	3.6	2	1.8		3.8	1.8				1.9		2.4	2		1.5
Feb-03	4.5	3.3	1.8		2.4	2.1				2.1	3.1	4.1	4.8	2.2	2.2
Mar-03	1.7	2.5	2.1		3.1	2.2	2.6	2.2	2.6	2.7	2.9	3	2.7	1	1.9
Apr-03	8.7	2.2		3.8	2.8	2.2	2		4.4	2.1	3.8	2.4	5	2.9	2.3
May-03	6.7	2.2	1.1	1.5		1.9	1.1	1.1	2	2.4	0.9	1.5	2.7	1.3	0.6
Jun-03		1.1	2.5	0.6	1.1	1.9	1.9	0.7	0.7	1.6	2.8	1	2.3	0.9	1.1
Jul-03	2.8	0.8	1	1.2	0.9	0.5	2.9	1.9	1.3	3.3	1.5	0.9	2.2	0.9	1.2
Aug-03	1.9	2	1.1	3.6	1.2	1.4	2.3	1.8	1.4	1.5	1.9	2.4	4.1	1.8	1.5
Sep-03	1.2		0.6	5.7	1.1	0.8	1.1	0.9	0.7	1.1	3.7	0.9	1.9	0.8	0.7
Oct-03	2.1	1.1	0.6	0.7	1.1	2	2.7	1	2.6	1.5	1.9	2.2	3.2	0.9	1.2
Nov-03	3.5	1.6	2.1	1.6	1.7	1.6	1	4	0.9	1.8	2.1	1.6	1.7	1.8	1.9
Dec-03	4.7	1.6	1.4	1.4	2.1	0.9	11.1	1.5	0.6	1.5	5	1.7	2.7	2.1	0.9
Average 2003	**3.8**	**1.9**	**1.5**	**2.2**	**1.9**	**1.6**	**2.9**	**1.7**	**1.7**	**2.0**	**2.7**	**2.0**	**2.9**	**1.5**	**1.4**
Jan-04	3.2	2.2	0.7	3.5	4.1	1.2	1.8	3.8	3.2	3		1.8	1.6	7.1	1.1
Feb-04	11	2.1	3.5	1.9	2.1	3.8	4.1	1.8	2	1.7	23.7	3.4	2.9	1.6	1.8
Mar-04	3.3	0.9	2.9	1	1.6	2.6	2	1	0.6	1	2.5	1.8	1.9	0.8	0.8
Apr-04	3.9	1.6	1.1	1.1	1.4	1.4	1.8	9.7	1.3	1.7	3.5	2.2	0.9	3.5	0.9
May-04	7.8	2	1.1	1.2	1.3	1.2	3.2	1.3	1.2	2.1	2.5	2.1	1.8	1.7	1
Jun-04	6.1	12	1	5	1.1	1.1	2.7	2.1	1	1.1	3.5	1.4	1.1	1.2	1.4
Jul-04	1.9	1.7	1.3	4.1	1	1.4	4.1	1	0.9	1.4	2.8	1.6	1.5	1.5	1.7
Aug-04	1.8	1.6	0.9	2.3	2.1	1.3	2.7	1.1	1.2	1.7	0.8	1.9	2.2	1.9	0.9
Sep-04	1.1	1.2	0.8	1.6	1	1.4	2.6	1	1.1	1.2	11.5	1.5	2	1.1	1.1
Oct-04	1.6	1.8	1	1	1.5	0.9	1.3	1	2.8	1.5	7.1	1.5	1.4	0.6	0.8
Nov-04	2.1	4.2	2.2	2.6	1.8	2.5	2.7	3.4	1.6	2.3	9.7	3.8	2.4	1.2	1.3
Dec-04	1.7	10	1.4	2.8	1.9	1.7	2.4	1	2.1	1.1	3.5	3.2	5.3	2.1	1.3
Average 2004	**3.8**	**3.4**	**1.5**	**2.3**	**1.7**	**1.7**	**2.6**	**2.4**	**1.6**	**1.7**	**6.5**	**2.2**	**2.1**	**2.0**	**1.2**
Jan-05		4.5	1.7		1.7	1.8	2.9	3	1.6	2.7	6.2	4.1	3.5	2.6	1.1
Feb-05		2.3	1.9	2.6	2.4	3.2	3	2	2.8	1.7	4.2	2.8	3.4	3.2	3.7
Mar-05		4.2	4	2.5	2.7	2.2	4.3	1.8	1.7	2	4.5	2.9	3.3	2.8	1.8
Apr-05		2.9	3.3	6.4	1.8	2	1.8	0.7	1.8	1.4	0.8	1.6	2.2	1.8	1.1
May-05		1.1	1.8	4.4	2	0.8	3.1	0.9	1.8	9.1	5.9	0.8	1.8	0.8	1.4
Jun-05		1.8	1.6	1.2	0.7	0.8	1.4	0.7	1.6	1.8	2.1	1.5	1.4	1	0.6

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Appendix C - Joint Wind Speed Wind Direction and Stability Class Tables for West Pit 2002

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STATISTICS FOR FILE: C:\WestPit\Met\2002 on-site met.isc
MONTHS: All
HOURS : All
OPTION: Frequency

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.005495	0.002060	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.007784
NE	0.004464	0.002060	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.006754
ENE	0.006868	0.001717	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.008700
E	0.008356	0.006639	0.001374	0.000000	0.000000	0.000000	0.000000	0.000000	0.016369
ESE	0.016712	0.031136	0.019689	0.010875	0.002976	0.000801	0.000000	0.000000	0.082189
SE	0.025984	0.065362	0.056548	0.031822	0.005838	0.000458	0.000000	0.000000	0.186012
SSE	0.026442	0.066850	0.036401	0.006181	0.000229	0.000000	0.000000	0.000000	0.136103
S	0.010875	0.013965	0.005266	0.000572	0.000114	0.000000	0.000000	0.000000	0.030792
SSW	0.005037	0.002175	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.008127
SW	0.004464	0.002633	0.000229	0.000229	0.000000	0.000000	0.000000	0.000000	0.007555
WSW	0.005151	0.002404	0.001030	0.000114	0.000000	0.000000	0.000000	0.000000	0.008700
W	0.013965	0.015911	0.006983	0.004350	0.002175	0.001145	0.000458	0.000000	0.044986
WNW	0.024954	0.050595	0.067651	0.030792	0.018887	0.008585	0.003549	0.001259	0.206273
NW	0.016026	0.030678	0.044872	0.028846	0.015682	0.007555	0.001946	0.000687	0.146291
NNW	0.008013	0.006868	0.005952	0.005151	0.003205	0.001145	0.000343	0.000000	0.030678
N	0.006754	0.003777	0.001832	0.000458	0.000000	0.000000	0.000000	0.000000	0.012821
CALM									0.059867
TOTAL	0.189560	0.304831	0.249199	0.119505	0.049107	0.019689	0.006296	0.001946	1.000000

MEAN WIND SPEED (m/s) = 3.01
NUMBER OF OBSERVATIONS = 8736

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 12.6%
B : 8.1%
C : 12.7%
D : 40.9%
E : 13.3%
F : 12.3%

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001717	0.001488	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
NE	0.001946	0.000916	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002976
ENE	0.001946	0.001030	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002976
E	0.003549	0.004121	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.008127
ESE	0.003777	0.014538	0.003777	0.000229	0.000000	0.000000	0.000000	0.000000	0.022321
SE	0.003549	0.013164	0.004579	0.000343	0.000000	0.000000	0.000000	0.000000	0.021635
SSE	0.002976	0.004693	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.008356
S	0.001832	0.001374	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.003663
SSW	0.001259	0.000458	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.001946
SW	0.001030	0.000572	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.001717
WSW	0.001488	0.000572	0.000343	0.000114	0.000000	0.000000	0.000000	0.000000	0.002518
W	0.002175	0.002175	0.000229	0.000343	0.000000	0.000000	0.000000	0.000000	0.004922
WNW	0.002289	0.006639	0.002060	0.001145	0.000000	0.000000	0.000000	0.000000	0.012134
NW	0.004464	0.007212	0.002976	0.001030	0.000000	0.000000	0.000000	0.000000	0.015682
NNW	0.001832	0.002747	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.005266
N	0.002289	0.001488	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.004006
CALM									0.005037
TOTAL	0.038118	0.063187	0.016827	0.003320	0.000000	0.000000	0.000000	0.000000	0.126488

MEAN WIND SPEED (m/s) = 2.03
NUMBER OF OBSERVATIONS = 1105

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000114	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
NE	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
ENE	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
E	0.000229	0.000572	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
ESE	0.001030	0.004693	0.006525	0.001603	0.000000	0.000000	0.000000	0.000000	0.013851
SE	0.000687	0.010760	0.011561	0.003434	0.000000	0.000000	0.000000	0.000000	0.026442
SSE	0.000458	0.001946	0.002289	0.000114	0.000000	0.000000	0.000000	0.000000	0.004808
S	0.000343	0.000343	0.001145	0.000000	0.000000	0.000000	0.000000	0.000000	0.001832
SSW	0.000000	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
SW	0.000114	0.000229	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000458
WSW	0.000000	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
W	0.000343	0.000916	0.000458	0.000572	0.000000	0.000000	0.000000	0.000000	0.002289
WNW	0.001030	0.005037	0.003663	0.003892	0.000000	0.000000	0.000000	0.000000	0.013622
NW	0.000801	0.004350	0.003549	0.002976	0.000000	0.000000	0.000000	0.000000	0.011676
NNW	0.000229	0.000572	0.000916	0.001030	0.000000	0.000000	0.000000	0.000000	0.002747
N	0.000000	0.000343	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000687
CALM									0.000916
TOTAL	0.005609	0.029876	0.031250	0.013736	0.000000	0.000000	0.000000	0.000000	0.081387

MEAN WIND SPEED (m/s) = 3.25
NUMBER OF OBSERVATIONS = 711

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
NE	0.000114	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
ENE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
E	0.000114	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
ESE	0.000801	0.000916	0.002404	0.005609	0.000000	0.000000	0.000000	0.000000	0.009730
SE	0.001030	0.006983	0.010989	0.012706	0.000000	0.000000	0.000000	0.000000	0.031708
SSE	0.000229	0.005609	0.011447	0.003434	0.000000	0.000000	0.000000	0.000000	0.020719
S	0.000114	0.001717	0.001603	0.000114	0.000000	0.000000	0.000000	0.000000	0.003549
SSW	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000343
SW	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000114
WSW	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000229
W	0.000114	0.001259	0.000687	0.000229	0.000000	0.000000	0.000000	0.000000	0.002289
WNW	0.001603	0.007212	0.014194	0.011561	0.000000	0.000000	0.000000	0.000000	0.034570
NW	0.000916	0.004464	0.005952	0.007555	0.000000	0.000000	0.000000	0.000000	0.018887
NNW	0.000114	0.000458	0.000572	0.000572	0.000000	0.000000	0.000000	0.000000	0.001717
N	0.000114	0.000229	0.000687	0.000343	0.000000	0.000000	0.000000	0.000000	0.001374
CALM									0.001259
TOTAL	0.005838	0.029533	0.048649	0.042125	0.000000	0.000000	0.000000	0.000000	0.127404

MEAN WIND SPEED (m/s) = 3.76
NUMBER OF OBSERVATIONS = 1113

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000801
NE	0.000114	0.000229	0.000000	0.000114	0.000000	0.000000	0.000000	0.000000	0.000458
ENE	0.000801	0.000229	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001145
E	0.000343	0.000114	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000687
ESE	0.001488	0.003091	0.006754	0.003434	0.002976	0.000801	0.000000	0.000000	0.018544
SE	0.004808	0.019231	0.029418	0.015339	0.005838	0.000458	0.000000	0.000000	0.075092
SSE	0.006754	0.029533	0.021864	0.002633	0.000229	0.000000	0.000000	0.000000	0.061012
S	0.001259	0.002747	0.001832	0.000458	0.000114	0.000000	0.000000	0.000000	0.006410
SSW	0.000572	0.000572	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
SW	0.000343	0.000343	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.000916
WSW	0.000343	0.000458	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
W	0.001488	0.003892	0.005266	0.003205	0.002175	0.001145	0.000458	0.000000	0.017628
WNW	0.006410	0.017056	0.041667	0.013507	0.018887	0.008585	0.003549	0.001259	0.110920
NW	0.002404	0.008929	0.028846	0.017285	0.015682	0.007555	0.001946	0.000687	0.083333
NNW	0.001717	0.001832	0.003777	0.003549	0.003205	0.001145	0.000343	0.000000	0.015568
N	0.001259	0.000916	0.000572	0.000114	0.000000	0.000000	0.000000	0.000000	0.002862
CALM									0.010188
TOTAL	0.030907	0.089171	0.141598	0.059638	0.049107	0.019689	0.006296	0.001946	0.408539

MEAN WIND SPEED (m/s) = 4.06
NUMBER OF OBSERVATIONS = 3569

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000801	0.000114	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001030
NE	0.000343	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000458
ENE	0.001145	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
E	0.001259	0.001145	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.002518
ESE	0.003777	0.006181	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.010188
SE	0.008242	0.012821	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.021062
SSE	0.009272	0.021864	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.031250
S	0.002633	0.005495	0.000229	0.000000	0.000000	0.000000	0.000000	0.000000	0.008356
SSW	0.001145	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
SW	0.000687	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001259
WSW	0.000801	0.000458	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.001374
W	0.002976	0.003320	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.006639
WNW	0.006868	0.009615	0.006067	0.000687	0.000000	0.000000	0.000000	0.000000	0.023237
NW	0.002175	0.003091	0.003549	0.000000	0.000000	0.000000	0.000000	0.000000	0.008814
NNW	0.001259	0.000458	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001717
N	0.001030	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001145
CALM									0.010760
TOTAL	0.044414	0.066049	0.010875	0.000687	0.000000	0.000000	0.000000	0.000000	0.132784

MEAN WIND SPEED (m/s) = 1.71
NUMBER OF OBSERVATIONS = 1160

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002060	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002404
NE	0.001832	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002175
ENE	0.002862	0.000343	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
E	0.002862	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003434
ESE	0.005838	0.001717	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007555
SE	0.007669	0.002404	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010073
SSE	0.006754	0.003205	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009959
S	0.004693	0.002289	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006983
SSW	0.001717	0.000572	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002289
SW	0.002175	0.000916	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003091
WSW	0.002404	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003205
W	0.006868	0.004350	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011218
WNW	0.006754	0.005037	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.011790
NW	0.005266	0.002633	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007898
NNW	0.002862	0.000801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003663
N	0.002060	0.000687	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002747
CALM									0.031708
TOTAL	0.064675	0.027015	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.123397

MEAN WIND SPEED (m/s) = 1.05
NUMBER OF OBSERVATIONS = 1078

Appendix D - Details Of Methodology Used to Estimate Dust Emissions

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CARRINGTON OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN 2006

Introduction

This appendix provides information on the way in which estimates of TSP emissions for 2006 have been made.

Calculations are presented to an apparent accuracy of ±1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in Hunter Valley Operations North (see below) it is stated that the activity will produce 108,623 kg/y of TSP [55,940,548 t/y x 0.00194kg/t]. Checking this formula using the printed figures gives an estimate of 108,524.7 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 108,623.1 kg/y, which then is written as 108,623 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ±40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

Coal & Allied (CNA) operations north of the Hunter River include Carrington Pit, West Pit, the Alluvial Lands, rehabilitated North Pit and the associated coal preparation plants (CPPs) at Hunter Valley (HVCPP) and West Pit (WPCPP) and rail loading facilities at the Hunter Valley Loading Point (HVLP), Newdell Loading Point (NLP) and the Ravensworth Coal Terminal (RCT).

This inventory takes into account the impacts of mining at Carrington in the year 2006, together with the mining activities in the rest of Hunter Valley Operations North (HVO north) in 2006 (that is the operations at West Pit, the Alluvial Lands and rehabilitated North Pit).

In addition, the cumulative impact of operations at other nearby mines, namely Ravensworth-Narama, Wambo, United Colliery, Cumnock No. 1 Colliery and HVO south of the Hunter River (Cheshunt and Riverview), are also included.

The emissions from Carrington and the rest of the HVO north operations are described in detail below.

Emissions from Ravensworth-Narama, Cheshunt and Riverview have been calculated based on the annual ROM coal output of each mine and an emission rate of 0.52 kg/ton ROM coal. In 2006 Ravensworth-Narama is expected to have a ROM coal output of 3,900,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 2,028,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are initial calculations for a 2003 EIS for Wambo, with emissions being 1,026,264 t/y and 3,969,329 t/y respectively. It is uncertain what activities will be occurring at Cumnock Colliery during the life of the Carrington project. According to an air quality study prepared in 1996 (**Holmes Air Sciences, 1996**), the open cut mining should have been completed by 2004. However, a subsequent assessment completed in 2001 (**Holmes Air Sciences, 2001)** noted that the open cut mining had been suspended for a period of time. In order to present a worst-case assessment, the maximum emissions expected at Cumnock have been assumed to occur during the period covered by this assessment. For 2004, the emissions from Cumnock were calculated to be 2,406,642 kg/y (**Holmes Air Sciences, 1996**)

OPERATIONS AT HVO NORTH (EXCLUDING CARRINGTON)

This section presents a detailed assessment of the activities that will occur at West Pit, the Alluvial Lands and rehabilitated North Pit in the year 2006. It also includes details on the movement of coal from south of the river to the HVO north site.

From data provided by CNA, in 2006, mining taking place in West Pit will produce approximately 6,382,647 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling process that is likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil
Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 h/y then the annual TSP emission rate will be 17,920 kg/y [1,280 h/y x 14.0 kg/h].

Drilling overburden
Based on data provided by CNA, it is estimated in 2006 that 50,090 holes will be required for overburden blasting in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP (**US EPA, 1985 and updates**), and so the total TSP emission from drilling holes for blasting overburden is estimated to be 29,553 kg/y [50,090 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the **US EPA (1985 and updates)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

$E_{TSP} = TSP\ \ emission\ \ factor$

$A = area\ to\ be\ blasted\ \ in\ m^2$

The area of a typical blast has been estimated to be 22,000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in 2006 there will be 133 shots, the emissions from West Pit will be 95,588 kg/y.

Loading overburden to trucks
Based on information provided by CNA, in 2006 approximately 23,308,561 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 55,940,548 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

$E_{TSP} = TSP\ \ emissions$

$k = 0.74$

$U = wind\ speed\ (m/s)$

$M = moisture\ \ content(\%)$

$[where\ 0.25 \le M \le 4.8]$

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP\ \ emissions$

$U = the\ wind\ \ speed\ \ in\ \ m/s.$

The annual average emission factor for loading overburden to trucks will therefore be 0.00194kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 108,623 kg/y [55,940,548 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in 2006 approximately 23,308,561 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 3 km the total TSP emissions for 2006 for West Pit will be 699,257 kg/y [23,308,561 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

In addition to this, approximately 833,333 bcm of overburden will be hauled from south of the River to the Alluvial Lands and the same amount will be hauled from North Pit to the Alluvial Lands . This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 3 km the total TSP emissions for 2006 will be:

- South of the River to Alluvial Lands - 25,000 kg/y [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

- North Pit to the Alluvial Lands - 25,000 [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in 2006 approximately 55,940,548 t of overburden will be dumped in the West Pit waste emplacement areas. Each tonne of material unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3**.

The annual average emission factor will therefore be 0.00194 kg/t. Thus the annual TSP emissions for 2006 for West Pit will be 108,623 kg/y [55,940,548 t/y x 0.00194 kg/t].

In addition, approximately 4,000,000 t of overburden will be dumped in the Alluvial Lands . The total TSP emissions for 2006 will be 7,767 kg/y [4,000,000 t/y x 0.00194kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

$E_{TSP} = TSP\ emissions$

$s = silt\ content(\%),\ and$

$M = moisture\ content(\%)$

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in 2006 dozers would spend 16,316 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 273,058 kg/y [16,316 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,

$E_{TSP} = TSP\ emissions$

$d = drop\ distance(m),\ and$

$M = moisture\ content(\%)$

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in 2006 18,465,907 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 868,599 kg/y [18,465,907 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in 2006, that 5,873 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 3,465 kg/y [5,873 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22,000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in 2006 there will be 25 shots, the emissions from West Pit will be 18,111 kg/y [718 kg/blast x 25 blasts/y].

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,

$s = silt\ content(\%),\ and$

$M = moisture\ content(\%)$

Taking M to be 6% and s to be 5%, the emission factor is estimated to be approximately 20.0 kg/h.

In 2006, it is estimated that dozers will work on coal for 16,316 hours. The total TSP emission from dozers working on coal is therefore 326,154 kg/y [16,316 h/y x 20.0 kg/h].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,

$E_{TSP} = TSP\ emissions$

$M = moisture\ content(\%)$

Taking M to be 6%, the emission factor is estimated to be 0.06755 kg/t. In 2006 approximately 6,382,647 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 431,169 kg/y [6,382,647 t/y x 0.06755kg kg/t].

Hauling coal to HVCPP and WPCPP
In 2006, based on information provided by CNA, 5,382,647 t of coal will be hauled from West Pit to the HVCPP and 3,500,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for 2006 are:

- West Pit to HVCPP – 179,422 kg/y [5,382,647 t/y / 240 t/trip x 8 km/trip x 1.0kg/VKT]
- West Pit to WPCPP – 116,667 kg/y [3,500,000 t/y / 240 t/trip x 8 km/trip x 1.0kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0kg/VKT].

OPERATIONS AT CARRINGTON
From data provided by CNA, in 2006, mining taking place in Carrington will produce a maximum 10,000,000 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

As with the operations at West Pit, open cut ROM coal will be hauled directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN
Dozers working on overburden
Dozers will work on the overburden for a total of 22,696 h/y. This includes the removal of vegetation and stripping of overburden. Dust is generated from dozers according to **Equation 4** (see above).

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. The total TSP emission from the dozers working on overburden is therefore 379,818 kg/y [22,696 h/y x 16.7 kg/h].

Drilling overburden
Based on data provided by CNA, it is estimated in 2006 that 35,627 holes will be required for overburden blasting in Carrington. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 21,020 kg/y [35,627 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the equation given in **Equation** 2 (see above).

The area of a typical blast has been estimated to be 22,615 m^2. The estimated emissions per blast will be 748 kg/blast. Assuming that in 2006 there will be 121 shots, the emissions from Carrington will be 90,532 kg/y [748 kg/blast x 121 blasts/y].

Loading overburden to trucks
Based on information provided by CNA, in 2006 approximately 39,902,736 bank cubic metres (bcm) will be handled by the truck and shovel in Carrington. Assuming a density of 2.4 t/bcm it is estimated that 95,766,566 t will be loaded to trucks in Carrington.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3** (see above).

Therefore the annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 185,956 kg/y [95,766,566 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in 2006 approximately 39,902,736 bcm of overburden will be hauled from Carrington to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 5 km the total TSP emissions for 2006 for Carrington will be 1,995,137 kg/y [39,902,736 bcm/y / 100 bcm/trip x 5 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in 2006 approximately 95,766,566 t of overburden will be

dumped in the Carrington waste emplacement areas. Each tonne of material unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3** (see above).

The annual average emission factor will therefore be 0.00194 kg/t. Thus the annual TSP emissions for 2006 for Carrington will be 185,956 kg/y [95,766,566 t/y x 0.00194 kg/t].

Rehandle of overburden
From information provided by CNA, it is estimated that 1,050,861 t of overburden will need to be re-handled. Assuming the same emission factor as above, namely 0.00194 kg/t, the total TSP emission from this operation will be 2,041 kg/y [1,050,861 t/y x 0.00194 kg/t]

OPERATIONS ON COAL

Dozers working on coal
Dozers will be used to rip the coal at Carrington. This will generate dust emissions according to **Equation 6** (see above).

Taking M to be 7.5% and s to be 5%, the emission factor is estimated to be approximately 14.6 kg/h.

In 2006, it is estimated that dozers will work on coal for 5,531 hours. The total TSP emission from dozers working on coal is therefore 80,900 kg/y [5,531 h/y x 14.6 kg/h].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7** (see above):

Taking M to be 7.5%, the emission factor is estimated to be 0.05168 kg/t. In 2006 approximately 9,913,576 t of ROM will be recovered from Carrington. Therefore the TSP emission from loading coal to trucks is 512,371 kg/y [9,913,576 t/y x 0.05168 kg/t].

Hauling coal to HVCPP and WPCPP
In 2006, based on information provided by CNA, 9,713,576 t of coal will be hauled from Carrington to the HVCPP and 200,000 t will be hauled from Carrington to the WPCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from Carrington to the HVCPP and 20 km (return) from Carrington to the WPCPP, the total estimated TSP emissions for 2006 are:

- Carrington to HVCPP– 323,786 kg/y [9,713,576 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- Carrington to WPCPP – 16,667 kg/y [200,000 t/y / 240 t/trip x 20 km/trip x 1.0 kg/VKT]

PROCESSING OPERATIONS

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in 2006 it is estimated that 3,500,000 t of coal will be unloaded at the WPCPP and 31,382,647 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughput.

Assuming an emission factor of 0.01kg/t, the total estimated TSP emissions are:

- WPCPP– 35,000 kg/y [3,500,000 t/y x 0.01kg/t]
- HVCPP– 313,826 kg/y [31,382,647 t/y x 0.01kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 538,265 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01kg/t, the total TSP emission from this operation will be:

- WPCPP – 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP – 5,383 kg/y [538,265 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,486,399 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for 2006 are:

- WPCPP to NLP – 59,674 kg/y [2,486,399 t/y / 100 t/trip x 12 km/trip x 0.2kg/VKT]
- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 25,200 kg/y [900,000 t/y / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003d**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,486,399 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 44,864 kg/y [4,486,399 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 3** (see above) with moisture assumed to be 7.5%. The emission factor is 0.00031kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,486,399 t at the NLP. The annual TSP emissions are therefore:

- HVLP – 4,272 kg/y [14,000,000 t/y x 0.00031kg/t]
- NLP – 1,369 kg/y [4,486,399 t/y x 0.00031kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 3**. The estimated annual TSP emission is therefore:

- WPCPP – 26,703 kg/y [17,500,000 t/y x 0.00153 kg/t]
- HVCPP – 239,432 kg/y [156,913,237 t/y x 0.00153 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/VKT$$

where,
$E_{TSP} = TSP$ *emissions*
$S =$ *speed of the grader in km/h*

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **SPCC (1983)** emission factor for wind erosion is 0.4 kg/ha/h. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

- West Pit pit area – 1,752,000 kg/y [500 ha x 0.4 kg/ha/h x 8,760 h/y]
- Alluvial Lands area – 175,200 kg/y [50 ha x 0.4 kg/ha/h x 8,760 h/y]
- West Pit overburden area – 1,752,000 kg/y [500 ha x 0.4 kg/ha/h x 8,760 h/y]
- Alluvial Lands overburden area – 175,200 kg/y [50 ha x 0.4 kg/ha/h x 8,760 h/y]
- Carrington pit area – 211,992 kg/y [61 ha x 0.4 kg/ha/h x 8,760 h/y]
- Carrington overburden area – 204,702 kg/y [58 ha x 0.4 kg/ha/h x 8,760 h/y]

CARRINGTON OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN 2011

Introduction

This appendix provides information on the way in which estimates of TSP emissions for 2011 have been made.

Calculations are presented to an apparent accuracy of ±1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in Hunter Valley Operations North (see below) it is stated that the activity will produce 110,318 kg/y of TSP [56,813,541 t/y x 0.00194kg/t]. Checking this formula using the printed figures gives an estimate of 110,218.3 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 110,318.26 kg/y, which then is written as 110,318 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ±40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

Coal & Allied (CNA) operations north of the Hunter River include Carrington, West Pit, the Alluvial Lands, North Pit and the associated coal preparation plants (CPPs) at Hunter Valley (HVCPP) and West Pit (WPCPP) and rail loading facilities at the Hunter Valley Loading Point (HVLP), Newdell Loading Point (NLP) and the Ravensworth Coal Terminal (RCT).

This inventory takes into account the impacts of mining at Carrington in the year 2011, together with the mining activities in the rest of Hunter Valley Operatio North (HVO North) in 2011 (that is the operations at West Pit, the Alluvial Lands and North Pit).

In addition, the cumulative impact of operations at other nearby mines, namely Ravensworth-Narama, Wambo, United Colliery, Cumnock No. 1 Colliery and HVO south of the Hunter River (Cheshunt and Riverview), are also included.

The emissions from Carrington and the rest of the HVO North operations are described in detail below.

Emissions from Ravensworth-Narama, Cheshunt and Riverview have been calculated based on the annual ROM coal output of each mine and an emission rate of 0.52 kg/ton ROM coal. In 2011 Ravensworth-Narama is expected to have a ROM coal output of 2,400,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 1,248,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are based on a recent EIS (**Holmes Air Sciences, 2003**) with emissions being 1,026,264 t/y and 5,122,771 t/y respectively. It is uncertain what activities will be occurring at Cumnock Colliery during the life of the Carrington project. According to an air quality study prepared in 1996 (**Holmes Air Sciences, 1996**), the open cut mining should have been completed by 2004. However, a subsequent assessment completed in 2001 (**Holmes Air Sciences, 2001)** noted that the open cut mining had been suspended for a period of time. In order to present a worst-case assessment, the maximum emissions expected at Cumnock have been assumed to occur during the period covered by this assessment. For 2004, the emissions from Cumnock were calculated to be 2,406,642 kg/y (**Holmes Air Sciences, 1996**)

OPERATIONS AT HVO NORTH (EXCLUDING CARRINGTON)

This section presents a detailed assessment of the activities that will occur at West Pit, the Alluvial Lands and North Pit in the year 2011. It also includes details on the movement of coal from south of the river to the HVO North site.

From data provided by CNA, in 2011, mining taking place in West Pit will produce approximately 6,491,605 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling process that is likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil
Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 hr/y then the annual TSP emission rate will be 17,920 kg/y [1,280 hr/y x 14.0 kg/h].

Drilling overburden
Based on data provided by CNA, it is estimated in 2011 that 31,091 holes will be required for overburden blasting in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 18,344 kg/y [31,091 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting CNA be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad \text{kg/blast}$$

where :

$E_{TSP} = TSP\ \ emission\ \ factor$

$A = area\ to\ be\ blasted\ \ in\ m^2$

The area of a typical blast has been estimated to be 22,000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in 2011 there will be 135 shots, the emissions from West Pit will be 96,994 kg/y.

Loading overburden to trucks
Based on information provided by CNA, in 2011 approximately 23,672,309 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 56,813,541 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad \text{kg/t}$$

where,

$E_{TSP} = TSP\ \ emissions$

$k = 0.74$

$U = wind\ speed\ (m/s)$

$M = moisture\ \ content (\%)$

$[where\ 0.25 \le M \le 4.8]$

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP\ \ emissions$

$U = the\ wind\ \ speed\ \ in\ \ m/s.$

The annual average emission factor for loading overburden to trucks will therefore be 0.00194kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 110,318 kg/y [56,813,541 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in 2011 approximately 23,672,309 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 3 km the total TSP emissions for 2011 for West Pit will be 710,169 kg/y [23,672,309 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

In addition to this, approximately 833,333 bcm of overburden will be hauled from south of the River to the Alluvial Lands and the same amount will be hauled from North Pit to the Alluvial Lands. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 3 km the total TSP emissions for 2011 will be:

- South of the River to Alluvial Lands - 25,000 kg/y [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

- North Pit to the Alluvial Lands - 25,000 [833,333 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in 2011 approximately 56,813,541 t of overburden will be dumped in the West Pit waste emplacement areas. Each tonne of material unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3**.

The annual average emission factor will therefore be 0.00194 kg/t. Thus the annual TSP emissions for 2011 for West Pit will be 110,318 kg/y [56,813,541 t/y x 0.00194 kg/t].

In addition, approximately 4,000,000 t of overburden will be dumped in the Alluvial Lands. The total TSP emissions for 2011 will be 7,767 kg/y [4,000,000 t/y x 0.00194kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,

$E_{TSP} = TSP\ emissions$
$s = silt\ content(\%),\ and$
$M = moisture\ content(\%)$

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in 2011 dozers would spend 16,448 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 275,268 kg/y [16,448 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,

$E_{TSP} = TSP\ emissions$
$d = drop\ distance(m),\ and$
$M = moisture\ content(\%)$

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in 2011 18,974,729 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 892,533 kg/y [18,974,729 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL

Drilling coal
It is estimated that in 2011, that 3,654 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 2,156 kg/y [3,654 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22,000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in 2011 there will be 16 shots, the emissions from West Pit will be 11,268 kg/y [718 kg/blast x 16 blasts/y].

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,

$s = silt\ content(\%),\ and$
$M = moisture\ content(\%)$

Taking M to be 6% and s to be 5%, the emission factor is estimated to be approximately 20.0 kg/h.

In 2011, it is estimated that dozers will work on coal for 16,448 hours. The total TSP emission from dozers working on coal is therefore 328,794 kg/y [16,448 h/y x 20.0 kg/h].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,

$E_{TSP} = TSP\ emissions$
$M = moisture\ content(\%)$

Taking M to be 6%, the emission factor is estimated to be 0.06755 kg/t. In 2011 approximately 6,491,605 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 438,529 kg/y [6,491,605 t/y x 0.06755kg kg/t].

Hauling coal to HVCPP and WPCPP

In 2011, based on information provided by CNA, 5,491,605 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for 2011 are:

- West Pit to HVCPP – 179,422 kg/y [5,491,605 t/y / 240 t/trip x 8 km/trip x 1.0kg/VKT]
- West Pit to WPCPP – 116,667 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0kg/VKT].

OPERATIONS AT CARRINGTON

From data provided by CNA, in 2011, mining taking place in Carrington will produce a maximum 10,000,000 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

As with the operations at West Pit, open cut ROM coal will be hauled directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Dozers working on overburden

Dozers will work on the overburden for a total of 6,176 h/y. This includes the removal of vegetation and stripping of overburden. Dust is generated from dozers according to **Equation 4** (see above).

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. The total TSP emission from the dozers working on overburden is therefore 103,357 kg/y [6,176 h/y x 16.7 kg/h].

Drilling overburden

Based on data provided by CNA, it is estimated in 2011 that 323 holes will be required for overburden blasting in Carrington. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 191 kg/y [323 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting CNA be estimated using the equation given in **Equation** 2 (see above).

The area of a typical blast has been estimated to be 22,615 m^2. The estimated emissions per blast will be 748 kg/blast. Assuming that in 2011 there will be 121 shots, the emissions from Carrington will be 90,532 kg/y [748 kg/blast x 121 blasts/y].

Loading overburden to trucks

Based on information provided by CNA, in 2011 approximately 6,884,772 bank cubic metres (bcm) will be handled by the truck and shovel in Carrington. Assuming a density of 2.4 t/bcm it is estimated that 16,523,452 t will be loaded to trucks in Carrington.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3** (see above).

Therefore the annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 32,085 kg/y [16,523,452 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas

Based on information provided by CNA, in 2011 approximately 6,884,772 bcm of overburden will be hauled from Carrington to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 5 km the total TSP emissions for 2011 for Carrington will be 344,239 kg/y [6,884,772 bcm/y / 100 bcm/trip x 5 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in 2011 approximately 16,523,452 t of overburden will be dumped in the Carrington waste emplacement areas. Each tonne of material unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3** (see above).

The annual average emission factor will therefore be 0.00194 kg/t. Thus the annual TSP emissions for 2011 for Carrington will be 32,085 kg/y [16,523,452 t/y x 0.00194 kg/t].

Rehandle of overburden
From information provided by CNA, it is estimated that 2,650,655 t of overburden will need to be re-handled. Assuming the same emission factor as above, namely 0.00194 kg/t, the total TSP emission from this operation will be 5,147 kg/y [2,650,655 t/y x 0.00194 kg/t]

OPERATIONS ON COAL
Dozers working on coal
Dozers will be used to rip the coal at Carrington. This will generate dust emissions according to **Equation 6** (see above).

Taking M to be 7.5% and s to be 5%, the emission factor is estimated to be approximately 14.6 kg/h.

In 2011, it is estimated that dozers will work on coal for 2,269 hours. The total TSP emission from dozers working on coal is therefore 33,183 kg/y [2,269 h/y x 14.6 kg/h].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7** (see above):

Taking M to be 7.5%, the emission factor is estimated to be 0.05168 kg/t. In 2011 approximately 4,066,287 t of ROM will be recovered from Carrington. Therefore the TSP emission from loading coal to trucks is 210,161 kg/y [4,066,287 t/y x 0.05168 kg/t].

Hauling coal to HVCPP and WPCPP
In 2011, based on information provided by CNA, 3,866,287 t of coal will be hauled from Carrington to the HVCPP and 200,000 t will be hauled from Carrington to the WPCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from Carrington to the HVCPP and 20 km (return) from Carrington to the WPCPP, the total estimated TSP emissions for 2011 are:

- Carrington to HVCPP – 128,876 kg/y [3,866,287 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- Carrington to WPCPP – 16,667 kg/y [200,000 t/y / 240 t/trip x 20 km/trip x 1.0 kg/VKT]

PROCESSING OPERATIONS

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in 2011 it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 21,491,605 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughput.

Assuming an emission factor of 0.01kg/t, the total estimated TSP emissions are:

- WPCPP – 34,000 kg/y [3,400,000 t/y x 0.01kg/t]
- HVCPP – 214,916 kg/y [21,491,605 t/y x 0.01kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 549,160 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01kg/t, the total TSP emission from this operation will be:

- WPCPP – 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP – 5,492 kg/y [549,160 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for 2011 are:

- WPCPP to NLP – 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2kg/VKT]

- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 25,200 kg/y [900,000 t/y / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,486,399 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 44,864 kg/y [4,486,399 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 3** (see above) with moisture assumed to be 7.5%. The emission factor is 0.00031kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,486,399 t at the NLP. The annual TSP emissions are therefore:

- HVLP – 4,272 kg/y [14,000,000 t/y x 0.00031kg/t]
- NLP – 1,369 kg/y [4,486,399 t/y x 0.00031kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 3**. The estimated annual TSP emission is therefore:

- WPCPP – 26,703 kg/y [17,500,000 t/y x 0.00153 kg/t]
- HVCPP – 239,432 kg/y [156,913,237 t/y x 0.00153 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/VKT$$

where,

$E_{TSP} = TSP \ emissions$

$S = speed\ of\ the\ grader\ in\ km/h$

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **SPCC (1983)** emission factor for wind erosion is 0.4 kg/ha/h. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

- West Pit pit area – 1,752,000 kg/y [500 ha x 0.4 kg/ha/h x 8,760 h/y]
- Alluvial Lands pit area – 175,200 kg/y [50 ha x 0.4 kg/ha/h x 8,760 h/y]
- West Pit overburden area – 1,752,000 kg/y [500 ha x 0.4 kg/ha/h x 8,760 h/y]
- Alluvial Lands overburden area – 175,200 kg/y [50 ha x 0.4 kg/ha/h x 8,760 h/y]
- Carrington pit area – 211,992 kg/y [61 ha x 0.4 kg/ha/h x 8,760 h/y]
- Carrington overburden area – 204,702 kg/y [58 ha x 0.4 kg/ha/h x 8,760 h/y]

CARRINGTON OPEN CUT MINE OPERATIONS ESTIMATED DUST EMISSIONS IN 2014

Introduction

It is anticipated that operations at Carrington will have ceased by 2011, however, in order to provide some flexibility in the operations, and to allow for market fluctuations, this appendix provides information on the way in which estimates of TSP emissions for 2014 have been made.

Calculations are presented to an apparent accuracy of ± 1 kg. There may appear to be minor discrepancies in the calculations – less than a fraction of 1%. These are due to rounding errors that arise because the emission factors displayed in the text of this appendix are not shown to the same precision as the emission factors actually used in the spreadsheets when the calculations are done.

For example, in the estimate of TSP emissions from loading overburden to trucks in Hunter Valley Operations North (see below) it is stated that the activity will produce 151,277 kg/y of TSP [77,907,411 t/y x 0.00194kg/t]. Checking this formula using the printed figures gives an estimate of 151,140.4 kg/y. However if the emission factor is written to greater precision eg (0.001941760 kg/t) the estimate becomes 151,277.5 kg/y, which then is written as 151,277 kg/y.

It is not intended to suggest the actual emissions can be estimated to the level of precision used in the calculations. The accuracy of individual estimates is not known precisely but validation tests performed in 1984 (**Dames & Moore, 1984**) indicate that model predictions of annual average dust deposition rates can be estimated with sufficient accuracy so that 80% of predicted annual average deposition rates lie within ± 40% of the measured deposition value. This provides an indication as to the overall accuracy of the modelling system. It includes the effects of errors in the estimated emissions, the potential errors introduced by uncertainties in meteorological conditions and the dispersion modelling process.

Coal & Allied (CNA) operations north of the Hunter River include Carrington Pit, West Pit, the Alluvial Lands, North Pit and the associated coal preparation plants (CPPs) at Hunter Valley (HVCPP) and West Pit (WPCPP) and rail loading facilities at the Hunter Valley Loading Point (HVLP), Newdell Loading Point (NLP) and the Ravensworth Coal Terminal (RCT).

This inventory takes into account the impacts of mining at Carrington in the year 2014 and assumes operations are identical to those in 2011. The assessment also includes the mining activities in the rest of Hunter Valley Operations North (HVO north) in 2014 (that is the operations at West Pit). By 2014 operations at the Alluvial Lands and North Pit are anticipated to have ceased.

In addition, the cumulative impact of operations at other nearby mines, namely Ravensworth-Narama, Wambo, United Colliery, Cumnock No. 1 Colliery and HVO south of the Hunter River (Cheshunt and Riverview), are also included.

The emissions from Carrington and the rest of the HVO north operations are described in detail below.

Emissions from Ravensworth-Narama, Cheshunt and Riverview have been calculated based on the annual ROM coal output of each mine and an emission rate of 0.52 kg/ton ROM coal. In 2014 Ravensworth-Narama is expected to have a ROM coal output of 2,400,000 t/y (**Peabody Resources Limited, 1997)** and corresponding TSP emissions of 1,248,000 kg/y. Cheshunt has a ROM output of 5,000,000 t/y and emissions of 2,600,000 kg/y; and Riverview has a ROM output of 3,000,000 t/y and TSP emissions of 1,560,000 kg/y. Emissions from United Colliery and Wambo are initial calculations for a 2003 EIS for Wambo, with emissions being 1,026,264 t/y and 5,139,243 t/y respectively. It is uncertain what activities will be occurring at Cumnock Colliery during the life of the Carrington project. According to an air quality study prepared in 1996 (**Holmes Air Sciences, 1996**), the open cut mining should have been completed by 2004. However, a subsequent assessment completed in 2001 (**Holmes Air Sciences, 2001)** noted that the open cut mining had been suspended for a period of time. In order to present a worst-case assessment, the maximum emissions expected at Cumnock have been assumed to occur during the period covered by this assessment. For 2004, the emissions from Cumnock were calculated to be 2,406,642 kg/y (**Holmes Air Sciences, 1996**).

OPERATIONS AT HVO NORTH (EXCLUDING CARRINGTON)

This section presents a detailed assessment of the activities that will occur at West Pit and North Pit in the year 2014. It also includes details on the movement of coal from south of the river to the HVO north site.

From data provided by CNA, in 2014, mining taking place in West Pit will produce approximately 9,530,884 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

Open cut ROM coal will be hauled by 240 t trucks directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling process that is likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Stripping topsoil
Stripping topsoil will generate dust at the rate of approximately 14.0 kg/h (**SPCC, 1983**). Assuming that stripping topsoil takes approximately 1,280 h/y then the annual TSP emission rate will be 17,920 kg/y [1,280 h/y x 14.0 kg/h].

Drilling overburden
Based on data provided by CNA, it is estimated in 2014 that 50,182 holes will be required for overburden blasting in West Pit. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 29,607 kg/y [50,182 holes x 0.59 kg/hole].

Blasting overburden
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2**.

Equation 2

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad kg/blast$$

where :

$E_{TSP} = TSP\ \ emission\ \ factor$

$A = area\ to\ be\ blasted\ \ in\ m^2$

The area of a typical blast has been estimated to be 22,000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in 2014 there will be 169 shots, the emissions from West Pit will be 121,604 kg/y.

Loading overburden to trucks
Based on information provided by CNA, in 2014 approximately 32,461,421 bank cubic metres (bcm) will be handled by the truck and shovel in the West Pit. Assuming a density of 2.4 t/bcm it is estimated that 77,907,411 t will be loaded to trucks in West Pit.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 3** shows the relationship between these variables.

Equation 3

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \qquad kg/t$$

where,

$E_{TSP} = TSP\ \ emissions$

$k = 0.74$

$U = wind\ speed\ (m/s)$

$M = moisture\ \ content(\%)$

$[where\ 0.25 \le M \le 4.8]$

For the West Pit meteorological data set used in the modelling the annual average value of $(u/2.2)^{1.3}$ is 1.64.

Assuming moisture content of 2% for overburden, the equation can be written as:

$$E_{TSP} = 0.00118 \times \left(\frac{U}{2.2}\right)^{1.3}$$

where,

$E_{TSP} = TSP\ \ emissions$

$U = the\ wind\ \ speed\ \ in\ \ m/s.$

The annual average emission factor for loading overburden to trucks will therefore be 0.00194kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 151,277 kg/y [77,907,411 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas
Based on information provided by CNA, in 2014 approximately 32,461,421 bcm of overburden will be hauled from West Pit to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 3 km the total TSP emissions for 2014 for West Pit will be 973,843 kg/y [32,461,421 bcm/y / 100 bcm/trip x 3 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas
Based on information provided by CNA, in 2014 approximately 77,907,411 t of overburden will be dumped in the West Pit waste emplacement areas. Each tonne of material unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3**.

The annual average emission factor will therefore be 0.00194 kg/t. Thus the annual TSP emissions for 2014 for West Pit will be 151,277 kg/y [77,907,411 t/y x 0.00194 kg/t].

Dozers on overburden
The US EPA emission factor equation is given in **Equation 4**.

Equation 4

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad kg/hour$$

where,
$E_{TSP} = TSP\ emissions$
$s = silt\ content(\%),\ and$
$M = moisture\ content(\%)$

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. Information provided by CNA shows that in 2014 dozers would spend 21,398 hours in West Pit. The total TSP emission from the dozers working on overburden is therefore 358,098 kg/y [21,398 h/y x 16.7 kg/h].

Dragline handling of prime overburden
The US EPA emission factor equation is given by **Equation 5**.

Equation 5

$$E_{TSP} = 0.0046 \times \frac{d^{1.1}}{M^{0.3}} \qquad kg/m^3$$

where,
$E_{TSP} = TSP\ emissions$
$d = drop\ distance(m),\ and$
$M = moisture\ content(\%)$

Using **Equation 5** and assuming a drop distance of 10 m and moisture of 2% the emission factor becomes 0.04704 kg/bcm.

Based on information provided by CNA, in 2014 19,385,703 bcm of overburden will be handled by dragline at West Pit.

The total TSP emission from dragline operations in each pit is therefore 911,865 kg/y [19,385,703 bcm x 0.04704 kg/bcm]

OPERATIONS ON COAL
Drilling coal
It is estimated that in 2014, that 6,906 holes will be required for drilling coal in West Pit. Each hole is estimated to result in the generation of 0.59kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting coal is estimated to be 4,075 kg/y [6,906 holes x 0.59 kg/hole].

Blasting coal
TSP emissions from blasting can be estimated using the **US EPA (1985)** emission factor equation given in **Equation 2** (see above).

The area of a typical blast has been estimated to be 22,000 m^2. The estimated emissions per blast will be 718 kg/blast. Assuming that in 2014 there will be 38 shots, the emissions from West Pit will be 27,044 kg/y [718 kg/blast x 38 blasts/y].

Dozers working on coal
The US EPA emission factor equation is given in **Equation 6**.

Equation 6

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \qquad kg/hour$$

where,
$s = silt\ content(\%),\ and$
$M = moisture\ content(\%)$

Taking M to be 6% and s to be 5%, the emission factor is estimated to be approximately 20.0 kg/h.

In 2014, it is estimated that dozers will work on coal for 21,398 hours. The total TSP emission from dozers working on coal is therefore 427,730 kg/y [21,398 h/y x 20.0 kg/h].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7**:

Equation 7

$$E_{TSP} = \frac{0.580}{M^{1.2}} \qquad kg/t$$

where,
$E_{TSP} = TSP\ emissions$
$M = moisture\ content(\%)$

Taking M to be 7.5%, the emission factor is estimated to be 0.05168 kg/t. In 2014 approximately 9,530,884 t of ROM will be recovered from West Pit. Therefore the TSP emission from loading coal to trucks is 492,592 kg/y [9,530,884 t/y x 0.05168kg kg/t].

Hauling coal to HVCPP and WPCPP
In 2014, based on information provided by CNA, 8,530,884 t of coal will be hauled from West Pit to the HVCPP and 3,400,000 t will be hauled from West Pit to the WPCPP. In addition, it is proposed that a maximum of 16,000,000 t of ROM coal will be hauled from south of the river to the HVCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from West Pit and 10 km (return) from south of the river, the total estimated TSP emissions for 2014 are:

- West Pit to HVCPP – 179,422 kg/y [8,530,884 t/y / 240 t/trip x 8 km/trip x 1.0kg/VKT]
- West Pit to WPCPP – 116,667 kg/y [3,400,000 t/y / 240 t/trip x 8 km/trip x 1.0kg/VKT]
- S. of river to HVCPP – 666,667 kg/y [16,000,000 t/y / 240 t/trip x 10 km/trip x 1.0kg/VKT].

OPERATIONS AT CARRINGTON

From data provided by CNA, in 2011, mining taking place in Carrington will produce a maximum 10,000,000 t of ROM coal.

Overburden will be drilled and blasted and then loaded to trucks by shovel.

As with the operations at West Pit, open cut ROM coal will be hauled directly to the HVCPP or WPCPP or to the ROM stockpiles located near the HVCPP and WPCPP and later transferred to the CPPs. Product coal will be stockpiled near the HVCPP and WPCPP. From the HVCPP, product coal will be conveyed or hauled along the Belt Line Road to the HVLP. From the WPCPP product coal will be transferred via conveyor to Bayswater Power Station or hauled to the NLP.

The following sections describe each activity in the mining and coal handling processes that are likely to generate dust and provide estimates of the quantity of dust generated.

OPERATIONS ON OVERBURDEN

Dozers working on overburden

Dozers will work on the overburden for a total of 6,176 h/y. This includes the removal of vegetation and stripping of overburden. Dust is generated from dozers according to **Equation 4** (see above).

Taking M to be 2% and s to be 10%, the emission factor is estimated to be 16.7 kg/hour. The total TSP emission from the dozers working on overburden is therefore 103,357 kg/y [6,176 h/y x 16.7 kg/h].

Drilling overburden

Based on data provided by CNA, it is estimated in 2011 that 323 holes will be required for overburden blasting in Carrington. Each hole is estimated to result in the generation of 0.59 kg of TSP **(US EPA, 1985)**, and so the total TSP emission from drilling holes for blasting overburden is estimated to be 191 kg/y [323 holes x 0.59 kg/hole].

Blasting overburden

TSP emissions from blasting can be estimated using the equation given in **Equation** 2 (see above).

The area of a typical blast has been estimated to be 22,615 m^2. The estimated emissions per blast will be 748 kg/blast. Assuming that in 2011 there will be 121 shots, the emissions from Carrington will be 90,532 kg/y [748 kg/blast x 121 blasts/y].

Loading overburden to trucks

Based on information provided by CNA, in 2011 approximately 6,884,772 bank cubic metres (bcm) will be handled by the truck and shovel in Carrington. Assuming a density of 2.4 t/bcm it is estimated that 16,523,452 t will be loaded to trucks in Carrington.

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3** (see above).

Therefore the annual average emission factor for loading overburden to trucks will therefore be 0.00194 kg/t. Thus the annual TSP emissions from loading overburden to trucks in each pit will be 32,085 kg/y [16,523,452 t/y x 0.00194 kg/t]

Hauling overburden to waste emplacement areas

Based on information provided by CNA, in 2011 approximately 6,884,772 bcm of overburden will be hauled from Carrington to the overburden emplacement areas. This will be done using haul trucks with a capacity of 100 bcm. Assuming an emission factor of 1.0 kg/VKT (after the application of water) and an average haul distance of 5 km the total TSP emissions for 2011 for Carrington will be 344,239 kg/y [6,884,772 bcm/y / 100 bcm/trip x 5 km/trip x 1.0 kg/VKT].

Unloading overburden to waste emplacement areas

Based on information provided by CNA, in 2011 approximately 16,523,452 t of overburden will be dumped in the Carrington waste emplacement areas. Each tonne of material unloaded will generate a quantity of TSP that will depend on the wind speed and the moisture content as shown in **Equation 3** (see above).

The annual average emission factor will therefore be 0.00194 kg/t. Thus the annual TSP emissions for 2011 for Carrington will be 32,085 kg/y [16,523,452 t/y x 0.00194 kg/t].

Rehandle of overburden

From information provided by CNA, it is estimated that 2,650,655 t of overburden will need to be re-handled. Assuming the same emission factor as above, namely 0.00194 kg/t, the total TSP emission from this operation will be 5,147 kg/y [2,650,655 t/y x 0.00194 kg/t]

OPERATIONS ON COAL

Dozers working on coal

Dozers will be used to rip the coal at Carrington. This will generate dust emissions according to **Equation 6** (see above).

Taking M to be 7.5% and s to be 5%, the emission factor is estimated to be approximately 14.6 kg/h.

In 2011, it is estimated that dozers will work on coal for 2,269 hours. The total TSP emission from dozers working on coal is therefore 33,183 kg/y [2,269 h/y x 14.6 kg/h].

Loading coal to trucks
The emission factor used for this process is given by **Equation 7** (see above):

Taking M to be 7.5%, the emission factor is estimated to be 0.05168 kg/t. In 2011 approximately 4,066,287 t of ROM will be recovered from Carrington. Therefore the TSP emission from loading coal to trucks is 210,161 kg/y [4,066,287 t/y x 0.05168 kg/t].

Hauling coal to HVCPP and WPCPP
In 2011, based on information provided by CNA, 3,866,287 t of coal will be hauled from Carrington to the HVCPP and 200,000 t will be hauled from Carrington to the WPCPP.

This will be done using haul trucks with a capacity of 240 t. Assuming an emission factor of 1.0 kg/VKT (after application of water to the haul roads) and an average haul distance of 8 km (return) from Carrington to the HVCPP and 20 km (return) from Carrington to the WPCPP, the total estimated TSP emissions for 2011 are:

- Carrington to HVCPP– 128,876 kg/y [3,866,287 t/y / 240 t/trip x 8 km/trip x 1.0 kg/VKT]
- Carrington to WPCPP – 16,667 kg/y [200,000 t/y / 240 t/trip x 20 km/trip x 1.0 kg/VKT]

PROCESSING OPERATIONS

Unloading coal to hoppers
Open cut ROM coal will be unloaded at the WPCPP and HVCPP dump hoppers.

Based on information provided by CNA, in 2011 it is estimated that 3,400,000 t of coal will be unloaded at the WPCPP and 24,530,884 t will be unloaded at the HVCPP respectively. It is recognised that the HVCPP has a maximum capacity of 20 Mtpa. However, to account for the flexibility in movement that is required it is necessary to assume a greater throughput.

Assuming an emission factor of 0.01kg/t, the total estimated TSP emissions are:

- WPCPP– 34,000 kg/y [3,400,000 t/y x 0.01kg/t]
- HVCPP– 245,309 kg/y [24,530,884 t/y x 0.01kg/t]

Rehandle of coal at WPCPP and HVCPP
From information provided by CNA, it is estimated that 175,000 t and 853,088 t of open cut ROM coal will need to be re-handled at the WPCPP and HVCPP respectively. Assuming the same emission factor as above, namely 0.01kg/t, the total TSP emission from this operation will be:

- WPCPP– 1,750 kg/y [175,000 t/y x 0.01 kg/t]
- HVCPP– 8,531 kg/y [853,088 t/y x 0.01 kg/t].

Transport product coal to user/loadout point
Based on information provided by CNA, approximately 2,257,558 t of product coal will be transported from the WPCPP to the NLP. Based on a maximum of 25,000 t/d, one day a month, a maximum of 300,000 t/y will be transported from the HVCPP to HVLP. Based on a maximum of 15,000 t/d, five days a month, a maximum of 900,000 t/y will be transported from the HVLP to the RCT.

The transfer of product coal will be done using haul trucks with a capacity of 100 t. Assuming an emission factor of 0.2 kg/VKT (these trucks travel on sealed roads) and an average haul distance of 12 km to the NLP and HVLP and 14 km from the HVLP to the RCT, the total estimated TSP emissions for 2011 are:

- WPCPP to NLP – 54,181 kg/y [2,257,558 t/y / 100 t/trip x 12 km/trip x 0.2kg/VKT]
- HVCPP to HVLP – 7,200 kg/y [300,000 t/y / 100 t/trip x 12 km/trip x 0.2 kg/VKT].
- HVLP to RCT – 25,200 kg/y [900,000 t/y / 100 t/trip x 14 km/trip x 0.2 kg/VKT].

In addition to this a maximum of 2,000,000 t/y will be transported from the HVLP to the NLP. An analysis of this operation estimated total emissions to be 0.00870 kg/t (**Holmes Air Sciences, 2003d**). Therefore, the total estimated TSP emissions are 17,400 kg/y [2,000,000 t/y x 0.00870 kg/t].

Unloading coal
Based on information provided by CNA, an average of 2,500,000 t/y of coal will be unloaded at Bayswater Power Station from the WPCPP, 14,000,000 t/y will be unloaded at the HVLP and 4,257,558 t/y will be unloaded at the NLP. Assuming an emission factor of 0.01 kg/t the total estimated TSP emissions are:

- Bayswater Power Station – 25,000 kg/y [2,500,000 t/y x 0.01 kg/t]
- HVLP– 140,000 kg/y [14,000,000 t/y x 0.01 kg/t]
- NLP – 42,576 kg/y [4,257,558 t/y x 0.01 kg/t]

Loading open cut coal to trains
The emission factor for loading trains from the rail-loading bin is calculated using **Equation 3** (see above) with moisture assumed to be 7.5%. The emission factor is 0.00031kg/t and the annual quantity is 14,000,000 t at the HVLP and 4,257,558 t at the NLP. The annual TSP emissions are therefore:

- HVLP – 4,272 kg/y [14,000,000 t/y x 0.00031kg/t]
- NLP – 1,299 kg/y [4,257,558 t/y x 0.00031kg/t]

Handling open cut coal within CHPP
Coal handling in the CHPP takes place at the WPCPP and HVCPP in enclosed areas and under conditions where moisture levels are high. To account for the emissions from this area it has been assumed that the emission is equivalent to five transfers each of which generates the same quantity of TSP as estimated by **Equation 3**. The estimated annual TSP emission is therefore:

- WPCPP – 25,940 kg/y [17,000,000 t/y x 0.00153 kg/t]
- HVCPP – 187,157 kg/y [122,654,421 t/y x 0.00153 kg/t]

Note: the quantities of coal assumed to be handled by these CPPs is higher than will occur in practice. This is necessary in order to preserve the flexibility of operations required for the whole operation. Also note that the emission assumes that all coal is handled five times in the CPPs.

Graders on roads
Estimates of TSP emissions from grading roads have been made using the **US EPA (1985)** emission factor equation (**Equation 8**).

Equation 8

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad kg/VKT$$

where,

$E_{TSP} = TSP\ \ emissions$

$S = speed\ of\ the\ grader\ in\ km/h$

Assuming an average speed of 8 km/h, the emission factor is 0.61547 kg/VKT. The distance travelled annually by the grader is estimated to be 100,000 km, which will result in an annual TSP emission of 61,547 kg [100,000 km/y x 0.61547kg/VKT].

WIND EROSION
The **SPCC (1983)** emission factor for wind erosion is 0.4 kg/ha/h. The estimated emissions and associated assumption for each of the major areas associated with wind erosion emissions are as follows:

- West Pit pit area – 1,752,000 kg/y [500 ha x 0.4 kg/ha/h x 8,760 h/y]
- West Pit overburden area – 1,752,000 kg/y [500 ha x 0.4 kg/ha/h x 8,760 h/y]
- Carrington pit area – 211,992 kg/y [61 ha x 0.4 kg/ha/h x 8,760 h/y]
- Carrington overburden area – 204,702 kg/y [58 ha x 0.4 kg/ha/h x 8,760 h/y]

Appendix E - Comparison of Results with Previous Assessment

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Comparison of results with HVO West Pit Extension and Minor Modifications EIS

There are some differences in the predicted concentrations at the residences when compared with those presented in the previous EIS (**Holmes Air Sciences, 2003a**). **Table D1** presents a comparison of the predicted concentrations at the nearby residences for both the current and previous assessments.

Table D1: Comparison of predicted concentrations at residences

Pollutant	PM$_{10}$ (μg/m^3)				TSP (μg/m^3)		Deposition (g/m^2/month)	
Averaging Period	**1-day**		**1-year**		**1-year**		**1-year**	
Goal	*50*		*30*		*90*		*2*	
Assessment	***Current***	***Previous***	***Current***	***Previous***	***Current***	***Previous***	***Current***	***Previous***
Residence ID	**Proposal in isolation**							
1	12.3	45.6	2.0	3.5	2.2	3.6	0.02	0.03
2	15.2	39.1	2.1	3.6	2.2	3.8	0.02	0.03
3	19.3	38.1	2.2	3.2	2.3	3.4	0.02	0.03
4	15.0	21.6	1.7	3.2	1.8	3.4	0.02	0.03
5	17.4	18.4	7.7	7.7	9.3	9.0	0.44	0.33
6	20.0	18.7	8.0	8.4	9.6	9.7	0.42	0.35
7	35.3	29.1	11.0	12.0	13.2	14.0	0.63	0.50
8	39.5	46.4	12.5	17.4	15.7	20.8	0.90	0.86
9	34.2	**186.7**	8.7	**41.3**	9.5	52.7	0.13	1.70
10	28.1	**93.0**	5.0	7.7	5.3	7.6	0.04	0.02
11	18.0	22.9	2.2	3.5	2.3	3.6	0.02	0.03
12	45.4	42.7	23.2	20.2	29.2	24.4	1.63	1.12
39	9.1	N/A	1.8	N/A	2.1	N/A	0.06	N/A
Residence ID	**Proposal with other sources**							
1	17.4	**57.1**	13.5	15.2	19.5	21.2	0.67	0.68
2	29.1	**51.3**	14.6	16.2	20.7	22.3	0.70	0.71
3	35.2	**53.6**	15.0	16.1	21.2	22.3	0.71	0.72
4	27.7	37.1	16.7	18.2	23.1	24.7	0.77	0.78
5	43.5	46.2	24.0	23.9	32.6	32.2	1.47	1.36
6	37.9	41.0	22.6	22.9	30.8	30.8	1.27	1.21
7	49.5	47.0	23.8	24.5	31.8	32.2	1.28	1.16
8	**57.0**	**60.4**	28.6	**34.7**	37.7	43.9	1.58	1.56
9	39.5	**197.1**	27.0	**60.2**	34.0	77.8	0.89	**2.47**
10	32.8	**107.1**	23.3	25.9	29.8	32.1	0.82	0.50
11	37.3	40.6	19.9	21.7	26.8	28.7	0.87	0.89
12	**180.4**	**231.7**	**103.0**	**119.9**	**136.0**	**164.5**	**5.79**	**7.36**
39	41.4	N/A	22.9	N/A	31.6	N/A	1.35	N/A

Bold font indicates predicted exceedances of goal

There are a number of differences between the two sets of modelling that will have contributed to these different predictions, in order of importance these are as follows:

1. Location of sources

In the current assessment, the overburden area and active mining area have been represented as six sources spread out over the area where the mining will take place. These sources are located approximately 1 – 2 km to the south-east of location used in the previous assessment (as shown in **Figure D1**).

2. Total emissions from activities

In the previous assessment (**Holmes Air Sciences, 2003a**), emissions data for Carrington were used from an EIS completed in 1999 by ERM (**ERM, 1999**). These emissions were scaled up by 10/6 to represent the production increase from 6 Mtpa to 10 Mtpa. The way the emissions were calculated in the ERM study is not identical to the way the emissions have been calculated for this assessment. In the previous assessment total emissions from Carrington were calculated to be 6,501,671 kg TSP/y.

In the current assessment, total emissions (including wind erosion) from Carrington are calculated to be 4,240,544 kg TSP/y. This represents approximately 65% of the value calculated from the using the information from the original ERM study.

This will have an impact on the predicted concentrations – not necessarily to always reduce them, this depends on the location of the sources in relation to the receptor.

3. Estimation of emissions by source

In the previous assessment, the emissions from Carrington were assumed to come from just three sources. These sources were allocated to three classes (wind erosion, wind sensitive and wind in sensitive) according to known proportions from other mines. A fuller explanation of this is presented in **Section 6** in the main body of the report.

In this assessment, the emissions from Carrington are from six sources but each of these sources has been allocated to a variety of specific activities, which are then allocated to one of the three classes, that is, one source represents more than one activity (and hence more than one of three classes of wind erosion, wind sensitive and wind insensitive).

Figure D1 shows the location of the sources in each assessment.

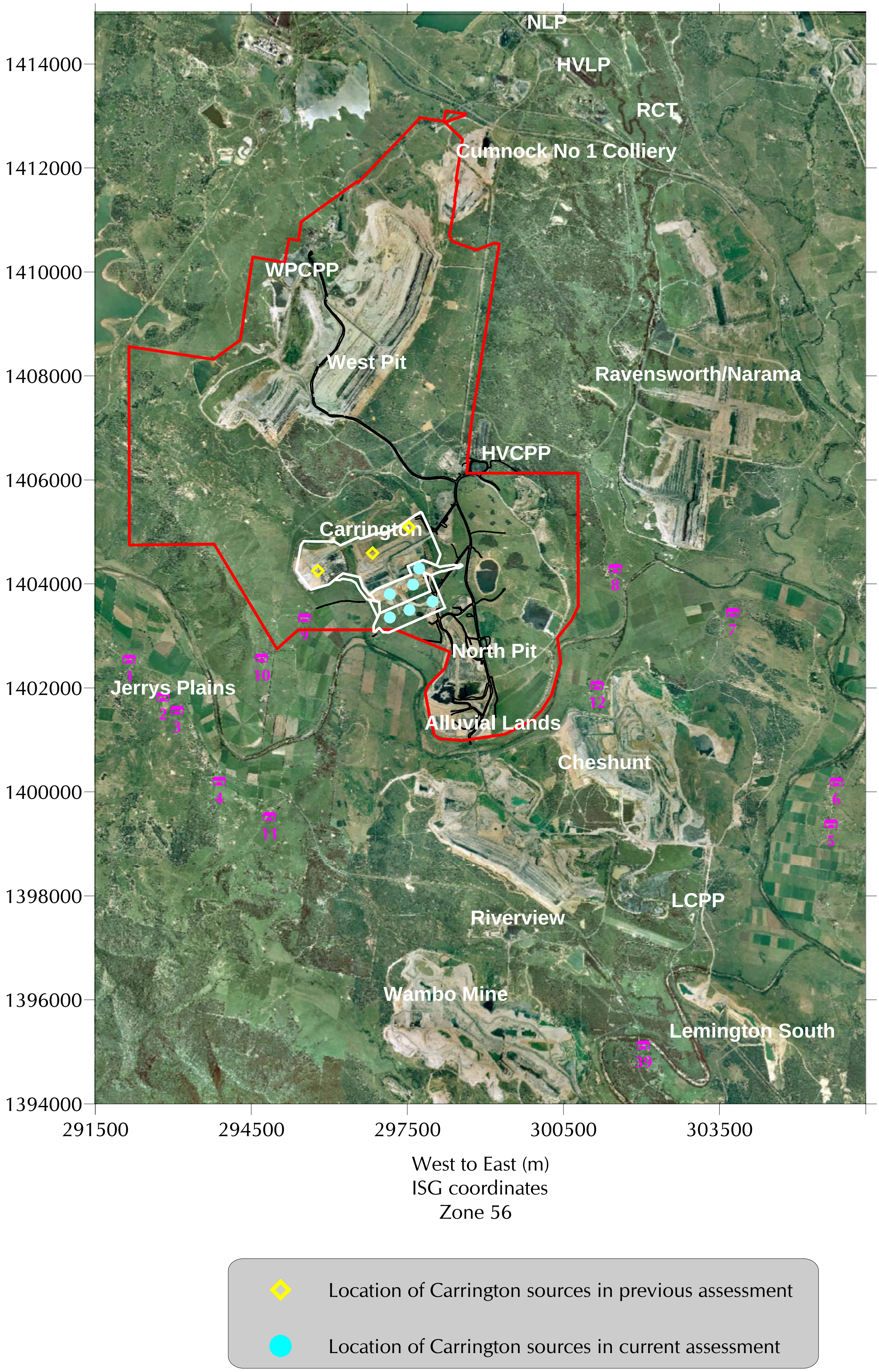
For want of a better expression, because we used six rather than three sources, the emissions in the new assessment will be "smeared" more than in the original assessment.

The distribution between the three classes for each of the assessments is shown **Table D2**. This will have some impact on the emissions, but will not be as significant as the impact from points 1 & 2.

Table D2: Comparison of distribution between source types

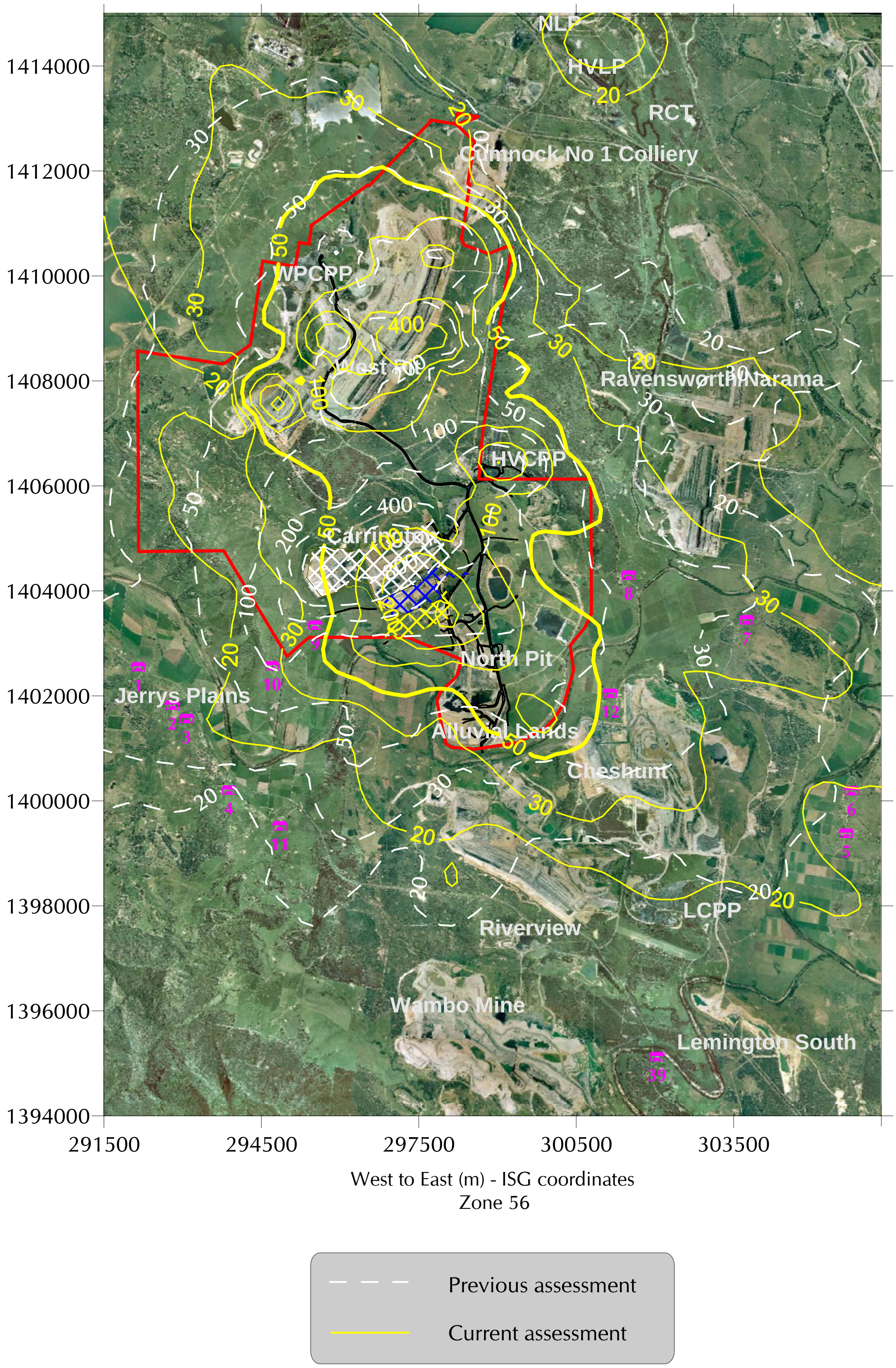
Emission Source Type	Previous Assessment	Current Assessment
Wind insensitive	0.732	0.814
Wind sensitive	0.135	0.088
Wind erosion	0.133	0.098

Figure D2 to **Figure D9** compare the contour plots for both the previous and current assessment for the year 2006. These show that the main difference in the predicted concentrations are occurring close to the Carrington mine. This is particularly evident on the contour plots showing the cumulative impacts with other sources.



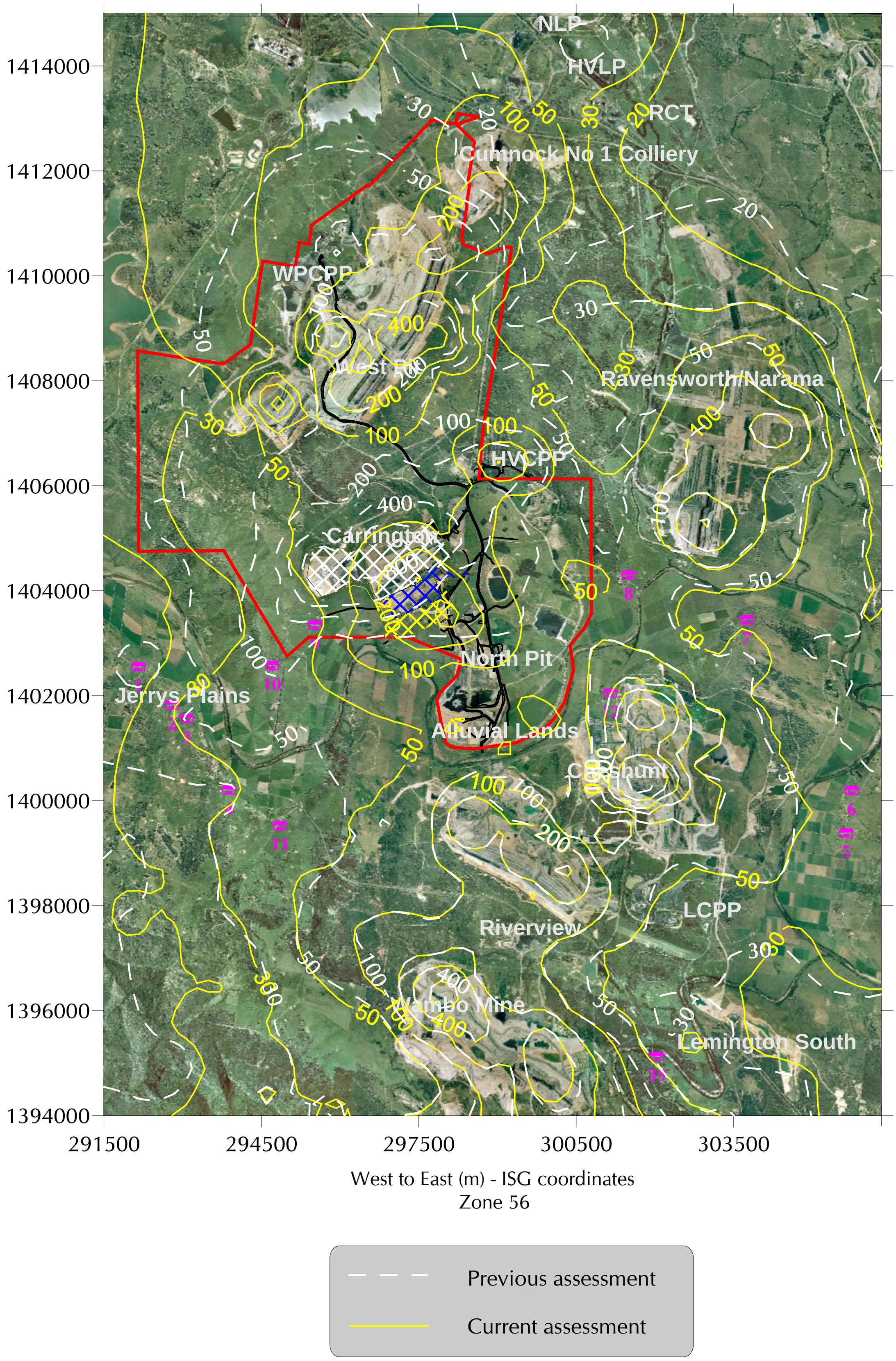
Location of Carrington sources compared

Figure D1



Predicted maximum 24-hour average PM_{10} concentration
due to emissions from the Proposal in the previous and current assessments ($\mu g/m^3$)

Figure D2



Predicted maximum 24-hour average PM_{10} concentration
due to emissions from the Proposal and other sources in the previous and current assessments ($\mu g/m^3$)

Figure D3

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Annex G

Archaeology Assessment

FINAL REPORT

Carrington Extension, Hunter Valley Operations
Cultural Heritage Assessment

October 2005

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EXECUTIVE SUMMARY

Coal & Allied Operations Pty Ltd. (CNA) propose to extend their Carrington mining area south beyond the current consent boundary and east into an existing overburden dump. CNA commissioned Environmental Resources Management Australia (ERM) to undertake a cultural and historical heritage assessment of the southern extension area to assess potential impacts and provide management recommendations.

The assessment involved a survey of the southern extension area and additional areas to the south and west of this area (combined, these areas are referred to as the study area). The assessment was carried out over two days, the 26th and 27th of October 2004, by ERM archaeologists and representatives from the Aboriginal community. The survey involved traversing the study area on foot or in a vehicle. Despite very poor archaeological visibility at the time of the survey, ten previously unrecorded sites were found and three recorded sites were relocated. While a number of houses and farm buildings were recorded during the survey, no historical heritage items of any significance were identified; nor were any historical heritage issues identified through historical background research.

The local area was found to have considerable cultural heritage value. Fifteen Aboriginal sites have been recorded in the study area: C1, C2, C3, C4, C5, C6, C7, C8, C9, C10 (recorded during the current survey, and CM1, CM2, CM45, CM46 and CM-CD1 (recorded during previous investigations). Twelve of the sites fall within the southern extension area. Of these sites CM-CD1 (fenced by CNA), defined by an area of colluvial deposit at the base of a low but prominent ridge, is particularly significant because of its potential to contain evidence of late Pleistocene or earlier Holocene Aboriginal occupation. The ridge itself is also of interest because it may have been a focus of Aboriginal occupation and also the source of raw material used in the manufacture of stone tools. Two previously recorded sites, CM19 and CM32, were not found during surveys and were recorded outside the present study area by ERM Mitchell McCotter, 1999a. These sites were not considered further in this assessment.

Management options for all known Aboriginal sites and areas of significant cultural value are provided in the tables below.

Table 1 Recommendations for sites located in the Study Area

Site	Recommendations	Further works required	Section 90
C1, C2, C8, C9 and C10	Sites be destroyed after further archaeological investigation	Further archaeological salvage work should be undertaken on the low ridge involving further recording of archaeological material on the ridge (may involve excavation and collection of artefacts) to clarify the nature and extent of archaeological material across the ridge. This work may or may not involve salvage at the specific sites.	Required
C3	Scarred tree be removed and relocated to a location where it will be protected from further development	The methods used to remove the tree, the precise area or place where the tree should be relocated and the way it should be housed should all be determined in consultation with the Aboriginal community. The work should be carried out under a section 90 application obtained from the DEC.	Required
C4	Site be destroyed	No further archaeological investigation is required.	Required

Table 2 Recommendations for previously identified sites located in the Study Area

Site	Recommendation	Further works required	Section 90
CM-CD1	Protect site against impact of development	Protection of buffer zone around this fence ideally to include CM1 and part of CM2 and consultation with local Aboriginal groups to develop management strategies. The size of the buffer zone will be dependent on the depth of the mine pit and will be sufficient to protect the site from structural failure of the underlying sediments, erosion that may occur during the life of the mine (ie prior to rehabilitation) and inadvertent damage that could be caused by mine personnel and machinery.	Not required
CM1	Site be protected against the impact of development	Erection of a permanent fence around the site and consultation with local Aboriginal groups to develop management strategies	Not required
CM2	That the part of CM2 within the buffer zone of CM-CD1 be protected against the impact of development and destruction of the part of CM2 within the study area.	Erection of a permanent fence around the site and consultation with local Aboriginal groups to develop management strategies. No further archaeological investigation required for the section of CM2 within the study area.	Required for part of CM2 within the study area
CM45 and CM46	Sites to be destroyed	No further work required.	Required

1 INTRODUCTION

Coal & Allied Operations Pty Ltd (CNA) propose to extend Carrington pit south beyond the current consent boundary and east into an existing overburden dump. CNA commissioned Environmental Resources Management Australia (ERM) to undertake a cultural and historical heritage assessment of the southern extension area to assess potential impacts and provide management recommendations. The eastern extension area has not been included in this assessment as it has previously been disturbed by mining.

This assessment draws on past work undertaken in and around the study area and describes sites which have previously been located as well as sites which were identified during the survey undertaken for this project.

1.1 THE STUDY AREA

The study area (*Figure 1.1*) is situated within the Central Lowlands of the Upper Hunter Valley region east of Jerrys Plains and 18 kilometres north - west of Singleton. The study area includes:

- the southern part of the proposed extension area;
- a service corridor which follows the southern boundary of the Carrington pit;
- areas that will be impacted by the construction of levees and other infrastructure;
- and additional areas that will not be disturbed by mining activities (*Figure 1.2*).

This study area comprises a total of 141 hectares and is largely situated on alluvial flats associated with the Hunter River. It has a long history of farming and is currently being used for grazing cattle.

1.2 PROPOSED DEVELOPMENT

Carrington pit is located in Hunter Valley Operations (HVO) north of the Hunter River. This pit, established in 2001, is well developed and it is now proposed to extend operations within Carrington pit to the south and east. Mining will initially continue to the south through the extension area, then turn to the east to mine through an overburden dump. The final void will be formed in the eastern extension area. Three levees are proposed to protect the workings from flood events: the southern levee, the gully levee and the archaeology levee. The largest of these levees will be the southern levee and will be located along the southern boundary of the extension area.

1.3 *OBJECTIVES*

The assessment involved the following tasks:

- a review of background information to understand the environmental, archaeological and historical context of the study area;
- a survey to identify and record archaeological sites and areas of archaeological potential;
- an archaeological assessment of sites and areas of archaeological potential;
- consultation with the Aboriginal community to understand the Aboriginal significance of the study area and any archaeological sites or areas of archaeological potential identified during the survey; and
- an assessment of the impacts of extending the mining area and the provision of management recommendations.

1.4 *REPORT AUTHORSHIP*

This FINAL report was prepared by Andy Collis and reviewed by Neville Baker.

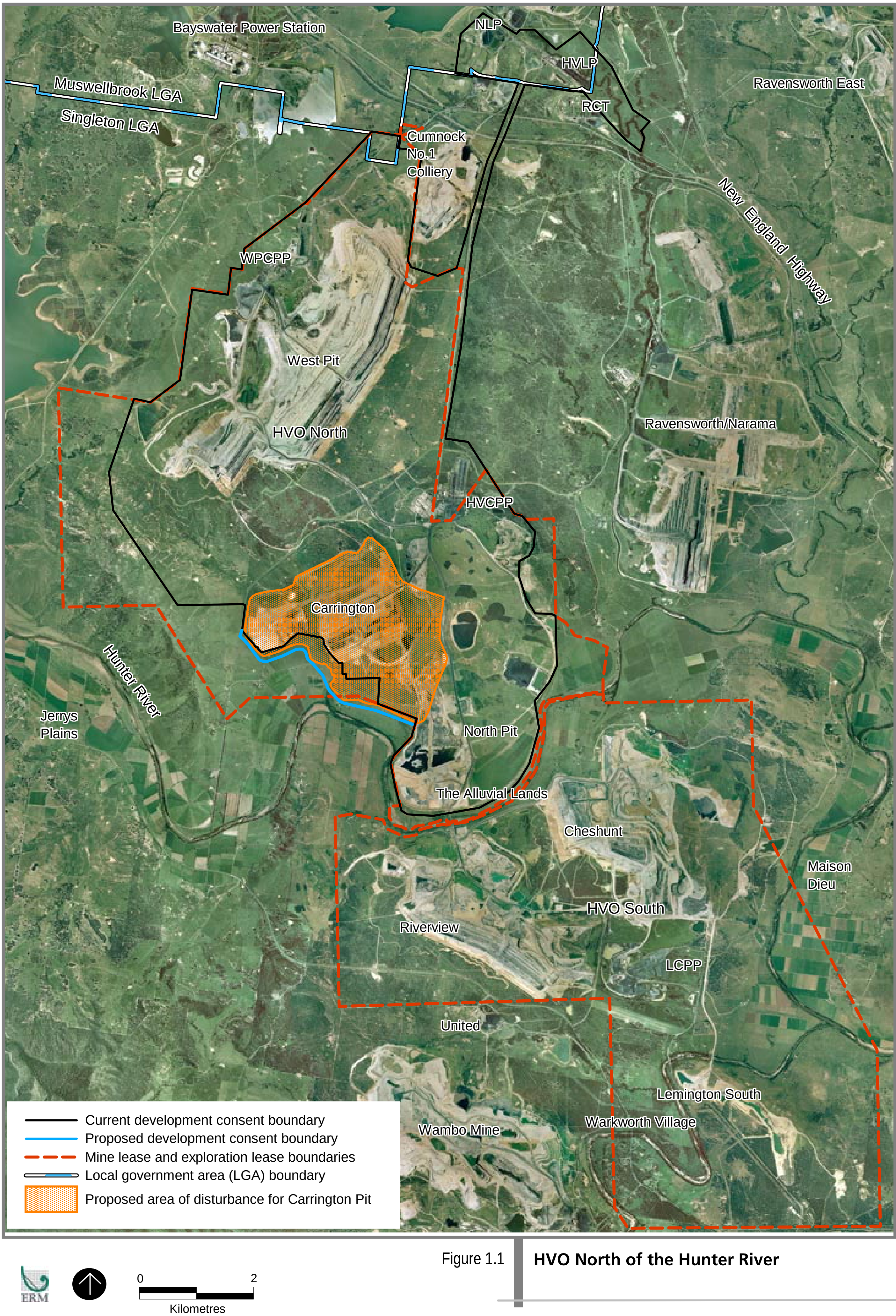

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Figure 1.1 **HVO North of the Hunter River**

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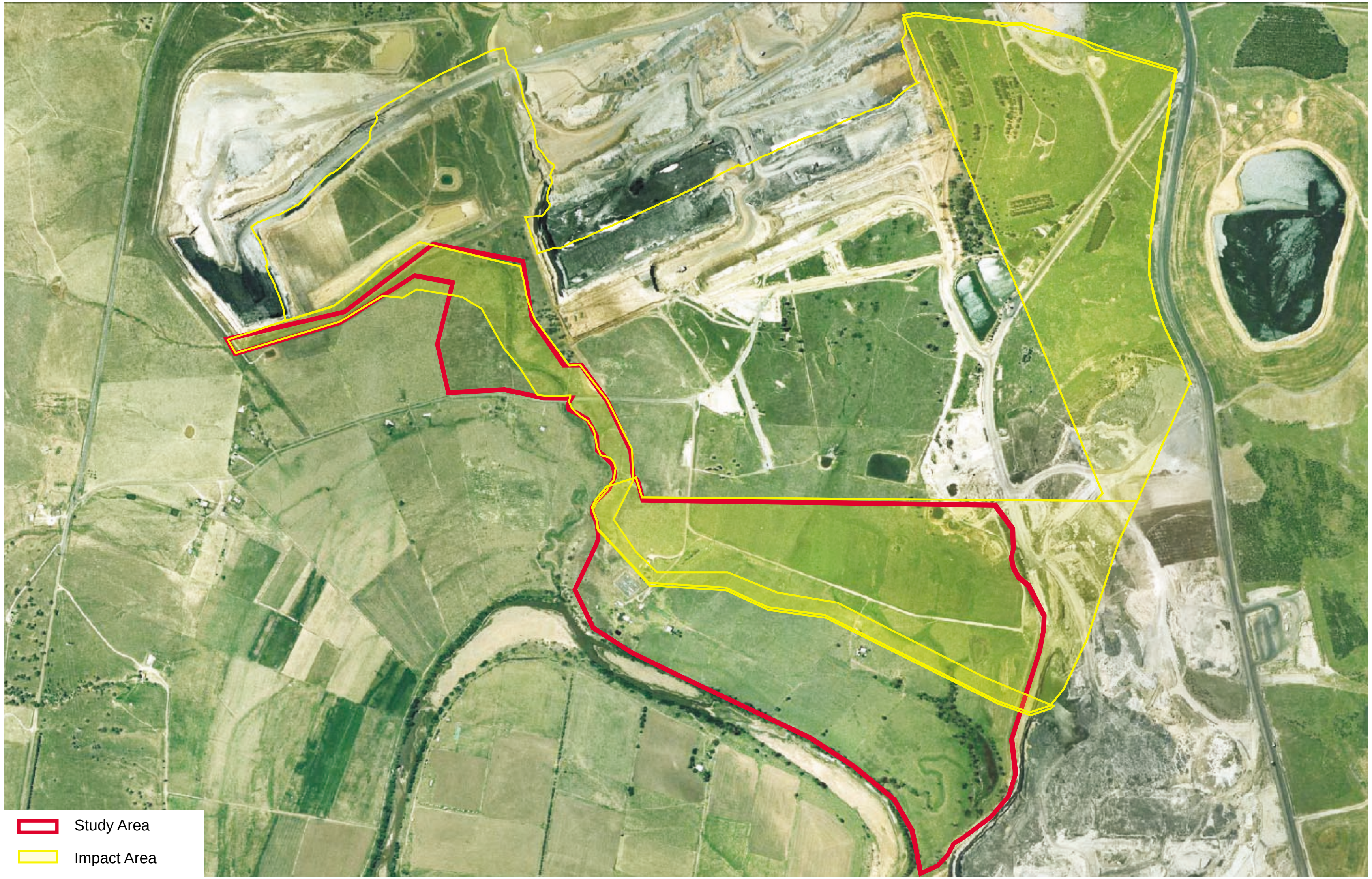


ERM

0 275m
Approximate Only

Figure 1.2 **Study Area in Relation to Impact Area**

Coal & Allied - Carrington Extension - Archaeological Assessment

2 *COMMUNITY CONSULTATION*

Community consultation involved consultation with 12 Aboriginal groups and two historical societies.

2.1 *ABORIGINAL CONSULTATION*

Initial Aboriginal consultation for the assessment was undertaken by GSS Environmental and involved a consultation meeting to which Aboriginal groups known to have expressed an interest in heritage assessment were invited. The meeting was held on the 15th of October 2004 (minutes of the meeting and a power point presentation are included in *Appendix A* of this report). An opportunity for a representative from each group to participate in the fieldwork was provided.

Seven Aboriginal people participated in the fieldwork: Barry French, Rhonda Ward, Beverley van Vliet, Scott Franks, Mick Matthews, Tony Matthews and Des Hickey. Barbara Foot also visited the site during the fieldwork.

Further consultation was undertaken by ERM. ERM prepared this FINAL assessment report detailing the results of the survey and proposed management recommendations. This report will be circulated to the following Aboriginal groups:

- Wanaruah Local Aboriginal Land Council;
- Wonnarua Nation Aboriginal Corporation;
- Ungooroo Aboriginal Corporation;
- Upper Hunter Wonnarua Council;
- Combined Council of Hunter Valley Aboriginal Corporation;
- Lower Wonnarua Tribal Consultancy Pty Ltd;
- Wonnarua Aboriginal Custodians Corporation;
- Wattaka Wonnarua CC Service;
- Yarrawalk Enterprises;
- Valley Culture;
- Upper Hunter Aboriginal Corporation; and
- Hunter Valley Cultural Consultants.

A representative from each group will be contacted to discuss the FINAL report and any issues related to ERM's archaeological assessment and proposed management recommendations. Subsequent to this consultation additional reporting of social (Aboriginal) assessment by the Aboriginal community will be incorporated into the report by ERM and management recommendations will be revised if this is deemed necessary. Communications between ERM and the Aboriginal groups will be documented (written responses from the Aboriginal community groups will be included in *Appendix A* of this report). The final assessment report will be forwarded to all groups.

2.2 *CONSULTATION WITH HISTORICAL SOCIETIES*

Two historical societies were consulted for input into the assessment

- Singleton Historical Society and Museum; and
- Singleton Family History Society Inc.

Consultation involved sending letters requesting information about heritage items that may occur within the study area. A map was included with the letter clearly showing the study area boundary. Ian Webb responded on behalf of the Singleton historical society.

3 *BACKGROUND INFORMATION*

The following information provides the context in which cultural material in the study area can be understood and assessed. It includes information on the local environment, previous archaeological investigations in the local area and region and historical context.

3.1 *ENVIRONMENTAL CONTEXT*

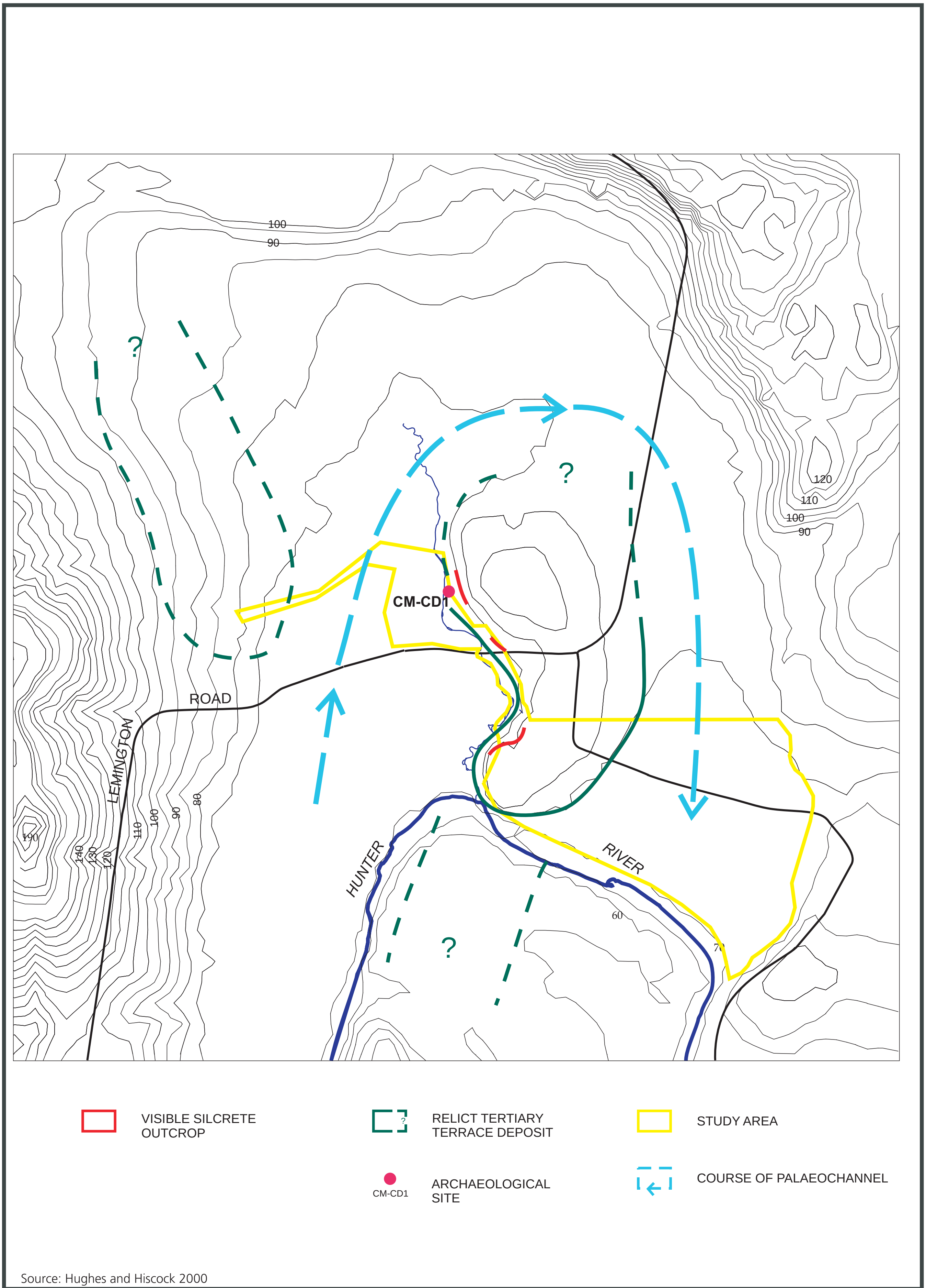
The study area is largely situated on alluvial flats adjacent to the Hunter River. A low ridge runs through the centre of the study area dividing the area into eastern and western parts. This ridge has been identified as a relict Tertiary river terrace and is associated with a palaeochannel of the Hunter River (*Figure 3.1*). The Hunter River is the major drainage channel in the vicinity of the study area and constitutes the study area's southern boundary. A minor unnamed creek bisects the study area at the foot of the low ridge. Another creek line runs through the eastern part of the study area.

Four different landform elements as well as disturbed areas can be identified within the study area (shown in *Figure 3.2*). These elements include:

- alluvial flats associated with the Hunter River;
- creek lines, which occur in both the eastern (eastern creek) and western (western creek) parts of the study area;
- slopes associated with a low ridge; and
- the ridge crest.

The underlying geology of the area is comprised of Tertiary alluvial deposits overlying Permian sediments of the Whittingham Coal Measures (1:100 000 Hunter Coalfield Sheet 90033). Silcrete outcrops are known to occur on the relict Tertiary terraces of the Hunter River *(Figure 3.1)* and these may have been important sources of raw material for Aboriginal people (ERM Mitchell McCotter 1999, White 1999:144, but see Hughes and Hiscock 2000:33). However, river cobbles of mudstone and silcrete and various other material in and along the Hunter River (ie the river's gravel beds) were likely to have been the most important raw material source.

The soils in the study area are of two types, rich alluvial soils on the floodplain belonging to the Hunter soil landscape, and sandy, loamy soils associated with the low ridge belonging to the Liddell soil landscape (Kovac and Lawrie 1991). Soils of the Hunter soil landscapes are formed in an aggrading landscape prone to seasonal flooding and drying (and cracking); alluvium is the parent material.



Source: Hughes and Hiscock 2000

Jobs/2004/0024143Fg3.1 Hunter River Palaeochannel.cdr 15 12 2004 SP Environmental Resources Management Australia Pty Ltd

ERM

0 500m
Approximate only

Figure 3.1 **The Hunter River Palaeochannel**

Coal & Allied - Carrington Extension - Archaeological Assessment

Jobs/2004/0024143/Final Report/-Fg3.2RevA Landform Elements.cdr 3.8.2005 AP Environmental Resources Management Australia Pty Ltd

Figure 3.2 **Landform Elements**

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Erosion of these soils is associated with stream bank erosion along watercourses (the most significant being the Hunter River). The soils of the Liddell soil landscape are formed in situ from parent rock in a degrading or erosional environment – minor to severe sheet erosion is common. Soils are described in greater detail by ERM Mitchell McCotter (1999a:4.4-4.6).

The study area is currently being used for grazing. Native vegetation, which would have consisted of lush riparian vegetation communities close to the river, and open woodland and grasses on the ridge and away from the river, were cleared long ago. Only two small areas of remnant woodland occur in the study area: along the creek in the east of the study area and on the western slope of the low ridge. A few isolated trees occur in the north east part of the study area and are associated with farm buildings. Prior to European settlement the river and native vegetation community would have provided a wealth of resources for Aboriginal people.

The clearing of the property would have had a significant impact on the archaeological material. The removal of trees and ploughing of fields may have disturbed artefacts at some depth. A small neglected vineyard, which takes up much of the western part of the study area, is associated with considerable disturbance on the alluvial flats and areas near the western creek. The hard hooves of grazing animals may also have impacted surface material. The construction of Old Lemington Road, houses and structures associated with farming activities (refer to *Section 3.3)*, may also have had some impact on cultural material. More recently, three areas within the study area (shown on *Figure 3.2*) have been disturbed. Disturbance in these areas involved the removal of the soil profile that may have contained cultural material and/or the dumping of large volumes of material on top of the intact ground surface. In either case these areas have little or no potential to contain material of any cultural value or material that is not in a highly disturbed context.

3.2 ARCHAEOLOGICAL BACKGROUND

A large number of archaeological investigations, most of which have been commissioned to assess mining developments, has lead to the archaeology of the region and the local area being quite well known in terms of the location, frequency and types of sites (ERM 2004a:73; see also Hughes 1984). Investigations in the local area include surveys by Dyall (1976), Brayshaw (1981, 1983, 1985 and 1989), Brayshaw and Rich (1992), ERM Mitchell McCotter (1995, 1999a and 1999b), Australian Museum Business Services (AMBS) (2000 and 2003) and excavations by Hiscock et al (2000), Hughes and Hiscock (2000), Hughes and Shawcross (2001) and AMBS (2001). This section draws from these studies to outline archaeological research themes related to modelling of past Aboriginal occupation, the antiquity of Aboriginal behaviour and cultural change over time. These themes or issues are considered the most important for the Hunter Valley region (ERM 2004a). These studies, together with data held by the

Department of Environment and Conservation (DEC), are also used to describe the archaeology in the local area and all previously recorded sites in the study area.

3.2.1 *Aboriginal Heritage Information Management System (AHIMS) Database Results*

A search of the DEC's AHIMS database within the area defined by AMG coordinates 306500 E to 312100 E and 6399500 N to 6406000 N found 106 sites (*Table 3.1*). The location of these sites is shown on *Figure 3.3.*

Table 3.1 Sites in the AHIMS Search Results

Site Feature	Total	Percentage (%)
Artefact (stone, bone, shell, ceramic and metal) (AFT)	101	95
Artefact, Scarred or Carved Tree (AFT,TRE)	3	< 3
Axe Grinding Groove (AFT)	1	< 1
Quarry, Artefact (STQ,AFT)	1	< 1
Total	**106**	**100**

Based on AHIMS search carried out on the 6th of October, 2004

The results of the AHIMS database search lists sites described in terms of site features. Recorded sites may contain numerous site features and are not designated a site type, however site features generally indicate site type. Sites described by feature AFT are typically stone artefact scatters or isolated artefacts.

3.2.2 *Archaeological Models*

Results of the previous investigations in the local area, listed above, are consistent with the general understanding of archaeology in the Central Lowlands of the Upper Hunter Valley, which describes sites being closely tied to water and particularly the many creeks which flow into the Hunter River (ERM 2004:52-54). Models of occupation explaining this pattern of site distribution are rarely articulated; instead models are generally framed in terms of predictive statements describing types and frequencies of sites within particular landscapes or landform elements. For example Koettig (1994:78) citing Hughes (1984) argued that 'One of the "models" for the distribution of archaeological evidence along the creek lines is that the frequency of evidence is higher along more permanent water courses than along more ephemeral ones'.

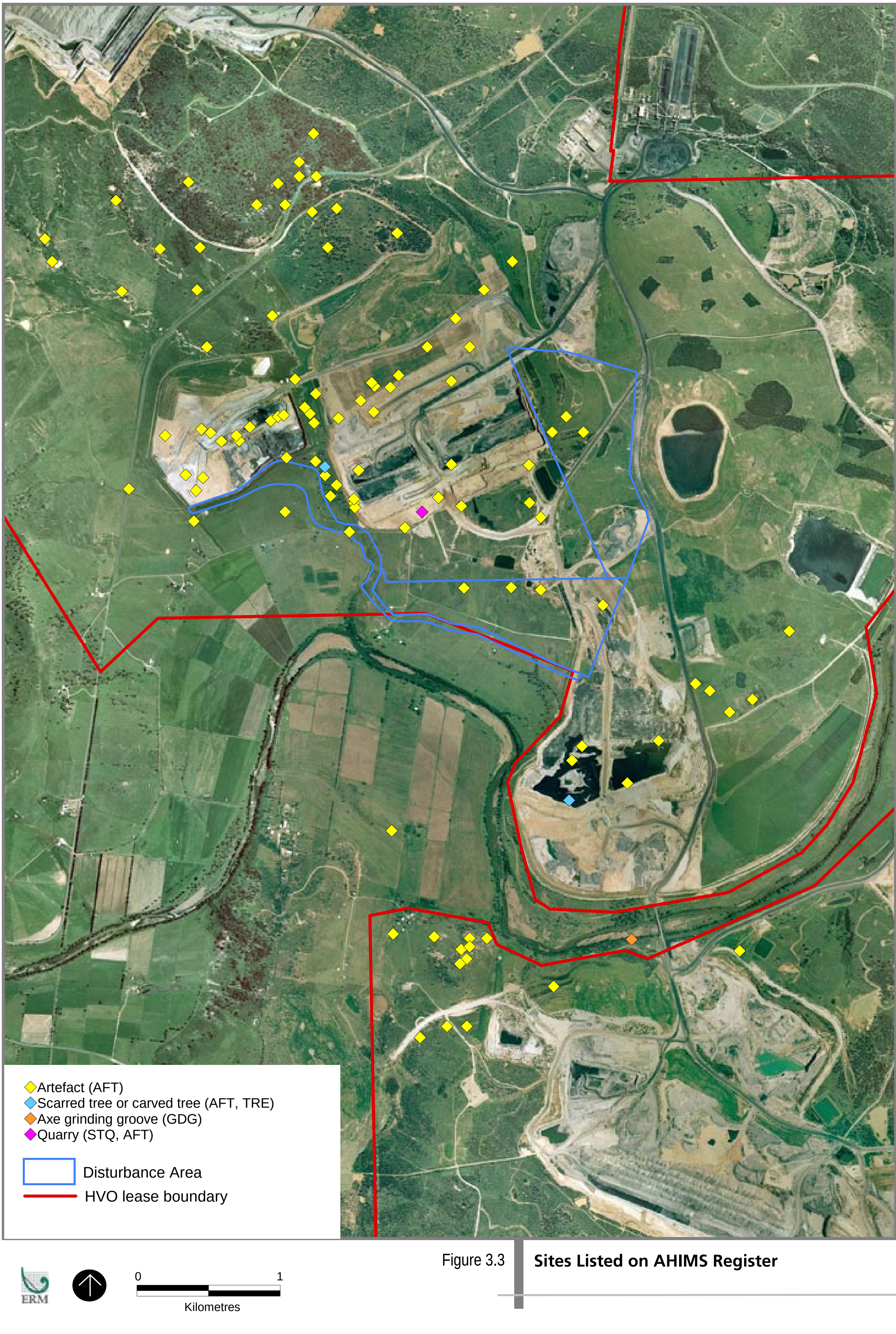

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Figure 3.3 **Sites Listed on AHIMS Register**

The degree to which 'the frequency of archaeological features reflects frequency of occupation or length of occupation has not been investigated for the Central Lowlands' (Koettig 1994:78) and little progress, in terms of understanding past Aboriginal behaviour, has been made since this study was published. Koettig went on to make some general statements concerning how occupation might be reflected by patterns in the archaeological record (derived from 'ethnographic evidence' from other parts of Australia), but did not formulate a clear archaeological model describing past Aboriginal occupation that might be confirmed or refuted by archaeological evidence.

Ethnohistoric records (reviewed in Miller 1985, Brayshaw 1986 and ERM 2004a) have proved of little use in understanding prehistoric Aboriginal behaviour (Hughes 1984:36, ERM 2004a:66). However a number of general models, framed within general models of hunter-gatherer settlement systems (sensu Binford 1980), have been proposed.

AMBS has proposed an archaeological model for a number of assessments in the Central Lowlands explaining the known pattern of site distribution in terms of small mobile groups (eg see AMBS 2003:10-14). AMBS (2003:43) proposed that 'archaeological material can be explained by sequential positioning of foraging radii along creek valleys over millennia'. AMBS argued that this pattern of settlement and mobility has resulted in 'a continuous archaeological distribution close to creeks, reflecting domestic and maintenance activities' and a sparse scatter of material away from creeks, including slopes and ridgelines, reflecting resource gathering activities.

Witter (cited in Kuskie 1999:48) suggests a different model, interpreting most sites along creeks to be peripheral to 'base camps' near the Hunter River and its major tributaries. This model describes Aboriginal occupation in terms of a collector system (see Binford 1980); rather then the forager system preferred by AMBS. Excavations at AHIMS site # 37-5-166 and AHIMS # 37-5-63 located on the southern and northern shores of the Hunter River respectively and approximately 500 m to the south west of the study area confirms the importance of the Hunter River as having been a focus of occupation and also suggests that sand bodies in this context may have been a particular focus (Hiscock et al 2000, Hughes and Shawcross 2001). ERM (2004a:54) also considered the Hunter River to have been an important (perhaps the most important) focus of occupation. However large sites that might represent 'base camps' are not common close to the Hunter River, possibly because of environmental factors, such as sedimentation and fluvial erosion that occur during flooding events, and lush riparian vegetation, which might destroy or obscure sites in this context. Criteria for distinguishing base camps from other sites typically found along creek lines, has also not yet been established although AMBS (2001, 2003) suggested a measure of intra site diversity may be a useful criterion.

The model proposed by AMBS is also difficult to test because it is very general – the results of most studies in the region will generally conform to its predictions. Also, neither model takes account of cultural changes over time (the implication being that the models only describe Aboriginal occupation in the mid to late Holocene or that settlement systems have not changed).

The focus on landscape archaeology, or at least the division of study areas into many landform elements (eg Kuskie 1999), has some potential to further our understanding of Aboriginal behaviour and develop existing behavioural models.

However this approach has not as yet provided any significant insights, either because the number of artefacts found within landform elements other than creek valley floors are generally too small to compare different landform elements, or because fieldwork and analysis has not been undertaken within any archaeological framework constructed to test more specific or alternative models.

With few exceptions past Aboriginal life in the Hunter has not been a focus of academic archaeological research (ERM 2004:52). Archaeological models for the Hunter Valley continue to be presented as lists of statements predicting the type and number of sites in particular parts of the landscape, based on previous archaeological investigations of local areas.

3.2.3 Antiquity Of Aboriginal Occupation And Cultural Change

The antiquity of Aboriginal occupation in the Hunter Valley has not been established. The vast majority of recorded sites in the region are open sites with no potential to date occupation. While it is likely that Aboriginal people lived in the Hunter Valley throughout the Holocene and during the late Pleistocene, only a few sites provide significant evidence for this. Sites at Warkworth (AMBS 2002, with additional information ERM 2004a), Fal Brook (Koettig 1986) and Moffats Swamp (Baker 1994) have been dated to the late Pleistocene period, however some questions remain regarding the association between the cultural material and the material dated at these sites. Two other sites are often referred to as Pleistocene in age, CM-CD1 (Hughes and Hiscock 2000, see *Section 3.2.3*), and a site at Lemington, reported by Kuskie (in his 1999 Mount Arthur assessment report, the Lemington excavation report has not been submitted to DEC).

There are also few sites in the region that have been identified as stratified. Sandy Hollow 1 and Milbrodale 1 are the only rock shelter sites to have been excavated in the Upper Hunter Valley region (Moore 1970). While shelter sites are the most likely type of site to contain stratified deposit, recent investigations have identified the potential of sand bodies and colluvial deposits to contain stratified deposits. For example, excavations of W14 at Warkworth (AMBS 2002), CM-CD1 at Carrington (Hughes and Hiscock 2000), and DE1 at Devils Elbow (ERM 2004b) all indicate stratification at these sites.

Given this paucity of dated sites and also known stratified sites in the region, the antiquity of occupation and the identifications of cultural changes over time are perhaps the two most outstanding archaeological issues in the region.

3.2.4 Investigations In The Local Area

The investigation most relevant to the present study is the archaeological assessment for the Carrington Mine Environmental Impact Statement (EIS) that was undertaken by ERM Mitchell McCotter in 1999. Authorisation A435, a large area of over 200 hectares north of the present study area, was the focus of ERM Mitchell McCotter's survey. This area includes a large portion of the creek line that runs through the western part of the study area. Part of the present study area was also surveyed. Geomorphic and archaeological investigations associated with the ERM Mitchell McCotter assessment (Hughes 1999, Hughes and Hiscock 2000) also provides valuable information including results of the excavation of a number of test pits along the creek line within the present study area. These studies found possible evidence of Pleistocene occupation. Also relevant are a number of investigations undertaken at site 37-5-63 which is located less than 500 metres south east of the study area (reviewed in Hiscock et al 2000) and the alluvial flats immediately east of the study area (Brayshaw 1985, Haglund and Rich 1992) and two studies undertaken by AMBS focussing on an area immediately north of the study area (AMBS 2000, 2001) and one desktop study (ERM 2003) which considers all previously recorded sites in the study area and local area.

ERM Mitchell McCotter's 1999 Surveys

ERM Mitchell McCotter (1999a, 1999b) recorded 47 sites during a number of surveys focussing on Authorisation A435 a large area including part of the present study area. The overwhelming majority of sites recorded were stone artefact scatters and isolated finds. Two sites were identified as silcrete sources (or quarry sites), CM2 and CM37. Both are on relict Tertiary river terraces and part of one of them, CM2, is within the present study area. CM37 was interpreted as having been a site used for the procurement of raw material or primary reduction; CM2 was interpreted as having been used for both stone procurement and general 'stone working' (1999b:11.22).

Large numbers of artefacts were recorded at both source sites and at many other sites recorded by ERM Mitchell McCotter (1999a and b) and much larger numbers of artefacts were predicted to occur, eg CM2 was predicted to contain 70,000 artefacts (1999a:11.5), subsequently revised down to 7300 (1999b:4.10). These estimates are not convincing and it is likely that many of the artefacts recorded during the ERM Mitchell McCotter surveys are in fact naturally fractured stone. Many of the artefacts recorded were classified as 'fragments' – 'flaked pieces which were obviously worked but had no distinctive percussion marks' (1999b:3.6). Of the artefacts from all sites for which data is provided (see 1999b:Table 4.6) approximately half were classified as fragments. Inspection of photographs (see eg 1999b:Photographs 14 and 17) also suggests non-artefactual fragments of stone may have been recorded as artefacts.

Further assessment of the sites by ERM Mitchell McCotter, Hughes and Hiscock (2000) indicated that artefact counts might have been inflated due to the presence of naturally heat fractured stone.

ERM Mitchell McCotter made a number of predictive statements for specific sites and landform elements that are relevant to the present study (these should be considered in light of the artefact identification issues discussed above):

- The alluvial flats 'may contain subsurface material, however the likelihood of finding such material is extremely low' (1999b:4.17), ERM Mitchell McCotter et al (2000) also predicted that the ephemeral drainage lines on the flats, which are likely to be late Holocene in age, may have acted as a slight focus of occupation;

- The low ridge exhibits a continuous spread of artefacts dominated by silcrete (1999b:4.11), however the ridge is an erosional environment and subsurface material is unlikely to occur (1999b:4.16); and

- CM2 is situated on an erosional environment, therefore subsurface material is unlikely to occur. Colluvial deposit at the base of CM2 (later designated CM-CD1) has significant archaeological potential (see below).

Hughes (1999), in an Appendix to ERM Mitchell McCotter's (1999b) report, also identified some potential evidence of Pleistocene occupation. This resulted in further investigation by Hughes and Hiscock.

Hughes And Hiscock's 2000 Excavation

Subsequent testing by Hughes and Hiscock (2000) confirmed Hughes' (1999) assessment and an area, designated as site CM-CD1, was identified as the area that could represent the extent of a Pleistocene deposit. This area is along the creek line in the western part of the study area. A total of 72 artefacts was identified in the sediments excavated at CM-CD1. Most of the artefacts (65) were contained in unit five, also referred to as the Older Stratum, which is a stratigraphic unit considered to be early Holocene or late Pleistocene in age. This assessment was based largely on the extent of weathering and physical alteration of the sediment. Despite the small sample size Hughes and Hiscock suggested a number of aspects of the site provide insight into past Aboriginal occupation:

- the relatively high artefact density within the Older Stratum ie much higher than the surrounding sites, suggests that a different system of occupation may have been employed by Aboriginal people in the early Holocene or late Pleistocene; and

- the absence of cores, extensively retouched flakes and small flakes suggest that knapping was done elsewhere and flakes were carried to the site.

CM-CD1 has been subsequently managed under a Cultural Heritage Indigenous Management Agreement.

Hiscock et al 2000

As described above, Site 37-5-63 was located less than 500 metres south east of the study area. This site was recorded as a very large artefact scatter containing large numbers of artefacts over an area of 24 hectares. The site was situated in a sandy context across a low spur in close proximity to the Hunter River. For some time this was considered one of the most significant sites in the region and consequently was the focus of numerous excavation programs before its destruction by mining (reviewed in Hiscock et al 2000). This large site was considered to reflect an important focus of Aboriginal occupation containing a large diversity of stone artefacts. However artefact analysis undertaken by Hiscock and Shawcross (in Hiscock et al 2000) found the sites to be very disturbed and was unable to provide much information about Aboriginal behaviour.

The environmental context associated with site 37-5-63 does not occur in the study area.

Surveys On The Alluvial Flats (Brayshow 1985, Haglund And Rich 1992)

A number of surveys have been undertaken on the alluvial flats east of the study area (eg Brayshaw 1985, Haglund and Rich 1992). Artefacts were found to occur at low densities in this context. The alluvial flats were generally considered to have little archaeological potential due to the low numbers of artefacts found, the perceived paucity of sub surface material and disturbance caused by growing crops and grazing cattle.

AMBS 2000 And 2001 Survey And Excavation

AMBS was commissioned to reinvestigate a number of sites recorded by ERM Mitchell McCotter (1995) about one kilometre north of the present study area. The aim of this reinvestigation was to record additional site information, inspect additional areas and compare findings with sites recorded by ERM Mitchell McCotter (1999a, 1999b) at Carrington. AMBS recorded a total of 179 artefacts from seven sites and identified two sites with high archaeological potential, ie potential to address questions concerning settlement patterns and antiquity. Subsequent excavations found a very low density distribution of stone artefacts in this area, interpreted as reflecting a variety of activities. No evidence of late Pleistocene or early Holocene material was found.

ERM's 2003 Review

ERM reviewed previous archaeological investigations undertaken within CNA Mine Lease areas north of the Hunter River as part of the West Pit Extension and Minor Modifications EIS *(ERM, 2003)*.

The purpose of this review was to consolidate development consents held by CNA. The subsequent development consent issued by the Department of Infrastructure, Planning and Natural Resources (DIPNR), incorporating the DEC's general terms of approval, included conditions (Condition 39, 40 and 41) which relate specifically to the previously recorded sites within the study area.

39. The applicant shall apply to the DEC for section 90 consents to destroy under the NP&W Act for the following sites: …[list including sites CM1, CM19, CM32, CM45 and CM46]

40. The Applicant shall continue the Cultural Heritage Indigenous Management Agreement developed in consultation with, and to the satisfaction of, the Wonnarua Tribal Council, particularly in relation to the management of Site CM-CD1 and Older Stratum… which may include consideration of permanent conservation status for the site CM-CD1, and also sites CM1, part of CM2, CM19 and CM32…

41. The Applicant shall not mine within 60 metres of the area CM-CD1, and the Older Stratum being measured from the margin of the predicted maximum extent of that deposit…, unless otherwise agreed by a Cultural Heritage Indigenous Management Agreement (condition 40).

3.2.5 Sites In The Study Area

Of the sites listed on the AHIMS register and reported in the studies described above, seven previously recorded Aboriginal sites are located in, or very close, to the study area (*Table 3.2* and *Figure 3.3*).

Table 3.2 Sites previously recorded within or near the study area

Site	AHIMS #	Location (AMG)	Site Type	Site Description
CM1	37-2-1504	308853E 6403098N	Artefact scatter	This site was recorded by ERM Mitchell McCotter (1999a: 11.14) as an 'Open Camp Site' along the creek for about 300 metres consisting of 214 artefacts. Its southerly extent is the culvert at Old Lemington Road, therefore it should be considered contiguous with, or overlapping two other sites: CM2 and CM-CD1.
CM2	37-2-1505	308763E 6403428N	Artefact scatter	This large site, 120 metres by 50 metres was interpreted by ERM Mitchell McCotter (1999a: 11.15) as 'an initial stone working area' containing an estimated seventy thousand artefacts. Subsequently reassessed by ERM Mitchell McCotter et al (2000) to have far fewer artefacts than was originally estimated. Much of this site has been destroyed (under consent # SZ311) and only a very small part of what remains of this site is within the study area.
CM19	37-2-1522	308400E 6403240N	Isolated find	This site is an isolated artefact located on alluvial flats near the western boundary of the study area.
CM32	37-2-1535	307758E 6403775N	Artefact scatter	This site is located near the western boundary of the study area. Six artefacts, exposed by vehicle and stock movement were recorded. The area of the site was not recorded.
CM45	37-2-1962	309992E 6402708N	Artefact scatter	This site is located on alluvial flats in the north east part of the study area. Two artefacts were recorded by ERM Mitchell McCotter in an area of approximately 150 metres by 50 metres. This site was not identified during this assessment.
CM46	37-2-1963	309660E 309660N	Artefact scatter	This site is located on alluvial flats in the north east part of the study area. Three artefacts were recorded by ERM Mitchell McCotter in an area of approximately 80 metres by 50 metres. ERM Mitchell McCotter estimated that approximately 500 artefacts would be contained in this site. This site was not identified during this assessment.
CM-CD1	37-2-1877	308720E 6403350N	Artefact scatter	This site is an archaeological deposit (CD=colluvial deposit) which may contain evidence of Pleistocene occupation (Hughes and Hiscock 2000). This site is located at the base of the low ridge in the western part of the study area, immediately below site CM2. The potential extent of this deposit is 450 metres by 25 metres.

3.3 *Predictive Statements*

Previous archaeological investigations in the local area and region lead to the following predictive statements for Aboriginal cultural heritage:

- archaeological material (stone artefacts) may occur in exposures or eroded areas (any area of archaeological visibility) wherever these occur in the landscape;

- the number of sites and artefact densities will be highest in the vicinity of the creek line (sites on slopes and ridges, if they occur, are likely to be isolated finds and low density artefact scatters over large surface areas);

- evidence of procuring stone from boulders or cobbles outcropping on the ridge may occur;

- trees that have been scarred by Aboriginal people may occur in areas of remnant eucalypt woodland; and

- other sites, such as burials, stone arrangements, grinding grooves and carved trees are unlikely to occur either because they are rare types or environmental conditions are not conducive to their preservation.

Historical research indicates it is unlikely that heritage items of any significance will occur in the study area. If heritage items do occur they are likely to be associated with farming activities.

3.4 *Historical Background*

The Hunter Valley was one of the first areas to be identified as suitable pastoral land early in the Colony's history. It was opened up to free settlement in 1820 and was quickly taken up (Heritage Office 1996:46). The Central Lowlands of the upper Hunter and particularly the alluvial lands around the Hunter River have been the focus for intensive farming ever since this time. Only in recent decades has coal mining become the major industry in the region.

The township of Lemington, also referred to as Leamington, was located approximately one kilometre east of study area (*Figure 3.4*). The township, now displaced by mining, was at one time planned to be a 'grand town' and Mitchell surveyed the Great North Road to pass through it (Heritage Office 1996:47). Parts of the Mitchell Line Road, indicating Mitchell's chosen route for the Great North Road, still remains in the area and passes only a few hundred metres east of the study area. Work on the Great North Road ceased in 1836 and presumably much of the northern section was never completed (Lavelle et al 1999:8-9, see also Griffin 2004)

In order to identify any historical heritage issues related to the study area research was undertaken that involved searching relevant heritage registers, viewing relevant historical and parish maps and consultation with the Singleton Historical Society. A previous cultural heritage assessment undertaken by ERM Mitchell McCotter (1999a: 11.36) focusing on Authorisation A435, which includes parts of the present study area, found no items of European heritage (1999a:11.36).

3.4.1 Heritage Register Searches

The following register searches were undertaken:

- Australian Heritage Database (includes the Register of the National Estate, Commonwealth Heritage List and National Heritage List);
- State Heritage Register and Inventory;
- EnergyAustralia Section 170 Register;
- Roads and Traffic Authority Section 170 Register;
- Singleton Local Environmental Plan;
- Hunter Regional Environmental Plan; and
- National Trust of Australia.

Australian Heritage Database (Includes The Register Of The National Estate, RNE, Commonwealth Heritage List, CHL And National Heritage List, NHL)

The RNE, CHL & NHL were searched on 20 October 2004 by local government area, Singleton. No heritage items were located within the study area.

State Heritage Register (SHR) and Inventory (SHI)

The SHR and SHI were searched on 20 October 2004 by local government area, Singleton. No heritage items were located within the study area.

Energy Australia Section 170 Register

This section 170 register was reviewed and there are no heritage items located within the study area.

Roads And Traffic Authority (RTA) Section 170 Register

The RTA's Heritage and Conservation Register for the Hunter region was reviewed on line on 22 November 2004. No heritage items were located within the study area.

Singleton Local Environmental Plan

No listings are within the study area.

Hunter Regional Environmental Plan (REP) 1989

The REP was reviewed and no heritage items were located within the study area.

National Trust Of Australia

No heritage items are listed within the study area based on information provided by Paul Fletcher, National Trust Sydney on 22 October 2004.

3.4.2 Consultation

Ian Webb of the Singleton Historical Society and Museum indicated that the only known heritage item in or near the study area is the Great North Road.

Historical maps, including a map of the Great Northern Road provided to ERM by Ian (dated 1833) indicates the Great North Road, or its proposed route known as the Mitchell Line, runs east of the study area (see *Figures 3.3* and *3.4*).

3.4.3 Historical Maps, Parish Maps, And Aerial Photographs

Historical maps and old parish maps (*Figures 3.4* and *3.5*) provide little evidence suggesting heritage items may occur in the study area. The study area falls within lands that have, until recently, been divided into large farming lots. Parish maps indicate that the existing road that runs through the study area, referred to as Old Lemington Road, was built sometime between 1920 and 1935. This suggests that houses in the study area are no older than this time. An aerial photograph taken in 1958 confirms that many of the structures in the study area were in place at that time.

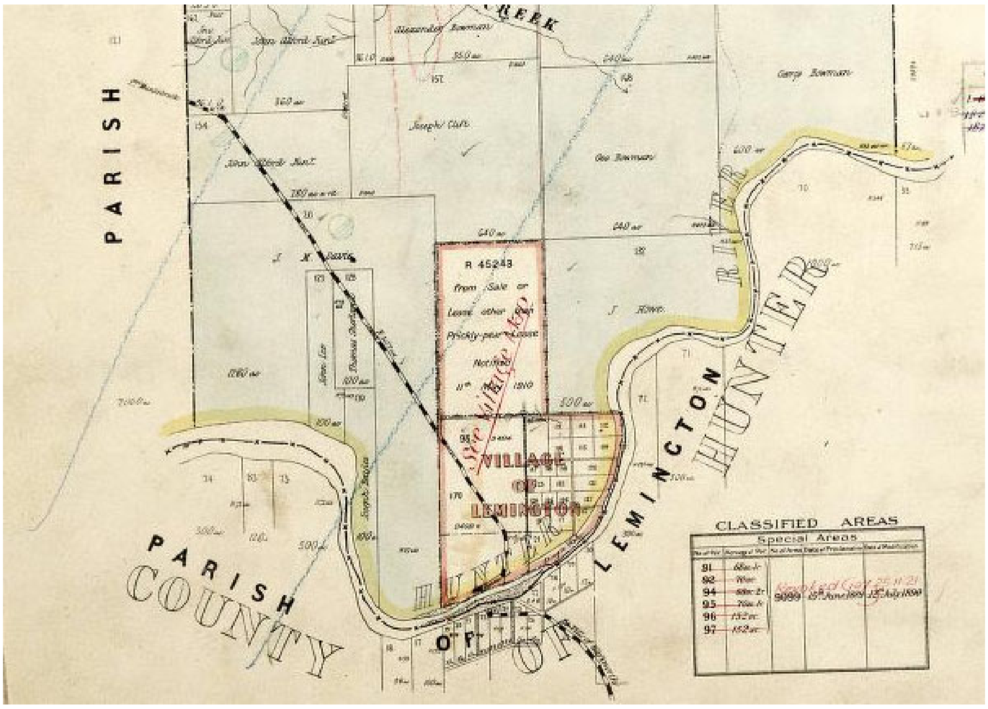

Figure 3.4 Extract from Ravensworth Parish map (1920)

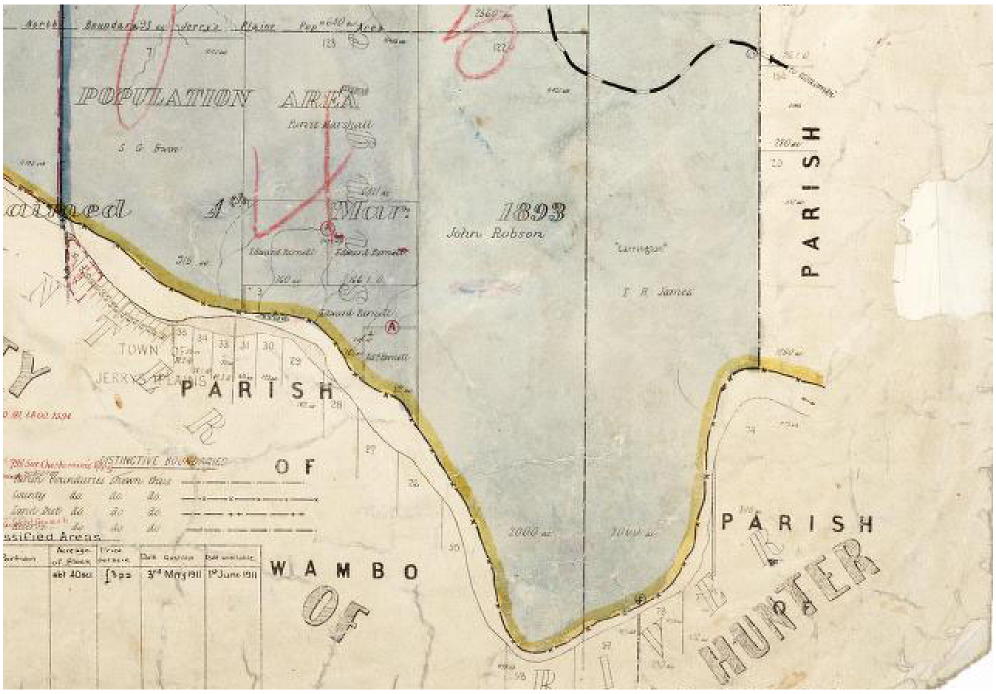

Figure 3.5 Extract from Howick Parish map (1893)

3.4.4 Historical Sites In The Study Area

No heritage items have been recorded in or around the study area.

4 SURVEY METHODOLOGY

The survey involved two archaeologists and seven Aboriginal representatives systematically walking over the survey area to inspect all areas of exposure or areas with some archaeological visibility. The survey aimed to achieve 100% coverage of the survey area. Methods used to identify and record exposures, artefacts and sites are detailed in the following sections.

4.1 EXPOSURES

For the purpose of this survey, exposures were defined as areas where erosional processes, such as sheet wash, vehicle and cattle tracks and gullying allow the detection of surface or sub-surface stone artefacts. Visibility refers to the proportion of the exposure area in which the ground surface was visible. Using these definitions small areas of exposure in close proximity could be grouped together as one exposure (with limited visibility). Note that exposures were not defined as areas in which the topsoil (Unit A) has eroded to reveal the subsoil (Unit B), a definition commonly used, because the depth of the topsoil on floodplain would in most cases preclude subsoil from being revealed. All exposures larger than approximately 50 square metres were recorded.

4.2 SITE DEFINITION AND ARTEFACT IDENTIFICATION

Archaeological sites are places where evidence of past Aboriginal occupation can be identified. Around the study area this evidence is typically in the form of stone artefact scatters. The extent of sites generally reflects the extent of archaeological evidence and is often determined by archaeological visibility. Artefact scatters are not defined by any behavioural criteria; they are simply defined in terms of artefacts in close proximity that typically occur in a single area of exposure. Artefact scatters do not necessarily reflect single events, activities or time periods.

4.2.1 Stone Artefact Identification

Given the presence of naturally occurring stone in the survey area it is important to have some criteria to distinguish the naturally occurring from stone that is Aboriginal in origin ie are the result of stone tool production, maintenance or use. Flaked stone artefacts have a number of diagnostic features that distinguish them from naturally occurring stone (Cotterell and Kamminga 1987). Features such as negative and positive bulbs of percussion, ring cracks, ripple mark, terminations and errailure scars are all indicative of flaked stone artefacts. The criteria used to identify flaked stone artefacts during this survey was one or more of these features.

Non-flaked stone artefacts, such as grindstones and anvils are identified by the presence of pitted, crushed or abraded surfaces.

4.2.2 *Scarred Tree Identification*

Trees that have been scarred by Aboriginal people through the removal of bark (Aboriginal scarred trees) may also occur in the study area. The identification of Aboriginal scarred trees can be a difficult and subjective process. Trees can be damaged by a variety of natural processes, such as breaking branches, disease and infestation, and also by damage caused by machinery such as tractors, that result in scars similar or the same as scars caused by Aboriginal people. Two broad criteria, detailed below, were employed in the identification of Aboriginal scarred trees during this survey.

- the scar must be of a size and shape and location on the tree that suggests it was caused by removal of bark by an Aboriginal person or Aboriginal people. Typically scars are symmetrical in form and a size that suggests the removal of bark for containers or carrying implements shields or canoes. There may also be small scars resulting from the cutting of footholds used to climb trees; and

- the tree (and the scar) must be sufficiently old to indicate that the removal of bark took place at a time when Aboriginal people were employing traditional methods in the production of their material culture. In the Hunter Valley region the trees must therefore have been at a mature age and size during the early to mid 1800's.

4.3 *SITE RECORDING*

The following list outlines what was recorded for each exposure located in the study area:

- location in AMG coordinates using a Garmin 12 Channel hand held Global Positioning System (GPS) unit;

- size (approximate dimensions in metres);

- the content (all stone artefact);

- the visibility (percent);

- the environmental context; and

- the integrity and land use disturbances.

4.3.1 Stone Artefact Recording

Information describing artefact provenance and artefact attributes were recorded on site. All artefact attributes recorded are described in *Table 4.1*.

Table 4.1 Artefact attributes recorded for analysis

Variable	Attribute
Artefact type	Flake (recorded as complete, proximal fragment or other fragment) Core Retouched flake (further categorised as Bondi point , geometric microlith, amorphous scraper, core – or producer) Flaked piece
Implement	Backed artefact (Bondi point, geometric microlith), scraper
Raw material	Mudstone Quartz Silcrete Chert
Size	Maximum dimension (mm)
Cortex	Proportion of cortex remaining on the artefact (%)
Platform type	Cortex – surface is outer weathered surface of a stone cobble or fragment Single scar – platform is a single flaked surface or freshly broken surface Several scars - platform is comprised of several flaked scars Facetted – platform surface is comprised of a series of small scars typically overlying larger scars
Notes	Includes notes on macroscopic signs of use

1. Artefact types defined by Hiscock 2001 (see McCarthy 1976 for implement types).
2. Mudstone is typically fine grained red or yellow material but also includes all other fine grained siliceous material.

5 SURVEY RESULTS

The survey of the study area was carried out over two days, the 26th and 27th of October 2004, by ERM archaeologists and representatives from the Aboriginal community. The survey involved traversing the entire area on foot or in a vehicle. Ten previously unrecorded sites were found and three recorded sites were relocated during the survey.

5.1 SURVEY COVERAGE

At the time of the survey there was limited archaeological visibility in the study area. Thick grass cover obscured the ground surface in all landform elements. *Photograph 5.1* and *5.2* shows the typical visibility (ie 0%) on the alluvial flats and along the creek lines. However there were a number of small areas of exposure associated with animal and vehicle tracks on the slopes and flats, and minor gully erosion on the slopes (*Photograph 5.3*, see also *Appendix B*). Effective coverage was estimated to be less than 1%. Note that survey coverage (the area within each survey area that was actually walked or driven over) was estimated to be less than 100% (between approximately 20% and 100%) in most survey units (refer to *Table 5.1*). However coverage was sufficient to judge that further traverses would have made little or no difference to effective coverage as the visibility was uniformly close to 0% over the entire study area.

Photograph 5.1 Creek line below CM2 (camera facing south)

Photograph 5.2 Alluvial flats north of Old Lemington Road (camera facing north west)

Photograph 5.3 Base of low ridge, western extent of cattle track in foreground, farmhouse and substation in background (camera facing west)

Table 5.1 Survey coverage data

Survey Unit	Landform Element	Area (Hectares)	Traverse Type	Coverage (%)	Visibility (%)	Effective Coverage (m^2)	Description	Sites
1	Flat	7.1	P	50	0	0	Grass and weeds cover the entire area, much of which is within a small neglected vineyard and therefore quite disturbed . Some areas of very limited visibility occur along a vehicle track which provides access to vineyard building.	CM19, CM32 (not relocated/outside study area),
2	Creek (west)	2.3	P	100	0	0	The creek is located on a flat west of the low ridge. The creek contained some water. Thick grass covers the entire creek line. Some areas of very limited visibility occur along a vehicle track that provides access to a vineyard building.	CM1, CM-CD1
3	Slope (west)	10.3	P/D	50	< 1	< 551	Some areas of visibility are associated with outcrops of large silcrete cobbles in the north of this survey unit, otherwise thick long grass covers the entire slope. Thick low grass cover continues south of Old Lemington Road. There are a number of areas of visibility associated with gully erosion and cattle tracks in this part of the survey unit.	C1, C2, C6, C8, C9, C10, CM2, CM-CD1
4	Crest	5.4	P	20	< 1	< 108	A few small areas of visibility associated with cattle tracks, erosion around buildings and the substation occur on the ridge crest. An area along the very edge of the crest above the steep western slope offers some visibility.	C7
5	Slope (east)	7.7	P	20	< 1	< 154	This east slope is covered in a low grass cover and has limited visibility. The visibility in this area is confined to a cattle track leading to a dam and around several of the buildings. This slope is steep and contains many naturally outcropping rocks.	C6
6	Flat	92.8	P/D	20	< 1	<1856	The alluvial flat consists almost entirely of pasture, which at the time of this survey, was quite thick offering little archaeological visibility. Old Lemington Road, which runs through this survey unit, was built from material transported to the site (and therefore offers no archaeological visibility). A few cattle tracks offer areas of visibility including one long track that runs a few hundred metres south of the road (approximately 300 metres by 0.4 metres). North of the road two areas have been disturbed (levelled) for drilling and offered some archaeological visibility (one area was approximately 40 metres by 30 metres	C3 (scarred tree)

Survey Unit	Landform Element	Area (Hectares)	Traverse Type	Coverage (%)	Visibility (%)	Effective Coverage (m²)	Description	Sites
							with overall visibility of approximately 40%, the other was approximately 30 metres by 20 metres with overall visibility of approximately 30%). A vehicle track north of the road also offered some areas of limited visibility.	
7	Creek (east)	8.6	P	100	< 1	< 860	This meandering creek line is deeply incised close to the river. A few small areas of visibility are associated with trampling on steep banks. The creek widens into what appears to be a small lagoon in the east – a large wide dry creek line with dry dark brown mud surrounded by mature eucalypts.	C4 and C5
	Disturbed areas	6.0	NA	0	NA	0	Disturbed – see description in text.	

1. P = traverse on foot (pedestrian), D = traverse in the vehicle (vehicular).

5.2 *SITES*

Ten previously unrecorded sites were found during the survey: seven artefact scatters, two isolated finds and one scarred tree. Two sites, previously recorded by ERM Mitchell McCotter (1999a) were also found: CM1 and part of CM2 and the third previously recorded site, CM-CD1 has been fenced by CNA. Sites CM19, CM32, CM45 and CM46 were not relocated. As sites CM19 and CM32 were not found and were recorded outside the present study area by ERM Mitchell McCotter, 1999a, they are not considered further in this assessment. All sites within the study area are shown on *Figure 5.1*. Photographs of sites are provided in *Appendix B*.

5.2.1 *Previously Unrecorded Sites*

Ten previously unrecorded sites were found during the survey. Detail of these sites, including site descriptions and locations, are provided in *Table 5.2*. Details of the contents of each site, ie the stone artefacts recorded at each site, are provided in *Appendix C*. Summary data for all artefacts recorded are provided in *Table 5.3*.

5.2.2 *Previously Recorded Sites Included In The Survey*

Five sites have previously been recorded within the study area, four sites by Mitchell McCotter (1999a): CM1, CM2, CM45 and CM46; and one site by Hughes (2000): CM-CD1. Site CM-CD1 has been fenced by CNA and was not further investigated during this survey however information pertaining to the site has been discussed as part of this report. Sites CM45 and CM46 were not relocated. A single artefact was found at CM1. Part of CM2 may have been collected by the local Aboriginal community and seventeen artefacts were recorded at the site during the present survey; most of these artefacts were recorded within one relatively small sample area.

Site CM2 was recorded by ERM Mitchell McCotter (1999a) as a relatively large site extending along the low ridge crest and slope. Most of the site is actually up slope and east of the study area. At the time of the present survey visibility was poor (note that photographs and data recorded by ERM Mitchell McCotter indicates visibility was quite good at the time of the 1999 surveys) and no attempt was made to establish the sites extent within or outside of the study area. Artefacts were found in most areas of visibility near the silcrete outcrops on the slope, but at low densities. Non artefactual fragments of silcrete were more common than artefacts. In order to obtain some data that might be useful in assessing previous estimates of artefact density at the site all artefacts were recorded within a relatively small recording area of approximately 10 metres by 10 metres (ie 100 m^2). This area, located a few metres east of the study area, was selected because it was the area on the slope where most artefacts were found and where visibility was unusually high (approximately 30%). Details of these artefacts are provided in *Table 5.4*.

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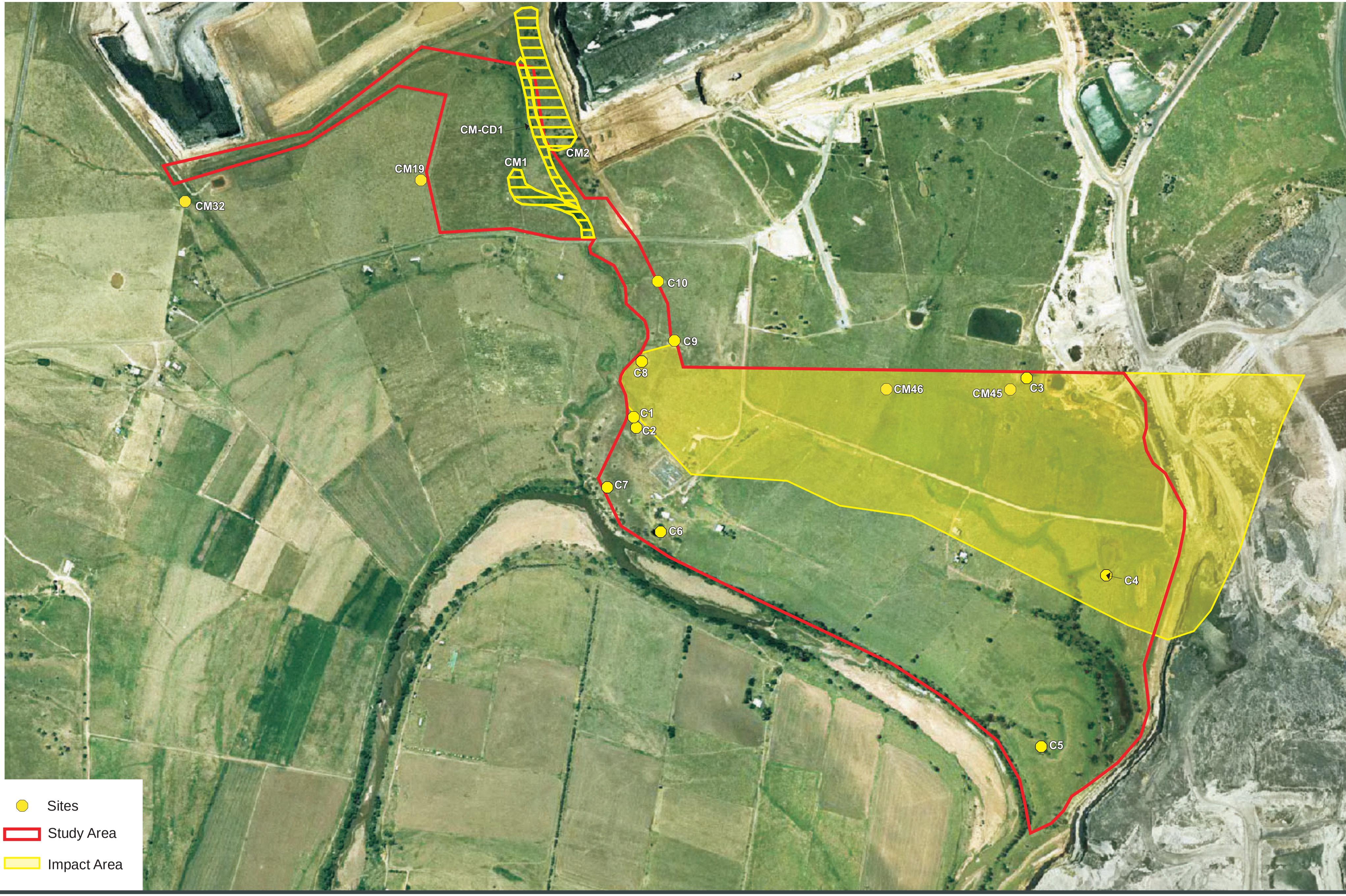

ERM

0 200m
Approximate Only

Figure 5.1 **Location of Aboriginal Sites**

Coal & Allied - Carrington Extension - Archaeological Assessment

Table 5.2 Previously unrecorded sites

Site Name	Site Type	Location (AMG)	Size (m)	Landform Element	Description	Number of Artefacts
C1	Isolated artefact	308983E 6402615N	NA	Slope (west)	Site C1, an isolated artefact, is located on an unformed vehicle track in a cleared paddock. Exposed in an area of very limited visibility. The surrounding area is covered in low grass. A creek is located approximately 100 metres down slope. The site is approximately 40 metres downslope from site C2.	1
C2	Artefact scatter	308990E 6402587N	8 x 5	Slope (west)	Site C2 is located near the crest of a west facing slope. Eight artefacts were recorded in an exposed area approximately eight metres by eight metres, associated with an unformed vehicle track in a cleared paddock. Visibility within the exposed area was approximately 60%. Low grass cover surrounds the site.	8
C3	Scarred tree	310035E 6402740N	NA	Flat	Site C3 is a scarred tree located in a cleared paddock in the north east of the study area approximately 300 metres from a minor creek and 800 metres north of the Hunter River. The tree is one of four remnant trees in an area approximately 100 metres by 20 metres. The tree (probably a eucalypt) appears to have been dead for many years – many borer holes were visible in the scar and on the tree's truck. The scar faces west and has the dimensions 300 millimetres long by 150 millimetres wide. The thickness of the regrowth around the scar is approximately 100 millimetres. A very small area of visibility occurred around the tree (erosion caused by cattle and kangaroos) but no artefacts were found.	Scarred tree
C4	Artefact scatter	310259E 6402215N	50 x 20	Creek (east)	Site C4 is an artefact scatter located near a drainage line in a cleared paddock on alluvial flats approximately 400 metres north of the Hunter River. This site is located in an area that has been excavated for a dam or borrow pit (approximately 70 metres by 60 metres) and in an incised meandering channel that drains this area. Artefacts occur in an area approximately 50 metres by 20 metres along the side of the dam and drainage channel. Overall visibility in this area was approximately 40% (visibility was obscured by sedimentation in the dam).	5
C5	Isolated artefact	310093E 6401752N	NA	Creek (east)	Site C5 is an isolated artefact that was found on a steep (approximately 40^0) side of a deeply incised creek bank in a cleared paddock less than 100 metres north of the Hunter River. The artefact was found in one of the few areas of visibility along the creek line – an area of approximately eight metres by four metres, eroded by cattle trampling. Mulberry trees are scattered along the creek line and large Eucalypts occurs closer to the river.	1

Site Name	Site Type	Location (AMG)	Size (m)	Landform Element	Description	Number of Artefacts
C6	Artefact scatter	309061E 6402309N	1 x 1	Slope (east)	Site C6 consists of two stone artefacts found on a cattle track (approximately 50 metres by 0.5 metres with visibility approximately 80%) leading to a small dam behind a farmhouse less than 50 metres from the Hunter River. The artefacts occur within an area of approximately one metre square a few metres from the dam. The site occurs on a gentle slope (approximately 5-10^0) which steepens towards the river. The surrounding area is cleared with low grass cover.	2
C7	Artefact scatter	308916E 6402426N	14 x 5	Crest	Site C7 is an artefact scatter located on the crest of a prominent ridge overlooking the Hunter River. The site occurs at the edge of a very steep west facing slope in an area with limited visibility (along the edge of the slope approximately 100 metres long and 10 metres wide with visibility less than 20%). Artefacts occur within an area of 14 metres (north-south) by five metres (east-west). The ground surface at the site is stony with small cobbles of various materials. Large cobbles of silcrete naturally outcropping near the site. The surrounding area and much of the site is covered by low grass. A single tree grows on the site; several trees occur downslope and close to the Hunter River.	11
C8	Artefact scatter	309001E 6402765N	15 x 10	Slope (west)	Site C8 is an artefact scatter located in the upper slopes of a low ridge approximately 20 metres east of a minor creek and 500 metres north of the Hunter River. The site occurs with an area of exposure caused by minor gully erosion (an area approximately 20 metres by 15 metres with overall visibility approximately 20%). Low grass cover surrounds the site.	18
C9	Artefact scatter	309084E 6402831N	20 x 5	Slope (west)	Site C9 is an artefact scatter located in the upper slopes of a low ridge less than 50 metres east of a minor creek and 600 metres north of the Hunter River. The site occurs within an area of exposure caused by minor gully erosion (approximately 50 metres by 30 metres with overall visibility less than 20%). Low grass cover surrounds the site and a number of small trees occur downslope in the gully. The site has been disturbed by the dumping of rubbish and fill in the eroded area.	11
C10	Artefact scatter	309041E 6402981N	10 x 20	Slope (west)	Site C10 is an artefact scatter located in the upper slopes of a low ridge approximately 60 metres east of a minor creek and 700 metres north of the Hunter River. The site occurs with an area of exposure caused by minor gully erosion (approximately 10 metres by 20 metres with overall visibility approximately 10%). Low grass cover surrounds the site	3

1. A complete list of artefacts recorded at each site is provided in *Appendix C*

Table 5.3 *Artefacts recorded during the survey – summary data*

Artefact type	Raw Material: Mudstone	Silcrete	Igneous	**Total**
Flakes	39	22	1	62
Cores	7	4	0	11
Retouched flakes	5	0	0	5
Total	51	26	1	78

1. Flakes include complete flakes and broken flakes
2. A complete list of artefacts is provided in *Appendix C*

Table 5.4 *Artefacts recorded in sample area at CM2*

No	Type	Raw material	Size	Platform	Cortex	Notes
1	F	S	120	S	0	
2	F	S	140	C	10	
3	F	S	100	S	0	
4	C	S	80		0	Broken core
5	C	S	90		10	Broken core
6	F	S	100	IND	10	
7	BFP	S	50	SEV	0	
8	BFO	S	80		70	
9	F	S	150	SEV	0	
10	F	S	100	C	80	
11	F	S	120	C	10	
12	C	S	130		20	Broken core, uni-directional
13	C	M	150		90	Uni-directional
14	F	M	90	C	10	

1. Three other artefacts were recorded outside the sample area
2. F = flake, C = core, BFP = broken flake (proximal fragment), BFO = broken flake (other fragment)

5.3 POTENTIAL ARCHAEOLOGICAL DEPOSIT

Due to the poor visibility, the survey results provide little evidence to suggest that any specific areas within the study area contain large numbers of sub-surface artefacts, however each of the major landform elements within the study area, identified in *Figure 3.2* is considered below.

5.3.1 The Creek Lines

Two creek lines, one in the east and a second on the western side of the study area were identified as landform elements. In the Upper Hunter region archaeological material is commonly associated with creek lines. Very few artefacts were found along either of the creek lines in the study area, with two sites found along the eastern creekline (C4 and C5) most likely because any material that does occur was either obscured by grass cover or buried in the topsoil.

Previous surveys in this area indicate artefacts do occur along the western creek north of Old Lemington Road (site CM1), however many exposures along the creek lines did not contain artefacts, prompting Hughes and Hiscock to argue that the minor creek lines in the area should only be considered 'slight' foci of occupation.

CM-CD1

CM-CD1 is actually situated partly within or close to CM1 and is closely associated with the existing creek line (but see discussion of this site, *Section 6.2.3*). The potential of this site has been assessed by Hughes and Hiscock (2000) and is described in *Section 3.3*.

5.3.2 The Low Ridge (Crest And Slopes)

The low ridgeline located on the western side of the proposed extension area and extending to the Hunter River represents a degrading landscape. While there does exist some potential for cultural material to occur within the topsoil (indicated by eroded areas on the slope, which contained low densities of stone artefacts, C1, C2, C6, C7, C8, C9 and C10) the depth of material (and topsoil) is likely to be quite shallow and artefact densities quite low.

5.3.3 The Alluvial Flats

The alluvial flats is an aggrading environment and there is some potential for cultural material to occur both within the existing topsoil and at greater depth on relict occupation surfaces that may occur below the present soil profile. It is also likely that cultural material has been eroded away in the past as a result of stream erosion, particularly where this may have been deposited close the river. The south east part of the study area is adjacent to a bend in the river which would have eroded the alluvial flats to the north. If subsurface cultural material does occur in the alluvial flats it is likely to be in low densities because no features occur that might have been a focus of occupation. The highest densities are likely to occur close to the Hunter River. It is possible that material is more likely to occur close to where the minor creeks meet the river or on the low ridge above the flats.

5.4 *HERITAGE ITEMS*

A number of buildings and other structures were recorded within the study area, these include a number of quite modern structures associated with the EnergyAustralia substation, two farmhouses, a dairy parlour and a number of sheds and other structures associated with farming. None of these buildings have significant heritage value. The oldest of the structures appear to be the two farmhouses and the dairy parlour, which probably date to about the mid 1900s. It is very unlikely that any occupation deposit (potential archaeological deposit) is associated with any of these buildings. No other area or structures that might contain historical archaeological deposit, such as wells or dumps, were found during the survey.

6 *DISCUSSION*

The following discussion focuses on three aspects of the study area that are important in assessing archaeological significance:

- the potential for archaeological material (not detected during the survey) to occur in the study area;
- the context of the stone artefacts that were recorded and the types of behaviour these artefacts are likely to reflect; and
- the extent to which the cultural material may address archaeological research questions.

Consideration of archaeological potential of the study area is perhaps the most important issue for this assessment because the archaeological visibility during the survey was low. The assessment must be based largely on predictive models rather than the results of the survey.

6.1 *POTENTIAL ARCHAEOLOGICAL DEPOSIT*

Sites are known to occur close to creek lines and it is very likely that stone artefacts will occur close to the creek lines in the study area. A number of investigations suggest that most stone artefacts will occur within a distance of about 50 metres from creek lines in the Central Lowlands (ERM 2004:52). Most or all of this material may have been deposited during the mid to late Holocene, in an unstratified context and have limited potential to address research questions.

Geomorphic investigation along the creek line in the eastern part of the study area undertaken by Hughes (1999) and Hughes and Hiscock (2000) identified an area that may contain early Holocene or late Pleistocene cultural materials in a stratified context. Hughes and Hiscock argued that this area, which they called CM-CD1, may be as large as 450 metres by 25 metres. This site has significant research value and has the potential to address questions concerning the antiquity of occupation and cultural changes over time.

6.2 *SITE FUNCTION*

The results of the survey provide very limited opportunity to interpret Aboriginal occupation. A total of 78 artefacts recorded during the survey is an extremely small sample, however if this is considered together with ERM Mitchell McCotter's survey results and the results of other studies in the area, some conclusions can be drawn. This section considers each of the landform elements in terms of past Aboriginal occupation.

6.2.1 *Creek Lines*

A total of seven artefacts at three sites (C4, C5 and CM1) were recorded along the two creek lines within the study area. Survey coverage was effectively 0% along both creek lines so these artefacts provided very limited information other than confirming that Aboriginal people occupied these areas – something that should be assumed. ERM Mitchell McCotter previously recorded a large site along the creek north of Old Lemington Road, site CM1. Over 200 artefacts were recorded in an area that extended 300 metres north of the road. Information concerning artefact densities within this site was not provided and reassessment of CM2 suggests that the criteria for identifying stone artefacts during their survey may have resulted in inflated artefact numbers.

Evidence from elsewhere in the Central Lowlands suggests creeks generally were an important focus of occupation and the overwhelming majority of artefacts (if not sites) occur in close proximity to creeks. The reason for this association is thought to be the importance of water and associated resources, in the subsistence strategy of Aboriginal people. Hence artefact scatters are often referred to as campsites ie the artefact scatters are generally thought to represent places where Aboriginal people camped. In the case of the two creeks within the study area there are two factors that suggest that they were not an important focus of occupation. The first factor is that both creeks are relatively minor and ephemeral ie they were probably not a good source of water. The second factor is the creek's proximity to the Hunter River, which would have been the primary source of water and resources in the local area.

6.2.2 *CM-CD1*

CM-CD1 is situated along the creek in the eastern part of the study area. This site is a colluvial deposit thought to contain evidence of early Holocene or late Pleistocene occupation and is therefore a particularly significant site. CM-CD1 is associated with both the creek line and the ridge slope, and therefore both sites CM1 and CM2.

While CM-CD1 is associated (spatially) with the creek line and site CM1, much of its cultural material, specifically artefacts that may date to the early Holocene or late Pleistocene, may have been discarded before a creek flowed through this area and before CM1 existed. The association with CM1 might therefore be spatial only.

The site's association with CM2 may be more substantial. Hughes and Hiscock argued that CM-CD1 should also be considered separate from CM2 in that the source of the material at CM-CD1 may be the river gravels, but that 'there is unlikely to be any conclusive means of distinguishing the contribution of these two sources in the CM-CD1 assemblage (2000:33). However this interpretation along with the inference that knapping did not occur at the site seems unlikely. Given the information we have, the most likely interpretation suggests that most of the material at CM-CD1 derives from material associated with the river terrace and therefore could be considered (in behavioural terms) part of CM2. The proportion of raw material at CM-CD1 (*Table 6.3*) is essentially the same as has been recorded at CM2, *Table 6.1* (during the present survey and surveys by ERM Mitchell McCotter) and different from most other sites in the region, where mudstone is more prevalent (at CM1 silcrete represents 69% of the artefacts recorded by ERM Mitchell McCotter). While silcrete may have derived from the Hunter River, the evidence suggests that it has come from the silcrete outcrops on the relict terrace (that occur as both in situ silcrete and silcrete in the form of large cobbles (ERM2004a:31-32)). The size and type of the artefacts also suggests they derive from the 'early phase of reduction' (Hughes and Hiscock 2000:34) consistent with material found at or near raw material sources.

Further investigation of CM-CD1, the remaining part of CM2 and CM1 focussing on the extent they may or may not be temporally and behavioural associated with each other has the potential to address questions concerning changes in the use of the landscape and in settlement systems over time. CM-CD1 alone has significant potential to address these issues and more generally questions concerning antiquity of occupation and cultural change.

Table 6.1 Counts of artefacts by raw material in Unit 5, CM-CD1

	Raw Material			
Groups	Silcrete	Mudstone	Other	**Total**
Top	23	3	0	26
Middle	11	2	2	15
Bottom	18	2	0	20
Other	1	0	1	2
Total	53	7	3	63

1. Data from Hughes and Hiscock 2000, Table 21
2. 'Other' refers to quartz, porcellanite and chert

6.2.3 *Low Ridge (Crest And Slope)*

ERM Mitchell McCotter predicted the low ridge to contain a continuous scatter of stone artefacts and specifically interpreted site CM2 as a source site (ie quarry) as well as an area of 'general stoneworking' (presumably meaning the manufacture and maintenance of stone tools). Subsequent reinvestigation of the site, including the present study, suggests that artefact density estimates made by ERM Mitchell McCotter were inflated due to the presence of naturally heat fractured material. However the results of the present study generally supports the predictions and interpretations made by ERM Mitchell McCotter. Stone artefacts were found in most exposures along the western slope and indicate that the ridge represents a single low density artefact scatter. Site CM2 was correctly interpreted as a quarry site.

This interpretation is supported by a number of factors that suggest CM2 was primarily used as a quarry site: the proportion of raw materials (predominantly silcrete), artefact types (see *Table 6.1* and *6.2*), artefact sizes, (see *Figure 6.1*), and its location near large silcrete outcrops. The presence of mudstone artefacts at this site (see also data in ERM Mitchell McCotter 1999b) might also indicate the ridge was a source of this material. Mudstone and a variety of other materials occur as cobbles within the relict terrace.

CM2, together with other sites in the local area, indicates there was some occupation of the ridge and that cobbles and boulders of silcrete and other material that outcrop in this context were used. However sites on the western ridge slope south of Old Lemington Road contain artefacts dominated by mudstone. This could be the result of procuring mudstone cobbles from the slope or the discard of mudstone (and silcrete) artefacts transported from another location.

Artefact densities recorded at sites across the entire ridge were very low suggesting that while there was some occupation of this ridge, it was not an important focus of occupation or at least not an important location for the procurement of raw material or the manufacture of stone tools. Calculations using the survey results (exposure, visibility and number of artefacts) indicate that the average artefact density at sites along the ridge south of Old Lemington Road (and therefore potentially the entire ridge) is one artefact per 13.3 m^2. At CM2 the artefact density recorded in the sample area (chosen because of its high artefact density) was one artefact per 7.1 m^2. Certainly there is no evidence that this source of raw material at CM2 has ever been intensively quarried. This is perhaps a consequence of the proximity to the gravel beds of the Hunter River, which may have provided material of greater quality than material on the terrace and may also have been more accessible (ie easier to procure). The ridge line may have been a focus of occupation because of its prominence in the landscape, its proximity to the creek, which it overlooks for hundreds of metres to the north, and to the Hunter River and its associated resources.

However sample size, both in terms of the number of artefacts recorded and the effective coverage of the area, does not provide a firm basis for this interpretation.

Table 6.2 Recorded artefacts at CM2

	Raw Material		
Artefact type	Mudstone	Silcrete	**Total**
Flakes	6%	64%	70%
Cores	6%	24%	30%
Total	12%	88%	100%

1. Flakes includes complete flakes and broken flakes
2. Sample size = 17 artefacts

Table 6.3 Recorded artefacts at all other sites

Artefact type	Raw Material Mudstone	 Silcrete	 Igneous	**Total**
Flakes	62%	18%	2%	82%
Cores	10%	0%	0%	10%
Retouched flakes	8%	0%	0%	8%
Total	80%	18%	2%	100%

1. Flakes includes complete flakes and broken flakes
2. Sample size = 78 artefacts

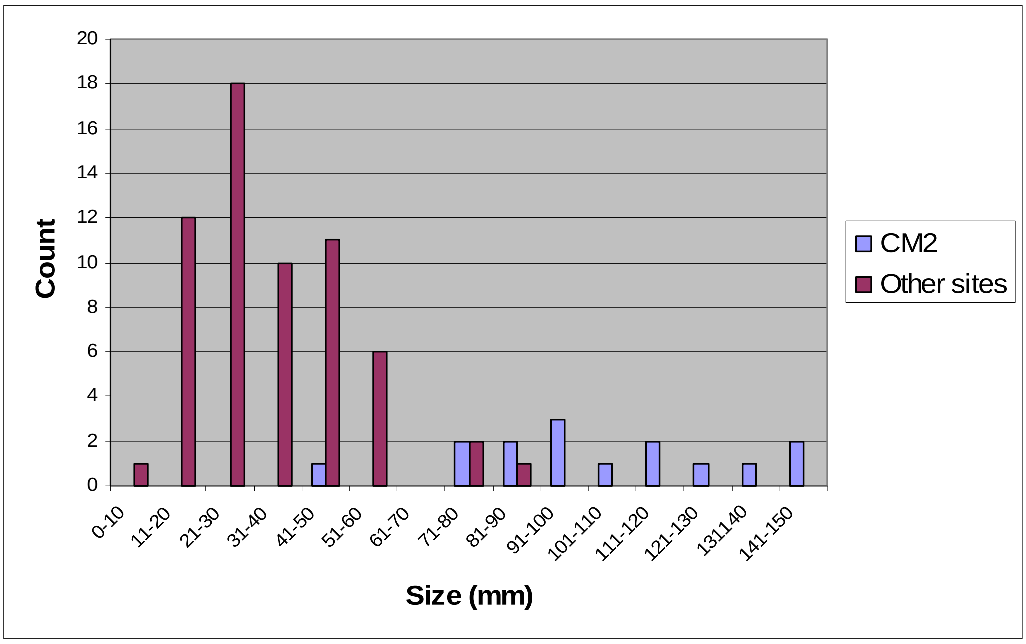

Figure 6.1 Artefact size

6.2.4 *Alluvial Flats*

One site was recorded on the flats, a scarred tree located in the north east part of the study area. The scar may be European in origin, however the size and shape of the scar is typical of scars made by Aboriginal people – perhaps for the production of a shield or coolamon. The age of the scar and the tree also appears to be old enough for the scar to have been made at a time when Aboriginal people were still using traditional methods in the production of material culture. The tree (probably a eucalypt) is large (height: 20 metres, dbh: 0.8 metres) and has been dead for many years - the trunk and scar are riddled with borer holes. Before the tree died, regrowth around the scar had reached a thickness of approximately 100 millimetres. Scarred trees were probably common in the local area prior to clearing of the land by early settlers.

7 SIGNIFICANCE ASSESSMENT

Cultural significance is a concept that rests on the perception of the community (Pearson and Sullivan 1994:21). The Burra Charter (Australia ICOMOS Burra Charter 1999) defines cultural significance as aesthetic, historic, scientific or social value for past, present or future generations. These aspects of significance may overlap and assessment can be a complex process. The cultural significance of most Aboriginal objects and sites is largely determined by their social value, assessed by the Aboriginal community, and their scientific value, assessed by archaeologists.

The identification of levels of significance for Aboriginal sites and relics is somewhat subjective and no precise guidelines for scaling are provided under the relevant legislation or under the Burra Charter. However, the terms low, moderate and high significance provide a basis for management recommendations.

- Sites that are assessed to be of high significance should be conserved. These sites warrant protection against development;
- Sites that are assessed to be of moderate significance should be conserved if possible. In the event that these may be affected by development some management strategies should be implemented to mitigate against the impact; and
- Sites that are assessed to be of low significance should be conserved if possible, but should not represent an obstacle to development.

7.1 SOCIAL (ABORIGINAL) SIGNIFICANCE

Archaeological sites, including stone artefacts scatters and isolated stone artefacts, represent an important component of Aboriginal cultural heritage in the region. Both site contents (Aboriginal objects) and site location (places) may be significant to Aboriginal people.

At the time of the fieldwork, no specific issues were raised by the Aboriginal people concerning any area of Aboriginal significance. No particular area of high cultural value was identified in or near the study area. The Aboriginal significance of the study area is therefore to a large part predicated by the presence of stone artefacts and the expected presence of other material not found during the survey. The Aboriginal people consider areas close to creek lines to have high potential to contain sub-surface artefacts, but also consider all areas to have some potential and therefore are of cultural value.

A number of the Aboriginal people expressed interest in the scarred tree (site C3) found in the north east of the study area.

The tree's cultural significance was confirmed by Barbara Foot (a senior representative of local Aboriginal community), who viewed photographs of the scar at the time of the survey. Scarred trees are generally considered to have considerable cultural value, perhaps because of their links to the recent past, or are more easily interpreted than stone artefacts, which may require skills in artefact identification and analysis before interpretations are forthcoming.

Another important consideration in the assessment of Aboriginal significance is an understanding of the cultural landscape. While not specifically raised by any of the Aboriginal people during the fieldwork, the study area should be considered a part of, or intrinsically linked to, a cultural landscape. This has significance separate from any particular site or artefact that has been or may be recorded. The low ridge that runs through the study area is a prominent feature in the landscape and may have been important as a cultural landmark, as a vantage point to view the surrounding landscape and the animals (resources) and people within it, and perhaps other cultural reasons outside of any prehistoric economic system that might be proposed by an archaeologist.

7.2 SCIENTIFIC (ARCHAEOLOGICAL) SIGNIFICANCE

The scientific significance of an Aboriginal site, object or place essentially refers to its potential to address research questions and provide additional information that will add to an understanding of past Aboriginal occupation (Australia ICOMOS Incorporated 2000:12). There are a number of criteria that need to be considered in order to determine the scientific significance of an Aboriginal site, place or object. These include rarity and representativeness, integrity and connectedness and how each of these contributes to research potential.

The archaeological significance of each of the fifteen sites identified in the study area is summarised in *Table 7.1* below.

Table 7.1 Archaeological Significance of sites in the Study Area

Landform	Site	Significance	Comment
Creek lines	CM1	Low to moderate	The site has research potential due to its association with sites CM2 and CM-CD1 and its potential to contain subsurface cultural material associated with the minor creek line.
	C4, C5	Low	While these sites have some potential to contain subsurface cultural material, similar sites are common in the local area and region.
	CM-CD1	High	This site has the potential to address archaeological questions concerning Aboriginal occupation during the early Holocene and late Pleistocene.
Low Ridge	C1, C2, C6, C7, C8, C9 and C10	Low to moderate	These sites have the potential to address questions concerning Aboriginal settlement systems and particularly the importance of the low ridge as a focus of occupation and/or a source of raw material in the local area.
	Remaining part of CM2	Moderate	While much of this site has been destroyed by mining it retains potential to address questions concerning Aboriginal settlement systems and mobility and particularly the importance of the Tertiary terraces of the Hunter as a raw material source for Aboriginal stone tools. Its association with site CM-CD1 also confers some archaeological value. Most of what remains of this site lies outside the study area. The portion of the site within the study area (in isolation) has limited potential to address any of the above research questions.
Alluvial Flats	CM45, CM46	Low	Similar sites are likely to occur in the local area and region. In isolation these sites have limited potential to address research questions.
	C3	Low	While similar sites are not common in the local area or region scarred trees have limited potential to address research questions.

This assessment addresses the scientific significance of each site. Sites within specific landform elements are considered separately in terms of criteria of rarity and representativeness, integrity and connectedness (*Table 7.2*). The assessments derived from these considerations are detailed below.

Table 7.2 Consideration of rarity and representativeness, Integrity and Connectedness of sites in the Study Area

Site(s)	Rarity and representativeness	Integrity	Connectedness
CM1	This site, recorded by ERM Mitchell McCotter is an artefact scatter along a minor creek line. This site type and context is very common in the local area and region. The site contents, in terms of artefact types and raw material, are also typical for sites in the local area and region. The artefact densities within the site cannot be determined from the original recording and visibility during the current survey did not allow any estimates of artefact numbers.	Artefacts at this site have been disturbed by erosion associated with the creek and by cattle trampling. Clearing and ploughing around the creek, and the establishment and maintenance of the now neglected vineyard immediately west of the site would also have disturbed cultural material at the site. Despite these disturbances there is some potential for artefacts to occur in situ within the A unit along the creek line.	This site is associated with both CM2, located on a ridge approximately 50 metres east of the site, and site CM-CD1 which is located at the base of the low ridge between CM2 and the site. It is difficult to determine the extent to which CM-CD1 may be temporally related to the site or related within a single settlement system employed by Aboriginal people, however it is likely that cultural material associated with the site is derived from the mid to late Holocene and is therefore only spatially related to CM-CD1 which is believed to represent early Holocene or late Pleistocene occupation.
C4, C5	These sites, an isolated artefact and small artefact scatter, situated with eroded areas along a minor creek are typical for the area and environmental context. The site contents, in terms of artefact types and raw material, are also typical for sites in the local area and region.	Artefacts at this site have been disturbed by erosion associated with the creek and by cattle trampling. Clearing and ploughing around the creek and the removal of a large amount of material, during the construction of a dam, has also disturbed cultural material in these areas.	The two sites probably represent a single low density distribution of artefacts along the minor creek. Creeks in this region were probably formed quite recently, mid to late Holocene, and the cultural material along it probably reflects one system of settlement employed by Aboriginal people.
C3	This site is a scarred tree on the alluvial flats, a remnant of the open woodland that would have once dominated the vegetation of the region. Scarred trees are quite rare in the local area and are also becoming less common at the regional level as a result of land clearing and the natural dying of trees that are sufficiently old to have been scarred by Aboriginal people. The scar should be considered a good example	The tree is dead and damaged by insects and weathering.	Unlike most other sites in the region the scarred tree can be confidently dated to the recent past. No sites were recorded near the tree during the current survey, however ERM Mitchell McCotter recorded site CM45 as being located within approximately 50 metres of the tree. It may be considered generally associated with or connected to other recently deposited material that may occur in the region in that it reflects one system of

Site(s)	Rarity and representativeness	Integrity	Connectedness
	of an Aboriginal scarred tree, and while there is some possibility that the scar was made by non-Aboriginal people it exhibits attributes that suggest it is more likely Aboriginal in origin.		settlement employed by Aboriginal people.
C1, C2, C6, C7, C8, C9, C10	Sites C1, C2, C6, C8, C9, C10 are all small low density artefacts scatters or isolated finds on the slope of the low ridge in close proximity to either a minor creek or the Hunter River. Site C7, a small artefact scatter, occurs on the crest of the ridge near the upper south west facing slope. These site types are typical for the local area and region, as is the site content of each. The geomorphic context is also relatively common in the local area (ie relict Tertiary river terrace close to the Hunter River).	Each of these sites is visible because of some disturbance of the topsoil, by erosion or vehicle or cattle track, or some combination of these.	These sites could be considered a part of a single low density distribution of artefacts across the low ridge, possibly associated with a variety of activities including the procurement of stone from cobbles that outcrop on the terrace. The ridge is an erosional context and it is likely that artefacts found in these sites may accumulate over a long period of occupation.
Remaining part of CM2	The remaining part of CM2 also occurs on the low ridge, however this site has been previously identified as a silcrete source or quarry. Quarry sites are rarely recorded in the local area or region (perhaps partly because they are not differentiated from artefact scatters that are not quarries. A number of silcrete sources have been identified in the local area and region. The importance of these sites within any system of Aboriginal settlement and mobility has not been established.	This site occurs on the ridge slope and crest (some of which has already been destroyed by mining). The large cobbles and boulders that occur on this site may have effectively protected the site from any significant disturbance by farming activities – remnant woodland on the slope in this area also suggests that the site has not been cleared. Cattle trampling in this area may have impacted artefacts.	This site is in close proximity to both CM-CD1 and CM1 and may be the source of much of the material at these sites.
CM45, CM46	Sites CM45 and CM46, two artefact scatters on the alluvial flats, were not relocated during the present	Cultural material on the alluvial flats have been disturbed by land clearing and perhaps also ripping	These sites represent what might be described as a continuous low density (background) scatter across

Site(s)	Rarity and representativeness	Integrity	Connectedness
	study, but were recorded by ERM Mitchell McCotter. Only a small number of artefacts were recorded however artefacts in this context are common in the local area and region though may not often be visible or occur on the surface.	and ploughing to improve pasture or plant crops. Seasonal flooding may bury occupation surfaces (and near drainage lines may wash them away). Seasonal wetting and drying of soil and sediments may also impact cultural material. Despite these disturbances there is some potential for artefacts to occur in situ within soil profiles.	much of the alluvial flats. Material in this context may have accumulated over a long period of time, however most surface, or near surface, material is probably relatively recent in origin ie late Holocene.
CM-CD1	CM-CD1 is one of the few sites in the Hunter River valley that has been identified as having potential to contain evidence of Pleistocene occupation. The site itself is stratified, which is also rare in the local area and region. While stratification within the Older Stratum has not been demonstrated there is some potential (Hughes and Hiscock 2000:38).	The integrity of CM-CD1 is demonstrated by its stratification. At a more specific level natural process such as fluvial erosion, bioturbation and soil cracking may have disturbed the deposit. The alluvial deposits immediately above the Older stratum are more likely to be stratified than the alluvial deposits that overly it.	CM-CD1 (ie the Older Stratum of CM-CD1) was formed in the early Holocene or late Pleistocene period when the local environment was quite different to the present environment. Much of the archaeology of the local area and region dates to after this period – to the mid to late Holocene. However the site is in close proximity to sites on the low ridge, which may also date to this earlier period. Site CM2, directly above the site, may be the source of much of the raw material found.

8 IMPACT ASSESSMENT

Fifteen sites were identified within the study area. The proposed Carrington Extension could directly impact eleven of these sites (*Table 8.1*) as well as the potential archaeological resource.

Table 8.1 Sites requiring a section 90 consent

Site name	AHIMS #	Site type
C1		Isolated find
C2		Artefact scatter
C3		Scarred tree
C4		Artefact scatter
C8		Artefact scatter
C9		Artefact scatter
C10		Artefact scatter
CM1	37-2-1504	Artefact scatter
Remaining part of CM2	37-2-1505	Artefact scatter/Quarry
CM45	37-2-1962	Artefact scatter
CM46	37-2-1963	Artefact scatter

Three sites, C5, C6 and C7, recorded during the present study, are outside the proposed impact area and will not be disturbed by the proposed extension and site CM-CD1 will continue to be protected. There is some potential for the mine extension to impact archaeological material that was not detected during the survey (either because it was obscured by grass or is buried in or below the topsoil). All landform elements within the study area have some potential to contain material that was not detected during the previous surveys, but material is more likely to occur near the Hunter River, creek lines and on the slope than on the alluvial flats.

The Carrington Extension will have some impact on the Aboriginal and social value of the study area. In addition to the potential impact to sites and stone artefacts, the extension of the pit and the construction of levees will also impact the cultural landscape. The landscape has to some extent already been compromised by over 100 years of farming and, more recently, by open cut coal mines in the vicinity of the study area, however the area is quite large and retains considerable cultural value.

While the extension area is relatively small compared to the existing mined areas in the region, the destruction of this area will add to the cumulative impact on archaeological, and more generally the cultural, resources within the Central Lowlands.

Archaeological investigations by ERM Mitchell McCotter (1999a and b) and Hughes and Hiscock (2000) to some extent provide information that mitigates the impact of mining in this local area. In addition, the mine plan for the proposed extension has been modified to ensure the ongoing protection of CM-CD1.

9 MANAGEMENT MEASURES

The following recommendations are based on:

- the results of the survey and assessment of the study area detailed in this report;
- previous assessments of sites within the study area;
- development consent conditions stipulated in Consent # DA 450-1-2003 issued by DIPNR; and
- the *National Parks and Wildlife Act 1974*, under which Aboriginal sites and objects are protected.

Recommendations are provided for each site within the study area in *Tables 9.1 and 9.2* below.

Table 9.1 Recommendations for newly identified sites

Site	Recommendations	Further works required	Section 90
C1, C2, C8, C9 and C10	Sites be destroyed after further archaeological investigation	Further archaeological salvage work should be undertaken on the low ridge involving further recording of archaeological material on the ridge (may involve excavation and collection of artefacts) to clarify the nature and extent of archaeological material across the ridge.	Required
C3	Scarred tree be removed and relocated to a location where it will be protected from further development	The methods used to remove the tree, the precise area or place where the tree should be relocated and the way it should be housed should all be determined in consultation with the Aboriginal community.	Required
C4	Site be destroyed	No further archaeological investigation is required.	Required

Table 9.2 Recommendations for previously identified sites located in the Study Area

Site	Recommendation	Further works required	Section 90
CM-CD1	Protect site against impact of development	Protection of buffer zone around this fence ideally to include CM1 and part of CM2 and consultation with local Aboriginal groups to develop management strategies. The size of the buffer zone will be dependent on the depth of the mine pit and will be sufficient to protect the site from structural failure of the underlying sediments, erosion that may occur during the life of the mine (ie prior to rehabilitation) and inadvertent damage that could be caused by mine personnel and machinery.	Not required
CM1	If mining is undertaken in this area, then a section 90 application will be applied for from the DEC.	Erection of a permanent fence around the site and consultation with local Aboriginal groups to develop management strategies	May not be required
CM2	That the part of CM2 within the buffer zone of CM-CD1 be protected against the impact of development and destruction of the part of CM2 within the study area.	Erection of a permanent fence around the site and consultation with local Aboriginal groups to develop management strategies. No further archaeological investigation required for the section of CM2 within the study area.	Required for part of CM2 within the study area
CM45 and CM46	Sites to be destroyed	No further work required.	Required

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Appendix A

GSS Environmental Presentation, Consultation Meeting Minutes & Aboriginal Community Correspondence

ARCHEAOLOGICAL AND CULTURAL HERITAGE SURVEY FOR THE CARRINGTON PIT EXTENSION, COAL & ALLIED, HUNTER VALLEY OPERATIONS.

18TH OCTOBER 2005

SUMMARY THE STAKEHOLDER CONSULTATION PROCESS –

1. Background:

Coal and Allied (CNA) intend to extend the current Carrington Pit to include an area south beyond the current consent boundary. CNA engaged ERM to undertake a cultural and historical heritage assessment of the area to assess the potential impacts and provide management recommendations. GSS Environmental (GSSE) was engaged separately by CNA to undertake the consultation with the Aboriginal community stakeholders.

The following report outlines the stakeholder consultation process undertaken by GSSE as part of this project.

2. Coal & Allied Consultation Procedure:

In early 2004, CNA Environmental Services recognised the need to develop and document a consistent, transparent and all-inclusive stakeholder consultation process when considering Archaeological and Aboriginal Cultural Heritage issues. A flowchart outlining a procedure for undertaking an Archaeological & Cultural Heritage assessment was developed **(Attachment 1)**.

It is important to note that this procedure was used as the initial field work preceded the Department of Environment & Conservation (DEC) Interim Guidelines for consultation which came into effect on the 1 January 2005. Notwithstanding this the process followed by CNA is considered consistent with the current draft guidelines.

3. Key stages of the Stakeholder Consultation Process:

On the **22 September 2004** an invitation was sent to all identified stakeholder groups outlining the intention of CNA to hold a Consultation Meeting to discuss the Carrington Extension Project. The same meeting was also used to discuss an entirely different project **(Attachment 2).** Six (6) Aboriginal Stakeholder groups responded indicating that they intended to attend the meeting.

The Stakeholder Consultation Meeting was held on the **15 October 2004**. The following individuals representing ten (10) Aboriginal groups attended the meeting:

• Allen Paget	Ungooroo
• Mark Hickey	WWCCS
• John Matthews	CCAC
• Margaret Matthews	CCAC

- Melissa Newman — UHHC
- Scott Franks — Yarrawalk Enterprises
- Christine Matthews — HVCC
- Larry Van Vliet — Valley Culture
- Luke Hickey — WNAC
- Trevor Griffiths — WLALC
- Barbara Foot — Wonnarua Custodians

An apology was received from Des Hickey (WWCCS).

The following individuals attended the meeting representing CNA as either project managers or archaeologists:

- Andrew Hutton — GSS Environmental (Project Manager)
- Chad Stockham — GSS Environmental (Project Manager)
- Andy Collis — ERM (Archaeologist)

A MS PowerPoint presentation was presented to the groups outlining the proposed methodology as well as site specific commercial and safety information **(Attachment 3)**.

Everyone attending the meeting was given a full copy of a colour aerial photograph showing the location of the site.

Following the presentation an inspection of the site was organised. Three (3) of the ten (10) groups participated in the site inspection. The groups who attended are listed below:

- Ungooroo
- Yarrawalk Enterprises
- Wonnarua Custodians

Minutes recording the meeting were sent to all groups who attended the meeting or who had apologised **(Attachment 4).**

On the 19th October 2004 a fax outlining the details of the fieldwork was sent to all groups who attended the meeting or who had apologised **(Attachment 5)**.

Following the Stakeholder consultation meeting only one (1) response was received from the Aboriginal Community in relation to the proposed methodology. The response was from the WLALC and was principally related to the WLALC requesting that representatives of the WLALC be involved in both days of the fieldwork **(Attachment 6).**

Two (2) days fieldwork were undertaken on the 26th & 27th of October 2004. Of the ten (10) groups who indicated that they wished to participate in the fieldwork, only seven (7) were available on the day. The CCAC, HVCC and the WNAC did not participate in the fieldwork. Barbara Foot of the Wonnarua Custodians visited the site for three (3) hours on the 27th October 2004 where she was shown all the sites that had been identified.

On the 8th September 2005 draft copies of the ERM Archaeological & Cultural Heritage assessment report were sent to all known Aboriginal community groups for review and comment **(Attachment**

7). The groups were encouraged to provide written comment on the report content with particular emphasis on any related Cultural heritage issues. The period for comment closed on the 21st September 2005.

There had been no comments (written or otherwise) received from any of the groups by the closure date.

On the 5th October 2005, Andrew Hutton of GSS Environmental contacted each of the groups by phone to follow up on the letter sent on the 8th September 2005. The following is a summary of the responses from the groups that could be contacted:

- **Yarrawalk (Scott Franks):** He couldn't find the report but indicated that he would go through the "...pile of reports that he has..." and get a response back to us. No response received at the time of writing this report.

- **WLALC (Barry McTaggart):** He indicated that he generally just files the reports, but said that he would try and find the report and make comment. No response received at the time of writing this report.

- **Ungooroo (Graham Ward):** He was surprised that he hadn't responded, but said that he would go back and take a look at the report and provide comment over the next few days. No response received at the time of writing this report.

- **Wonnarua Custodians (Barbara Foot):** She indicated that the report was fine and that she was very happy with the approach that we had taken following. She indicated that she was very busy and may not be able to write a letter but reiterated that she was very happy with what we had done.

- **Valley Culture (Larry Van Vliet):** Hadn't read the report and would try and get something to us in the next week.

- **Giwiir Consultants (Rodney Matthews):** Said that he had read it and was generally happy. He indicated that he would try and write a letter ASAP.

Phone messages were left with:

- Upper Hunter Wonnarua Council (Victor Perry)

- Wonnarua Nation (Robert Lester)

- Aboriginal Native Title Elders Consultants (Margaret Matthews)

- Lower Wonnarua Tribal Consultancy (Barry Anderson)

- Wattaka Wonnarua CC Service (Des Hickey)

- Upper Hunter Heritage Consultants (Darrel Matthews)

- Hunter Valley Cultural Consultants (Christine Matthews)

At the time of writing this report there had been no responses received from the groups.

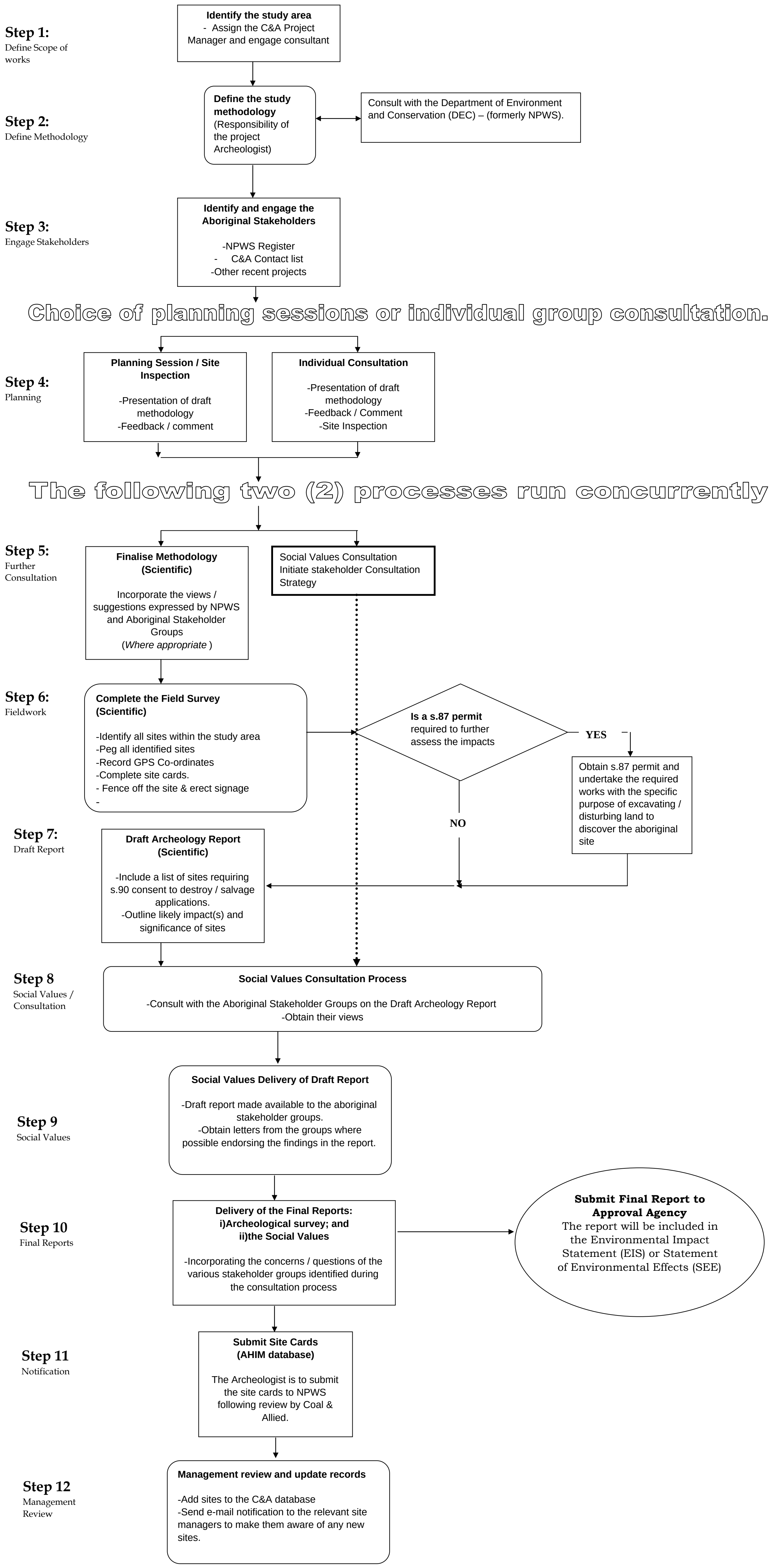
Report prepared by:

GSS Environmental

ANDREW HUTTON
Senior Environmental Projects Manager

ATTACHMENT 1:

Integrated Development Application (IDA) Archaeological Sites Survey Process



ATTACHMENT 2:

COAL & ALLIED

A Rio Tinto Group Company

Facsimile

Corporate Centre

PO Box 315
Singleton NSW 2330
Phone: +61 2 6570 0300
Fax: +61 2 6570 0399

Date 22 September 2004		*Total pages (incl cover pg):* 3
To Margaret Matthews	*Company:* Combined Council of Hunter Valley Aboriginal Corporation	*Fax:* (02) 6541 1392
From ANDREW HUTTON *Email: hutton@globalsoils.com*	*Direct Phone:* 0409 288 909	*Direct Fax:* (02) 6570 0377

☒ *Urgent* ☒ *For your information* ☒ *Please Comment*

FUTHER ARCHEAOLOGICAL ASSESSMENT AND COMMUNITY SALVAGE PROJECTS – CARRINGTON EXTENDED & WEST PIT.

Dear Margaret,

Please find below detail in relation to upcoming Aboriginal & Cultural Heritage works at Coal & Allied (CNA). Please be advised that we are planning a **Consultation & Planning meeting** to discuss these projects. There are **two (2) distinct** projects and it is intended that both projects will be discussed on the same day to maximise the opportunity by having all stakeholders together.

The two (2) projects are described below:

Project 1: *Carrington Extended Pit – Aboriginal & Cultural Heritage Survey*
CNA intended to seek approval to extend the current Carrington Pit to recover further coal resources. As such a detailed Archaeological & Cultural Heritage survey is required to be completed and the findings included as part of the documentation to accompany this application. In accordance with the consultation commitments adopted by CNA, we wish to discuss the proposed methodology prior to the work being undertaken. It is anticipated that this work will commence by the end of October, early November 2004.

Project 2: *West Pit – Aboriginal Community Salvage.*
The second project is an Aboriginal Community Salvage for the West Pit area. A Development Consent has been issued by DIPNR to mine the area. In accordance with the EIS and the Development Consent, prior to the commencement of mining a s.90 needs to be obtained and the representatives of the Aboriginal community are to be given the opportunity to participate in the salvage of artefacts from the site. Like the current Warkworth project, the work will commence once the s.90 permits have been obtained from DEC. It is expected that this will be at least two (2) months after the consultation has been completed.

In accordance with our commitment to engage the local Aboriginal groups, we invite you to attend. Please find below the details. We look forward to your valued contribution to this work.

Date: Friday 15th October 2004.

Time: 9.00am.

Where: Howick Training Rooms

The following is a brief agenda proposed for the meeting:

9.00am:	Welcome
9.20am:	Presentation on the Carrington extended Archaeological & Cultural Heritage Survey
11.20am:	Questions & Concerns
12 noon:	Lunch (provided by CNA).
1.00pm:	Presentation of the West Pit Aboriginal Community Salvage Program
2.00pm:	Questions & Concerns
2.30pm	Site Inspections if required.

If you wish to attend the site visit you will be required to provide steel capped boots, a hard hat, a reflective vest and safety glasses. Without this PPE you will be unable to attend the site inspection, as this is the minimum site safety requirement for being on the mine site. Transport to and from the inspection will be provided by CNA. Please indicate your intension to attend this inspection so appropriate transport can be arranged for the day.

Could you please indicate your intention to have a representative attend the meeting by filling out the section on the next page and return faxing to Andrew Hutton on **(02) 4960 3322.** If you have any further questions in relation to this matter please have no hesitation in contacting me directly on my mobile 0409 288 909.

Kind Regards,

ANDREW HUTTON
Project Manager.

Return Fax: (02) 49603322

Attention: Andrew Hutton.

Combined Council of Hunter Valley Aboriginal Corporation: (please tick)

☐ Would like to be involved ☐ Is not able to be involved

Our nominated representative for this meeting is:

……………………………………………………………

☐ We would like a site inspection following the meeting.

Signed: ……………………… Date: ……………………

ATTACHMENT 3:

Proposed Aboriginal & Cultural Heritage Works:

Part a): West Pit – Aboriginal Community Salvage

Part b): Carrington Pit Extension – Arch Survey

Presentation by Coal & Allied

Friday 15th October 2004.

Howick Mine Training Rooms,

Pike's Gully Rd.

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MEETING AGENDA

PART A:

1. Welcome
2. **West Pit -** Aboriginal Community Salvage
3. Applications of s.87 & s.90 permits
4. 3. General Discussion & Feedback

PART B:

1. **Carrington Extension** – Project Background
2. Project Field Work & Presentation of Methodology
3. General Discussion & Feedback
4. Lunch
5. **Site Orientation & Familiarisation -**

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WELCOME

Introductions & Welcome

Housekeeping & Safety Issues

- Exits and Emergency Response procedures
- Toilets & Conveniences
- Attendance list

Please fill out:

Name
Group you represent
Contact details (phone, fax & e-mail)

PART A:

West Pit s90 applications & subsequent Aboriginal Community Salvage

WEST PIT: BACKGROUND

- Development Consent was obtained to mine the West Pit area on the **8 July 2004.**

- An Archaeological survey of the area was completed in 2003 with all the sites identified being fenced off.

- The next stage of the project is to obtain a s.90 approval and undertake a salvage of the known artefacts prior to the commencement of works in the area. NPWS through planning approval process have demonstrated support of a s.90 application.

- The meeting today is to consult with the community and consider any information that should be considered as part of the s90 application.

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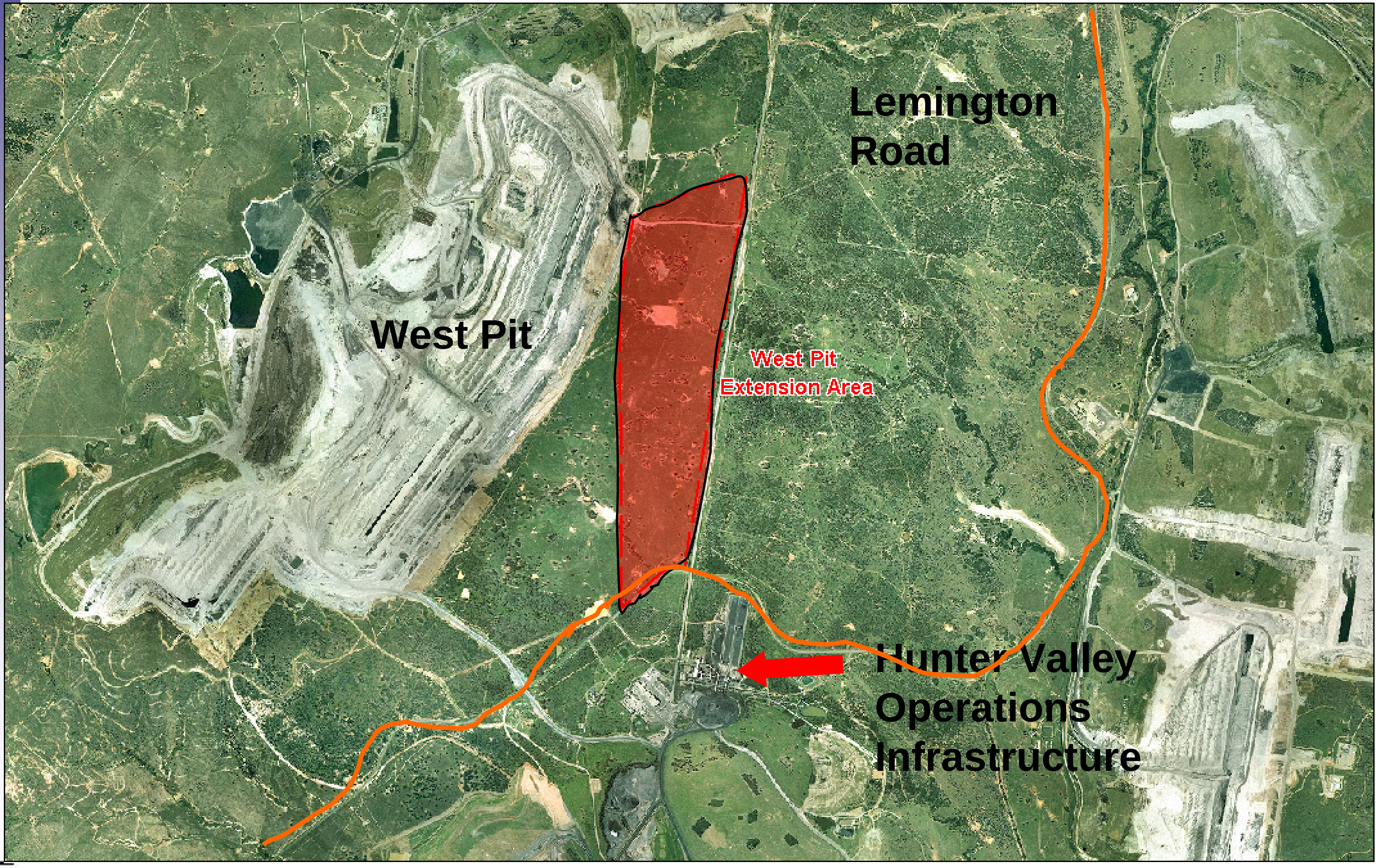
WEST PIT: BACKGROUND



West Pit –
Section 87 & Section 90 applications

- Before any of this work can commence CNA are required to apply for and obtain permits / consent under section 87 & 90 of the ***National Parks & Wildlife Act (1974).***

- ERM (Andy Collis) will be responsible preparing the permit applications.

- As part of this Community Consultation phase CNA would encourage a formal response (a letter) from the interested Aboriginal groups related to the proposed ***project methodology*** as well as the ***s.87 and s.90 applications.*** This is to be provided to DEC as part of the permit application process.

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WEST PIT: Proposed Methodology

- Once the s90's are obtained, the second part of the project is the salvage of all known sites within the proposed extension area.

- It is proposed that the methodology be identical to the W1, W6, W79 and Abbey Green projects completed earlier this year. It will include:
  - Pedestrian traverses across sites and collection areas
  - Aim for 100% coverage of sites and collection areas
  - Field team to consist of representatives from the local Aboriginal community and ERM archaeologists

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WEST PIT: Methodology

- Provenance (AMG coordinates to be recorded by hand held GPS)
- Artefact attributes (type, raw material, size, cortex, platform preparation)
- Collected artefacts will be bagged, boxed and labelled in accordance with the Australian Museum guidelines.
- The artefacts are to be stored with the artefacts collected as part of the Warkworth salvage works (W1, W6 & W79) & Abbey Green projects

WEST PIT: Methodology

- NPWS have indicated that no additional archaeological research is warranted in this area, however they recognise that additional cultural heritage works are required.

- CNA recognises that the area has some cultural significance and as such is open to some cultural heritage investigations. This could include:

  - Some excavation along Emu Creek using hand excavation as per Abbey Green; and/or

  - The use of Grader Scraps;

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WEST PIT: Methodology

- It is anticipated that this work should take no more than a week.

- Based on the size and scale of the program it is proposed that **eleven (11)** Aboriginal representatives and **two (2)** Archaeologists will be required.

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Submissions from Aboriginal Community

- All correspondence relating to the proposed works and the methodology at West should be provided to Andrew Hutton by **Monday 29th October.**

- All responses will be considered and where appropriate recommendations from the community will be incorporated into the methodology proposed for this work.

- Andrew Hutton Contact details.
  - Mail: GSS Environmental
    Unit 4/56 Industrial Drive
    Mayfield, NSW, 2304.
  - E-mail: hutton@globalsoils.com
  - Fax: (02) 49 603322.

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PART B:

Carrington Pit Archaeology & Aboriginal Cultural Heritage Assessment

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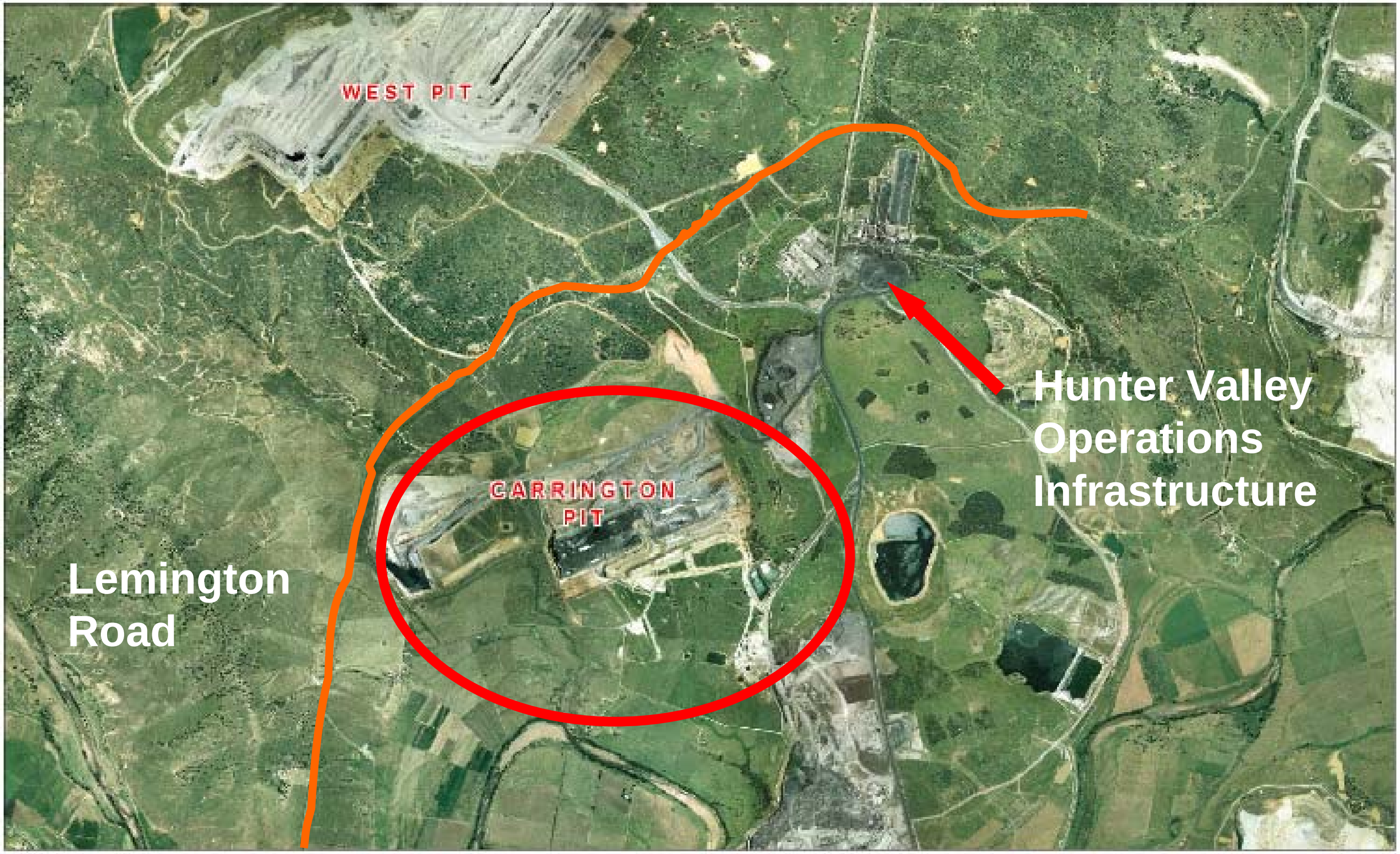
CARRINGTON EXTENSION



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CARRINGTON PIT: BACKGROUND

- Mining commenced at the Carrington Pit in 2001.
- The proposal is for a small extension of the existing operations.
- The pit will be extended to the south and east over a period of 6-8 years.
- The proposal initially includes the construction of additional water management structures.

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CARRINGTON PIT: BACKGROUND

- Under the proposal, Carrington Pit will continue to operate as an open cut, multi-seam truck & shovel operation.
- A Statement of Environmental Effects (SEE) will be prepared for an application to modify the North of the River Development Consent.
- An Archaeological Survey is required to be included in the SEE.

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Substation Access Road

- In addition this work includes a survey to establish an alternative access to the Energy Australia Sub Station, required due to the progression of Carrington Pit.

- This road will operate for the life of the Sub Station.

- A SEE will also to be prepared to accompany a Development Consent Application for construction and use of the access road.

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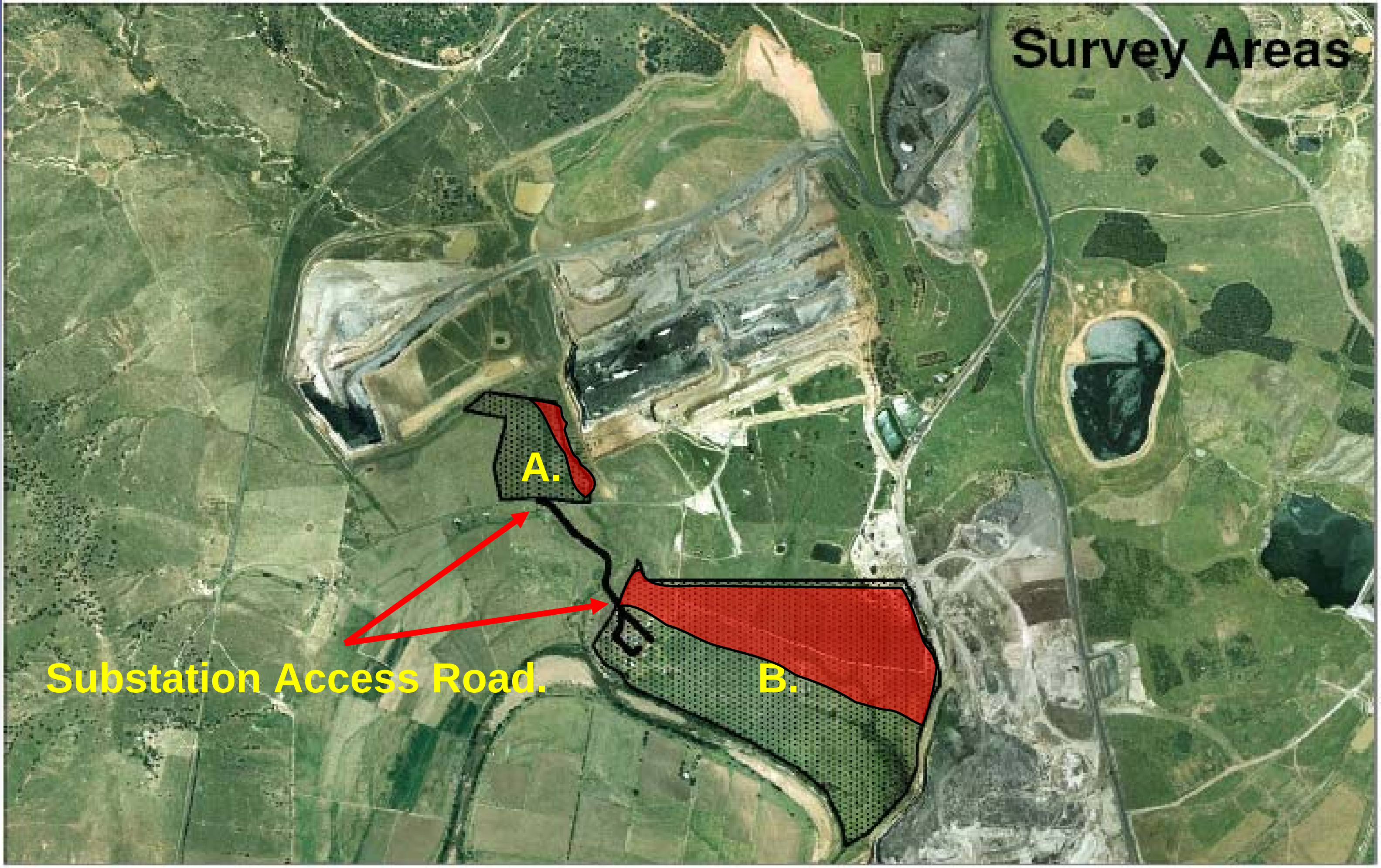
Total Survey Area.



CARRINGTON PIT: SURVEY

It is proposed that the survey will involve:

- vehicle and pedestrian traverses across the study area
- pedestrian traverses will concentrate on areas of known exposure or archaeological sensitivity (e.g. along creek lines)
- vehicle traverses will be made across all parts of the study area (and will be primarily aimed at locating areas of exposure or visibility which will be more closely inspected on foot)

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CARRINGTON PIT: SURVEY

What will be recorded:

- recording all exposures, sites and artefacts (if large numbers of artefacts occur on any one site we may record only a sample of the artefacts)

- exposure attributes recorded will include type, size and visibility

- artefact attributes recorded will include raw material, type, size, cortex, and platform

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CARRINGTON PIT: SURVEY

- Information will also allow calculation of survey coverage and effective survey coverage (based on estimates of the number and size of exposures and the archaeological visibility).

- The survey will aim to exceed 50% coverage of the study area, however effective coverage is expected to be less than 5%.

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FIELD WORK:

The field work as part of the Archaeological survey is planned to commence on **Tuesday 26th October 2004,** however comments on Aboriginal Cultural Heritage aspects of the will be taken until the **12th November 2004.**

Based on the detail presented within the scope of works, Coal & Allied would like to get feedback from the groups in relation to number of participants that would be required to undertake the fieldwork component.

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CARRINGTON PIT: SURVEY

- It is anticipated that the survey will be undertaken in **two (2)** days, with a focus on the areas that are to be disturbed by mining.

- Based on the size and scale of the survey it is proposed that **four (4)** Aboriginal representatives and **1- 2** Archaeologists will be required.

- Information recorded during the survey will be sufficient to characterize both the **Archaeological & Aboriginal cultural heritage** resource within the study area.

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Any questions related to the proposed methodology for either the West Pit Community Salvage or the Carrington Pit Aboriginal and Cultural Heritage survey.

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PART C:

Fieldwork Considerations & Commercial Issues

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FIELD WORK – Key Considerations

- Reasonable representation of the stakeholder groups
- Having experienced / competent people who can offer the greatest value to the project
- OH&S requirements
- Budgets for the project
- Logistics (i.e moving people safely around the site)
- C&A generic + specific site inductions
- Having organisations that are registered as a C&A supplier (i.e. insurances, work cover, professional indemnity).

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Commercial Arrangements & Rates for both Projects

- Groups that are not currently registered on the CNA supplier register at least three (3) weeks before the commencement of the field work will **not** be able to participate in the project.

- All groups participating in the fieldwork will be issued a Professional Service Agreement (PSA) and a Purchase Order from CNA **prior** to the commencement of works. The PSA will outline all the commercial terms & conditions including rates of pay and the terms of payment.

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Commercial Arrangements & Rates for both Projects

- All fieldworkers will be offered the same rate of pay.

- The rate of pay for this project is **$550 /per day.** A day is considered to be eight (8) hours from sign on. (ie. 8am – 4pm). Where a full eight (8) hours is not completed in any one day a rate of **$68.75** will be paid for each hour of work completed.

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PART D:

Field Inspection

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SITE INSPECTION

- All participants of the site inspection are required to have the following:
  - Hard hat
  - Steel capped boots (lace up)
  - Safety Glasses
  - Reflective vest / stripes

- All participants are required to sign in as visitors and must be accompanied by a C&A representative at all times.

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ATTACHMENT 4:

Record of issues discussed at the Aboriginal Community Consultation Workshop.

Coal & Allied – West Pit Extension and Carrington Extension

Date/Time: 15 October 2004, 9:00 am – 2:00 pm

Location: Howick Office, Hunter Valley

Attendees: Chad Stockham (GSSE),
Andrew Hutton (GSSE),
Andy Collis (ERM),
Scott Franks (Yarrawalk),
Trevor Griffiths (Wanaruah LALC),
Larry Van Vliet (Valley Culture),
Allen Paget (Ungooroo),
Melissa Newman (Upper Hunter Heritage Consultants),
Margaret Matthews (CCAC),
John Matthews (CCAC),
Luke Hickey (WNAC),
Barbara Foot (W. Custodians),
Mark Hickey (Wattaka),
Christine Matthews (Hunter Valley Cultural Consultants);
James Bailey (Hansen).

Apologies: Des Hickey (Wattaka).

Attached: Presentation given at the workshop.

Notes prepared by Chad Stockham

West Pit

- PowerPoint presentation made by Andrew Hutton on the proposed West Pit Extension (attached).

- Allen asked whether determination had been made on tree previously identified as significant by Barbara. Andy advised that final determination had not been made. During the afternoon inspection it was confirmed that the tree is within the area to be disturbed by mining, and Andy advised that management of the tree would be addressed in the assessment for the area, and that comments from Aboriginal community would be sought regarding the treatment of the tree.

- Scott asked whether Section 90 application would specifically address where the artifacts will go, and how will contention between Aboriginal groups be managed? Andy/James advised that it was anticipated that NPWS would probably accept the majority view on the final location of the artifacts, however until it was resolved the artifacts would be retained and stored by CNA.

Carrington

- PowerPoint presentation made by Andrew Hutton on the proposed Carrington Extension (attached).

- Scott asked whether offsets would include allocation of a "voluntary conservation area"? James advised that the land (red and black hatched land from overheads) is not proposed to be mined as part of this application and could potentially be protected in some form of conservation area.

- It was asked how close C&A can mine to the river? James advised that C&A must stay 150 m from the alluvial edge, which is effectively about 500 metres from the river in this case.

- It was asked if future underground mining was likely? James advised that C&A does not have plans to underground mine in the area.

- Luke raised need for a Regional Aboriginal management study/plan to address these issues on a more regional level, rather than ad hoc on individual parcels of land, and that the Aboriginal community wants a keeping place/educational center to store the artifacts. James advised that C&A were aware of the desire for a keeping place and were looking at future options, and that the desire for a regional study/plan is beyond the scope of this exercise, and should be addressed in a different forum. Both James and Trevor Griffith commented on the industry funded study which is under way that has this specific objective.

- Larry asked why other Aboriginal communities were not present at the recent discussion between C&A and the Wonnaruah Lands Council? James advised that this was just one of many discussions to be held by C&A as part of a consultation process which included this meeting.

- Luke raised desire for offsets that benefit Aboriginal community. Scott raised opportunity for all Aboriginal groups to get together on this issue and to collectively determine what offsets are appropriate.

Survey Methodology

- PowerPoint presentation made by Andrew Hutton on Survey Methodology, including proposal for 4 Aboriginal reps, over 2 days, and 2 scientific reps (ie ERM)

- Scott requested that due to high up-front SGS induction costs, C&A consider a plan to pay the SGS fees on behalf of the Aboriginal group, and that the SGS costs be progressively deducted from subsequent payments made by C&A to the group. James advised that scheme sounded possible and that he would take the matter up with C&A.

- Audience asked for future group SGS induction to be undertaken for future large jobs. Most groups have SGS inductions for this job already, and this could be considered if appropriate in future pre-survey consultation.

- It was asked why it wasn't possible to have one or two representatives per Aboriginal group at the survey? James advised that 2 people for each of 16 (potentially) groups (ie 32 people) would be excessive, and that this was only a relatively small project. The cost would be high for C&A, and it would be difficult to manage so many people. Scott suggested that the C&A budget for the work be tabled and the groups discuss amongst themselves the best way to divide up the budget whilst still giving each group potential for a site inspection. After some discussion it was determined that there were 10 groups represented at this workshop that had shown an interest in being party to the workshop discussions. James suggested that we have 5 people on the first day and 5 people on the second day, which would allow all 10 groups to be represented over the two days. There appeared to be general agreement for this proposal. The audience made the request that the tributary on site be looked at by all people attending the site, regardless of what day they were attending.

- It was agreed that if groups were unable to attend then the vacant position on the survey **would not** be filled by another group or additional members of a groups who could attend so that it was fair to all groups on the survey.

- Andrew re-iterated the requirement for SGS induction to be up to date prior to any survey work, explaining that if groups did not have SGS inductions they **would not** be able to attend.

- In addition to the above 10 people, it was agreed that Barbara will be able to inspect the site as an 'advisor' (or 'visitor'?) under the escort of James/Andy/Andrew, even if she doesn't have SGS induction.

- Trevor requested that outcomes for previous projects (in a broader sense) be provided back to the Aboriginal community, and clarify if Aboriginal advice has been incorporated into management plans.

- Luke requested that Aboriginal groups be paid for attendance at meetings (such as this meeting). Other audience members disagreed and saw attendance today much like a "painter providing a free quote on a job", for which the painter would be remunerated later if he/she got the work.

- A Handout of both the proposed extension areas was provided.

Site Visit

- The site visit was attended by Chad Stockham, Andy Collis, Allen Paget, Andrew Hutton, Barbara Foot and Scott Franks.

Meeting Closed: 1.45pm

ATTACHMENT 5:

COAL & ALLIED

A Rio Tinto Group Company

Facsimile

Date		*Total pages (incl cover pg):*
19th October 2004		2
To	*Company:*	*Fax:*
Trevor Griffith	Wonnaruah Local Aboriginal Lands Council	(02) 65
From	*Direct Phone:*	*Direct Fax:*
Andrew Hutton *Email: hutton@globalsoils.com*	0409288909	(02) 49603322

CARRINGTON PIT EXTENSION – ABORIGINAL & CULTURAL HERITAGE SURVEY.

Dear Trevor,

Following the Aboriginal Community Consultative meeting held on the Friday 15th October 2004 please find below detail on the Aboriginal & Cultural Heritage Survey to be held in the Carrington Pit extension area. Please note that copies of the presentation and minutes from the meeting will be send via mail this week.

The survey work will commence on **Tuesday 26th October 2004** and is expected to take two (2) days.

As discussed at the meeting one (1) representative from each of the Aboriginal Groups will be invited to attend the survey on either the first or second day of the survey. Notwithstanding this, all nominated representatives will be required to attend a site specific induction at **8am** on the **26th October 2004** to be held at the Hunter Valley Operations offices on Lemington road (where we signed in for the site inspections).

The following groups have been randomly selected to attend each of the days.

Tuesday 26th October 2004	Wednesday 27th October 2004
• Yarrawalk Enterprises • Wattaka • Valley Culture • Upper Hunter Heritage Consultants • WLALC	• CCAC • WNAC • W. Custodians • Hunter Valley Cultural Consultants • Ungooroo

Under site safety rules, all representatives attending the induction and the survey will be required hold a current SGS Coal & Allied Induction. Please advise Andrew Hutton if you are unable to provide representatives with SGS inductions so that equal opportunity is given to all those groups who do currently have the inductions.

Please bring the following safety equipment and PPE to both the induction and survey work.

1. Hard Hat;
2. Lace up steel capped boots;
3. Safety Glasses;
4. Reflective vests or reflective strips on clothing; and
5. Gloves.

If you have any further questions in relation to this survey please have no hesitation in contacting me directly on my mobile phone 0409 28909.

Kind Regards,

ANDREW HUTTON
Project Manager.

Cc: Andy Collis (ERM) (02) 49642152

ATTACHMENT 6:

LOCAL ABORIGINAL LAND COUNCIL
WANARUAH

P.O. BOX 127
19 MAITLAND STREET,
MUSWELLBROOK 2333
ABN 33 251 730 169

PH.: (02) 6543 1288
(02) 6543 1962
FAX: (02) 6542 5377
EMAIL:wanaruah@hunterlink.net.au

Andrew Hutton
GSS Environmental
PO Box 3214
Wamberal NSW 2260

21.10.04

Dear Andrew,

RE: Carrington Extended Pit- Aboriginal & Cultural Heritage Survey

In response to the Carrington Extended Pit, Aboriginal Cultural & Heritage survey meeting, held at Howick Training Office 15.10.04. Wanaruah Local Aboriginal Land Council (WLALC) would like the following comments noted. Wanaruah LALC would like to advise you of the WLALC statutory function in the protection and promotion of the Cultural Heritage of our people. Under section 52(1) (m) of the Aboriginal Land Rights Act 1983(NSW), the Local Aboriginal Land Council(LALC) is to promote the protection of Aboriginal Culture and the Heritage of Aboriginal Persons in its area. For the WLALC to be able to fulfil this function I insist that the Land Council have Field Officers present through the whole duration of the Aboriginal Heritage & Culture survey for this area or any future activities undertaken within the land council area concerning Aboriginal Cultural Heritage in accordance with our Statutory functions and NPWS guidelines. If C&A refuse the WLALC participation on both days of the survey (26.10.04, 27.10.04), WLALC would consider that as effectively excluding the Wanaruah Local Aboriginal Land Council From the Consultation process.

Regards

T. Griffiths

Trevor Griffiths
Cultural Heritage Officer

ATTACHMENT 7:

Our Ref: RIO0-0604-01

8th September 2005

Upper Hunter Wonarua Council
PO Box 184
SINGLETON, NSW 2330

Attention: Mr Victor Perry

Dear Mr Perry,

CNA Carrington Extension, Hunter Valley Operations – Draft Report for Review & Comment

In accordance with the CNA policy of engaging the wider Aboriginal community in Archaeological and Cultural Heritage related projects, please find enclosed a DRAFT report for the Archaeological & Cultural Heritage assessment undertaken for the extension of the Carrington Pit area on the 26th & 27th October 2004.

Could you please review the report and provide written comment for consideration in the preparation of the final report. Importantly we would encourage you to respond on both the detail contained within the report itself as well as any additional Cultural Heritage issues that you may see as relevant to the study area. Could you please provide your written response to Andrew Hutton by **21st September 2005.** All correspondence should be sent to:

> **GSS Environmental**
> Unit 4/56 Industrial Drive
> **MAYFIELD**, NSW 2304.
>
> ph: 0409288909
> fx: 49 603322.

If you have any further questions or comments, please have no hesitation in contacting me directly on my mobile phone 0409 288909.

Yours Faithfully,
GSS Environmental

Andrew Hutton
Senior Environmnental Projects Manager

Appendix B

Photographs

Photograph 1

Site CM1 (facing south).

Photograph 2

Site CM2 (facing east).

Jobs/2004/0024143 Photos 1 & 2.cdr 22 12 2004 JD Environmental Resources Management Australia Pty Ltd

Photograph 3

Site C2 (facing north).

Photograph 4

Site C3 (facing north east).

Photograph 5

Site C3 (facing east).

Photograph 6

Site C4 (facing north).

Photograph 7

Site C5 (facing south east).

Jobs/2004/0024143 Photos 6 & 7.cdr 22 12 2004 JD Environmental Resources Management Australia Pty Ltd

Photograph 8

Site C7 (facing south).

Photograph 9

Site C9 (facing west).

Photograph 10

Site C10 (facing west).

Photograph 11

South east corner of site CM-CD1 (facing north towards site CM2).

Jobs/2004/0024143 Photos 10 & 11.cdr 22 12 2004 JD Environmental Resources Management Australia Pty Ltd

Appendix C

List of Stone Artefacts Recorded During the Survey

Table C.1 Recorded Artefacts

Site	No	Type	Raw material	Easting (AMG)	Northing (AMG)	Size	Platform	Cortex	Notes
CM1	1	BFO	S	308656	6403190	23		0	
C4	2	C	M	310272	6402236	55		30	Multi-directional
	3	F	M	310259	6402215	46	S	0	
	4	F	M	310259	6402215	25	C	10	
	5	F	S	310252	6402203	39	IND	0	
	6	BFO	S	310252	6402203	44		0	
C6	7	BFO	S	309061	6402309	15		0	
	8	BFO	M	309061	6402309	52		70	
C2	9	RF	M	308990	6402587	27	C	15	Use wear along right margin
	10	BFO	M	308990	6402587	23		0	
	11	F	M	308990	6402587	42	C	10	Edge damage along distal margin
	12	BFO	M	308990	6402587	26		0	
	13	F	M	308990	6402587	36	C	40	Recent edge damage

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA 0034143RP1V5 ACLC/FINAL/24 OCTOBER 2005
C1

Site	No	Type	Raw material	Easting (AMG)	Northing (AMG)	Size	Platform	Cortex	Notes
	14	F	M	308990	6402587	29	C	15	
	15	C	M	308990	6402587	35		20	Uni-directional (one scar only)
	16	F	M	308990	6402587	26	C	20	Possible use wear along lateral margin
C1	17	F	M	308983	6402615	44	C	15	
C8	18	F	M	309001	6401765	80	S	90	
	19	F	M	309001	6401765	30	C	10	
	20	BFP	M	309001	6401765	27	S	0	
	21	BFP	M	309001	6401765	17	IND	0	
	22	BFO	M	309001	6401765	12		0	
	23	F	M	309001	6401765	17	IND	0	
	24	F	M	309001	6401765	22	S	0	Distal and right margin have use wear
	25	BFP	M	309001	6401765	30	S	30	Use wear along left margin
	26	BFO	S	309001	6401765	26		0	Possible use wear along right margin
	27	RF	M	309001	6401765	42	S	50	Retouch along right, left and distal margins.
	28	BFO	M	309001	6401765	43		0	

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA 0034143RP1V5 ACLC/FINAL/24 OCTOBER 2005
C2

Site	No	Type	Raw material	Easting (AMG)	Northing (AMG)	Size	Platform	Cortex	Notes
	29	BFO	M	309001	6401765	16		0	
	30	F	M	309001	6401765	19	S	0	
	31	C	M	309001	6401765	36		60	
	32	RF	M	309001	6401765	47	IND	80	Retouch along right margin
	33	F	M	309001	6401765	80	SEV	30	
	34	F	IG	309001	6401765	55	C	70	
	35	F	M	309001	6401765	44	SEV	10	
C10	36	BFO	S	309084	6402831	21		0	
	37	C	M	309087	6402830	39		20	
	38	F	M	309085	6402824	47	C	30	
	39	F	M	309088	6402822	19	IND	20	
	40	RF	M	309088	6402822	89	S	15	Retouch along right and left margin
	41	RF	M	309088	6402822	38	S	10	Retouch along distal edge
	42	F	S	309088	6402822	57	S	0	use along right margin
	43	BFO	M	309088	6402822	47		10	

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA 0034143RP1V5 ACLC/FINAL/24 OCTOBER 2005
C3

Site	No	Type	Raw material	Easting (AMG)	Northing (AMG)	Size	Platform	Cortex	Notes
	44	BFO	S	309094	6402801	31		0	
	45	C	M	309094	6402801	46		25	Rotated
	46	F	M	309094	6402801	35	C	10	Longitudinal cone split
C12	47	F	S	309041	6402981	38	S	0	
C12	48	C	M	309037	6402985	51		70	Uni-directional (one scar only)
C12	49	BFO	M	309049	6402988	21		30	
C5	50	BFO	M	310093	6401752	17		0	
CM2	51	C	S	308703	6403436	110		0	Multi-directional
	52	F	S	308730	6403502	73	S	60	
	53	F	S	308751	6403354	86	S	0	
	54	F	S	308781	6403356	120	S	0	
	55	F	S	308781	6403356	140	C	10	
	56	F	S	308781	6403356	100	S	0	
	57	C	S	308781	6403356	80		0	Broken core

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA 0034143RP1V5 ACLC/FINAL/24 OCTOBER 2005
C4

Site	No	Type	Raw material	Easting (AMG)	Northing (AMG)	Size	Platform	Cortex	Notes
	58	C	S	308781	6403356	90		10	Broken core
	59	F	S	308781	6403356	100	IND	10	
	60	BFP	S	308781	6403356	50	SEV	0	
	61	BFO	S	308781	6403356	80		70	
	62	F	S	308781	6403356	150	SEV	0	
	63	F	S	308781	6403356	100	C	80	
	64	F	S	308781	6403356	120	C	10	
	65	C	S	308781	6403356	130		20	Broken core, uni-directional
	66	C	M	308781	6403356	150		90	Uni-directional
	67	F	M	308781	6403356	90	C	10	
C7	68	F	M	308916	6402426	23	IND	0	
	69	BFO	S	308916	6402426	15		0	
	70	BFP	M	308916	6402426	10	S	10	
	71	BFP	M	308916	6402426	23	S	0	
	72	F	S	308916	6402426	40	S	0	

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA 0034143RP1V5 ACLC/FINAL/24 OCTOBER 2005
C5

Site	No	Type	Raw material	Easting (AMG)	Northing (AMG)	Size	Platform	Cortex	Notes
	73	F	M	308916	6402426	24	C	10	
	74	F	M	308916	6402426	18	C	80	
	75	F	M	308916	6402426	53	C	40	
	76	F	M	308916	6402426	19	S	0	
	77	BFO	M	308916	6402426	22		70	
	78	BFP	M	308916	6402426	20	S	20	

1. F= flake, C = core, BFP = broken flake (proximal fragment), BFO = broken flake (other fragment), RF = retouched flake

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA 0034143RP1V5 ACLC/FINAL/24 OCTOBER 2005
C6

Annex H

Ecology Assessment

FINAL REPORT

Coal and Allied

Carrington Pit Extended
Flora and Fauna Assessment

October 2005

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1 *INTRODUCTION*

1.1 *BACKGROUND*

This report assesses the potential ecological constraints to extension of the Carrington pit within Hunter Valley Operations north of the Hunter River. Mining activities are proposed for areas south and east of the existing approved Carrington Pit.

The extension area assessed in this investigation consists of cleared land used for grazing of cattle (hereafter referred to as 'the southern extension area') and a small area north of Old Lemington Road with scattered native trees, hereafter referred to as 'the services corridor'. The services corridor will be approximately 10 m in width and will contain a road, pipelines, drainage and other associated services. Additional areas included in this assessment, but not proposed for mining activities, include a billabong and associated remnant woodland and cleared areas north of and adjacent to the Hunter River. These additional areas, the services corridor and the southern extension area are hereafter referred to as 'the study area' (*Figure 1.1*). The proposed eastern extension area was not assessed as part of this investigation as it is an overburden dump that was recently rehabilitated to grazing land use.

1.2 *EXISTING ENVIRONMENT*

The study area has been highly modified through clearing and farming activities and is predominantly pasture (*Photograph A.1*). Remnant native trees remain in two areas of the study area. Drainage lines within the study area are dominated by exotic groundcover species and are highly eroded. Riparian vegetation along the Hunter River in the south of the study area is dominated by exotic ground, shrub and canopy species.

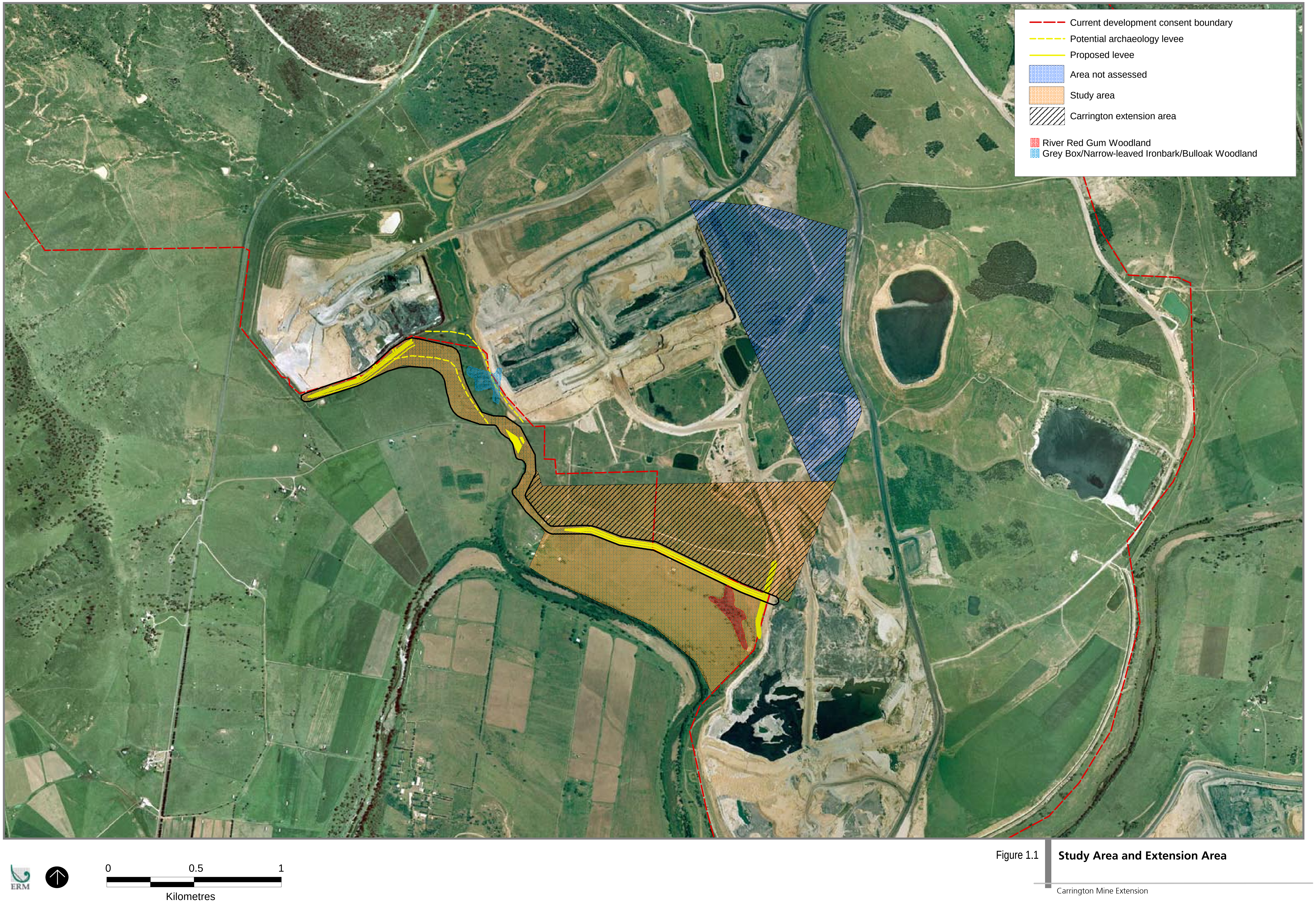

Figure 1.1 **Study Area and Extension Area**

Carrington Mine Extension

2 METHODS

2.1 DESKTOP ASSESSMENT

Prior to a field investigation, background literature reviews and database searches were undertaken to obtain records of threatened flora and fauna species and vegetation communities previously recorded within the locality (within a 10 km radius of the study area) and listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Sources of information included:

- Department of Environment and Conservation (DEC) Wildlife Atlas for threatened species listed under the TSC Act;
- Department of Environment and Heritage (DEH) for matters of National Environmental Significance;
- Royal Botanic Gardens Sydney, Birds Australia and Australian Museum databases for threatened species listed under the TSC and EPBC Acts;
- Hunter Catchment Management Trust (HCMT) Vegetation Community Mapping (2005); and
- previous impact assessments conducted within the locality (ERM 2002, 2003 & Resource Strategies 2003).

2.2 FIELD INVESTIGATION

A field investigation of the flora and fauna of the study area was undertaken by three ecologists between 18 and 20 October 2004.

Flora

A list of dominant flora species was compiled as the study area was traversed. Areas of focus included the woodland and billabong in the south east of the study area and riparian vegetation along the Hunter River. Meandering surveys were conducted across grazed pasture areas.

The occurrence of vegetation communities within the study area was evaluated by assessing the recorded flora species and general environmental attributes of the area including soil type and landform. Particular attention was paid to the diagnostic features of endangered ecological communities known to exist within the locality.

Fauna

All opportunistic sightings of fauna were recorded during the field investigation and scats and hair samples were sent to Barbara Triggs of Dead Finish for identification. Birds were surveyed by one ecologist during the morning and late afternoon, and opportunistically over the three-day survey period.

Frog call playback for the Green and Golden Bell Frog (*Litoria aurea*) was undertaken on 18 October 2004 within the billabong in the southeast of the study area. After an initial site inspection this area was considered to provide potential Green and Golden Bell Frog habitat. However, due to the absence of water within this billabong and the absence of any frog species calling, it was considered unlikely that frogs were present and call playback was discontinued.

Anabat detectors were placed at the billabong and along the Hunter River over two consecutive nights and tapes sent to Glenn Hoye of Fly By Night Bat Surveys for analysis.

During the field investigation the study area was also assessed for its potential to provide habitat for native fauna species. Microhabitat diversity was assessed by recording the following habitat characteristics:

- the presence of nesting / shelter sites such as tree hollows, litter, fallen timber and logs and rocks;
- the cover / abundance of ground, shrub and canopy layers;
- the presence of free water or waterbodies; and
- rocks and basking sites for reptiles.

In addition, a hollow-bearing tree survey was conducted within the woodland surrounding the billabong. The number of hollows in each tree surrounding the billabong was recorded.

This level of fauna survey was considered appropriate given the disturbed nature of the study area and surrounding areas, current land use and lack of native fauna habitat.

3 *RESULTS*

3.1 *FLORA*

3.1.1 *Extension Area*

The extension area assessed consisted of the proposed southern extension area and the proposed services corridor. The flora results for these areas are described below. A complete list of flora recorded within the study area during the survey is provided as *Table 3.1*.

Proposed Southern Extension Area

The southern extension area has been highly modified and as such the majority of flora species recorded were exotic pasture species. Dominant species included Cobbler's Peg (*Bidens pilosa*), Paterson's Curse (*Echium* sp.), Paspalum (*Paspalum dilatatum*), Fireweed (*Senecio madagascariensis*) and Milk Thistle (*Sonchus oleraceus*).

Proposed Services Corridor

A small stand of remnant native trees (approximately 20 in total) occurred within the services corridor adjacent to the Carrington mine. Tree species in this area included Grey Box (*Eucalyptus moluccana*) and Narrow-leaved Ironbarks (*Eucalyptus crebra).* This area has been mapped by the Hunter-Central Rivers Catchment Management Authority (HCRCMA 2004) as Grey Box/Narrow-leaved Ironbark/Bulloak Woodland. A small disused vineyard was also located in this area. The area was extremely dry and dominated by exotic species including Paspalum, Fireweed and Cobblers Peg (*Photograph A.2*).

3.1.2 *Additional Areas*

Additional areas included in this assessment, but not proposed for mining activities, include a billabong and remnant woodland and cleared areas north of and adjacent to the Hunter River. The results for these areas are described below.

Billabong

Mature River Red Gum (*Eucalyptus camaldulensis*) trees occurred adjacent to the billabong and along the associated drainage line to the north of the billabong (*Photograph A.3*). This area has been mapped by HCMT (2005) as River Red Gum Woodland, having evidence of dieback or waterlogging. Spike-rush (*Eleocharis plana*), Common Rush (*Juncus usitatus*) and Tall Sedge (*Carex appressa)* were the dominant species on the banks of the billabong with Couch (*Cynodon dactylon*) and Annual Beardgrass (*Polypogon monspeliensis*) becoming dominant further from the billabong edge. Exotic herbaceous species were also prominent in this area and included Burrs (*Xanthium* sp.), Purpletop (*Verbena bonariensis*) and Narrow-leaf Cotton Bush *(Gomphocarpus fruticosus)*. Three patches of Bulrush (*Typha* sp.) occurred on the eastern side of the billabong and Windmill Grass (*Chloris* sp.) was prominent near the banks in this area.

Southern Cleared

The remainder of the southern section of the study area was dominated by exotic pasture species. Drainage lines within this area connected to the billabong to the east and the Hunter River to the south. The drainage lines were highly eroded and impacted by rubbish dumping (*Photograph A.4*).

Riparian Zone

Vegetation along the riparian zone of the Hunter River was dominated by exotic species (*Photograph A.5*). Willow (*Salix* sp.), Caster Oil Plant (*Ricinus communis*), Tree Tobacco (*Nicotiana glauca*), Pepper Tree (*Schinus areira*) and White Mulberry (*Morus alba*) dominated the banks. The understorey was dominated by exotic species. River She-Oak (*Casuarina cunninghamiana*) also occurred intermittently along the riparian zone.

3.1.3 Threatened Flora

No threatened flora have been previously recorded within the locality and none were recorded in the study area during the field investigation. Given the modified nature of the study area, it is unlikely that any would occur.

Table 3.1 Flora Species Recorded within the Study Area

		Proposed Extension Area		Additional Areas		
Scientific Name	**Common Name**	**Southern Extension**	**Services Corridor**	**Billabong**	**Riparian**	**Southern Cleared**
Native Species						
Austrostipa verticillata	Speargrass			X	X	
Carex appressa	Tall Sedge			X		
Casuarina cunninghamiana	River She-Oak				X	
Chloris sp.	Windmill Grass			X		
Cynodon dactylon	Native Couch			X		
Eleocharis plana	Spike-Rush		X			
Eleocharis sphacelata	Spike-Rush			X		
Eucalyptus camaldulensis	River Red Gum			X	X	
Eucalyptus crebra	Narrow-leaved Ironbark		X			
Eucalyptus moluccana	Grey Box		X			
Geranium solanderi	Native Geranium			X		
Juncus usitatus	Common Rush			X		
Melia azedarach	White Cedar				X	
Persicaria decipiens	Slender Knotweed			X		
Rumex brownii	Dock		X		X	
Exotic Species						
Bidens pilosa	Cobbler's Peg	X	X	X		X
Brassica sp.	Mustard	X			X	X
Bromus catharticus	Prairie Grass			X		
Bromus sp.	Brome				X	
Cayratia sp.	Grape				X	
Chloris gayana	Rhode's Grass			X	X	
Chondrilla juncea	Skeleton Weed			X		
Echium plantagineum	Paterson's Curse	X			X	X

		Proposed Extension Area		Additional Areas		
Scientific Name	**Common Name**	**Southern Extension**	**Services Corridor**	**Billabong**	**Riparian**	**Southern Cleared**
Ehrhata erecta	Panic Veldtgrass				X	
Foeniculum vulgare	Fennel				X	
Fumaria bastardii	Fumaria				X	
Galium aparine	Cleavers				X	
Gomphocarpus fruticosus	Narrow-leaf Cotton Bush			X		
Lolium sp.	Rye Grass	X		X	X	X
Melilotus indica	Hexham Scent				X	
Morus alba	White Mulberry	X			X	X
Nicotiana glauca	Tree Tobacco				X	
Onopordum sp.	Thistle			X		
Paspalum dilatatum	Paspalum	X	X	X	X	X
Plantago lanceolata	Plantain			X		
Polypogon monspeliensis	Annual Beardgrass			X		
Ranunculus sceleratus	Poison Buttercup			X		
Ricinus communis	Castor Oil Plant				X	
Rumex tenax	Shiny Dock			X		
Salix sp.	Willow				X	
Schinus areira	Pepper Tree				X	
Senecio madagascariensis	Fireweed	X	X		X	X
Sida rhombifolia	Paddy's Lucerne			X		
Solanum nigrum	Deadly Nightshade			X	X	
Sonchus oleraceus	Milk thistle	X			X	X
Tradescantia albiflora	Wandering Jew				X	
Trifolium sp.	Clover			X		
Typha sp.	Cumbungi			X		
Verbascum thapsus	Aaron's Rod			X		
Verbena brasiliensis	Purpletop	X		X	X	X

		Proposed Extension Area		Additional Areas		
Scientific Name	**Common Name**	**Southern Extension**	**Services Corridor**	**Billabong**	**Riparian**	**Southern Cleared**
Xanthium sp.	Burr			X		

1. X = Present

3.2 *ENDANGERED POPULATIONS*

River Red Gum (*E. camaldulensis*) was recorded surrounding the billabong in the southeast corner of the study area. '*E. camaldulensis* in the Hunter Catchment' has been listed as an endangered population in Part 2 (f) Schedule 1 of the TSC Act. Potential impacts to the River Red Gums from extension of the Carrington mine has been assessed under Section 5a of the NSW *Environmental Planning and Assessment Act 1979* (EP & A Act) (Eight-part Test), provided as Appendix C.

3.3 *ENDANGERED ECOLOGICAL COMMUNITIES*

Three ecological communities listed as endangered under the TSC Act and the EPBC Act have previously been recorded within a 10 km radius of the study area. These include:

- White Box Yellow Box Blakely's Red Gum Woodland (Box-Gum Woodland);
- Warkworth Sands Woodland in the Sydney Basin Bioregion; and
- Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions.

DEC Final Determinations and Identification Guidelines for each community were used to assess the occurrence of, or potential occurrence of, each of these communities within the study area.

No floral assemblages diagnostic of any endangered ecological community were identified during the field investigation of the study area.

3.4 *FAUNA*

3.4.1 *Extension Area*

Southern Extension Area

The southern extension area provides limited foraging and sheltering resources for native fauna, as the majority is comprised of exotic pasture. Native fauna species observed within the extension area during the field investigation included an Australian Kestrel (*Falco cenchroides*) and Eastern Grey Kangaroos (*Macropus giganteus*). Exotic pasture would provide a foraging resource for bird species, and areas with piles of litter, such as drainage lines, would provide habitat for reptiles and introduced small mammals such as mice.

Services Corridor

The stand of scattered trees within the services corridor provides potential habitat for bird and bat species. Some of these trees were hollow-bearing. However the lack of native shrubs or ground cover means this area is unlikely to provide habitat for native ground-dwelling fauna and the scattered and isolated nature of the trees makes it unlikely that arboreal mammals would inhabit this area. There was a lack of fallen timber or small shrubs that provide habitat for threatened birds such as Grey-crowned Babbler (*Pomatostomus temporalis*), Speckled Warbler (*Chthonicola sagittata*) and Hooded Robin (*Melanodryas cucullata*).

Table 3.3 lists the fauna species recorded within the study area during the investigation.

3.4.2 *Additional Areas*

Billabong

The billabong area with the surrounding hollow-bearing trees provides nesting and breeding habitat for a variety of bird species including hollow-dependent species such as the Sulphur-crested Cockatoo (*Cacatua galerita*). The fallen logs and thick grass adjacent to the billabong provide sheltering habitat for reptiles and small ground-dwelling mammals. Scats and hair samples collected within the billabong area were identified by Barbara Triggs (Dead Finish) as Brushtail Possum (*Trichosurus* sp.) and European Wild Rabbit (*Oryctolagus cuniculus*). When water is present, the billabong would also provide habitat for native frog species. However, during this survey no frogs were heard calling and there was no response to Green and Golden Bell Frog call playback from the billabong area. One individual frog was found dead within the mud of the billabong. However, due to the immature stage of development of the frog, its species could not be determined.

A total of 33 hollow-bearing trees and 86 hollows were recorded around the billabong. Results of the survey are shown in Appendix B. The high number of stags in the area (22%) agrees with the HCMT (2005) mapping that this woodland vegetation has undergone some dieback. However, the stags provide nesting habitat for a number of hollow-dependent bird species and during the time of the survey there were a high number of parrots utilising the area. In addition, stags could be used by various bat species including those detected in this survey. The identification of Brushtail Possum scats in this area indicates the area is also utilised by hollow-dependent arboreal mammals.

Three species of bats were identified from Anabat tape analysis. The results of this analysis are provided as *Table 3.2* below. One species, the Eastern Freetail Bat (*Mormopterus norfolkensis*), is listed as Vulnerable on Schedule 2 of the TSC Act and is known to use hollow-bearing trees.

Table 3.2 ***Results of bat analysis – billabong area***

Date	Location	***Rhinolophus megaphyllus* (Eastern Horseshoe Bat)**	***Mormopterus norfolkensis* (Eastern Freetail Bat)***	***Vespadeuls vulturnus* (Little Forest Bat)**	**Number of Passes**
18.10.04	Billabong	Possible	**Possible**	Probable	11

* listed as threatened under the NSW TSC Act.

Riparian Zone

Riparian vegetation was fruiting during the time of the survey, providing a foraging resource for birds, including seasonal migrants such as the Channel-billed Cuckoo (*Scythrops novaehollandiae*). The insectivorous Dollarbird (*Eurystomus orientalis*), also a migrant, was also recorded in this area. A tortoise shell (empty) was recorded along the bank of the river.

Aquatic habitat is present within the Hunter River and would also be present in the drainage lines and billabong within the study area during times of rain. The banks of the Hunter River were approximately 10 m in height and extremely steep and it was not possible to descend to the river. At the eastern end of the study area the river was approximately 10 m in width with grassy, vertical banks dominated by Willows. There was no instream vegetation present and the river appeared to be flowing slowly. Towards the centre of the study area the riverbanks became less steep and the sandy riverbed became exposed, with a 10 m channel flowing through the middle. Exotic species, in particular Mulberry and Willow Trees, dominated the vegetation in this area. Towards the western end of the study area the riverbed became more exposed. Vegetation did not change significantly in this area apart from some weeds that had colonised the sand-gravel riverbed. Given its current condition, the river is considered to provide habitat for fish, bird and reptile species but did not appear to provide suitable habitat for frogs due to the lack of instream debris and vegetation, and no frogs were heard calling during the survey.

Southern Cleared

The southern cleared area provides limited resources for fauna in the form of exotic pasture. Fauna recorded within the southern cleared area during this investigation included birds and macropods. It is unlikely any other species of native fauna utilise the area.

Table 3.3 Fauna recorded within the Carrington study area.

Species		Extension Area		Additional Areas			Observation Type
Scientific Name	**Common Name**	**Southern Extension**	**Services Corridor**	**Billabong**	**Riparian**	**Southern Cleared**	
Birds							
Cacatua galerita	Sulphur-crested Cockatoo		X	X			O
Cacatua roseicapilla	Galah			X			O
Cacatua sanguinea	Little Corella			X			O
Cracticus nigrogularis	Pied Butcher Bird				X		O
Dacelo novaeguineae	Laughing Kookaburra				X		O
Eurystomus orientalis	Dollarbird				X		O
Falco cenchriodes	Australian Kestrel	X			X	X	O
Geopelia humeralis	Bar-shouldered Dove				X		O
Haliastur sphenurus	Whistling Kite			X			O
Malurus cyaneus	Superb Fairy-wren			X	X		O
Manorina melanocephala	Noisy Miner				X		O
Merops ornatus	Rainbow Bee-eater				X		O
Ocyphaps lophotes	Crested Pigeon				X		O
Platycercus eximius	Eastern Rosella			X			O
Psephotus haematonotus	Red-rumped Parrot	X		X		X	O
Scythrops novaehollandiae	Channel-billed Cuckoo				X		O
Sericornis frontalis	White-browed Scrubwren				X		O
Malurus cyaneus	Superb Fairy-wren	X					O
Zosterops lateralis	Silvereye				X		O
Mammals							O
Macropus gigantus	Eastern Grey Kangaroo	X	X	X		X	O
Mormopterus norfolkensis	**Eastern Freetail Bat**			X			A

Species		Extension Area		Additional Areas			Observation Type
Scientific Name	Common Name	Southern Extension	Services Corridor	Billabong	Riparian	Southern Cleared	
*Oryctolagus cuniculus**	European Wild Rabbit			X			H
Rhinolophus				X			A
megaphyllus	Eastern Horseshoe Bat						
Trichosurus sp.	Brushtail Possum			X			S
Vespadeuls vulturnus	Little Forest Bat			X			A
Vulpes vulpes *	Red Fox		X				O
Reptiles							
Chelodina longicollis	Eastern long-necked Tortoise				X		O

1. O = Observed, S = Scat, H = Hair sample, A = Anabat recording
2. X = present
3. * = Exotic species
4. Bold = listed as threatened under the TSC Act.

3.4.3 *Threatened Fauna*

Threatened fauna species previously recorded within the locality, together with a consideration of the likelihood of their occurrence within the proposed extension area are provided as *Table 3.4*.

Table 3.4 Threatened Fauna Previously Recorded within the Locality

Scientific Name	Common Name	EPBC Act Status	TSC Act Status	Likelihood of occurrence within extension area
Birds				
Calyptorhynchus lathami	Glossy Black-Cockatoo		V	Low
Climacteris picumnus	Brown Treecreeper		V	Low
Melanodryas cucullata	Hooded Robin		V	Low
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subsp.)		V	Low
Pyrrholaemus sagittatus	Speckled Warbler		V	Low
Tyto novaehollandiae	Masked Owl		V	Low
Mammals				
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat		V	Low
Myotis adversus	Large-footed Myotis		V	Low
Petaurus norfolcensis	Squirrel Glider		V	Low
Petrogale penicillata	Brush-tailed Rock-wallaby	V	E	Low
Amphibians				
Litoria aurea	Green and Golden Bell Frog	V	E	Low

1. E = Endangered, V = Vulnerable;

2. TSC Act = *Threatened Species Conservation Act 1995*, EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999.*

Due to the disturbed nature of the proposed extension area, and based on the habitat preferences and requirements of the other threatened species known from the locality, it is considered unlikely any of these species would utilise the extension areas for foraging or shelter.

There was no response to call playback for the Green and Golden Bell Frog at the billabong. However, when inundated the billabong may provide potential habitat for this species. Given that there was no water in the billabong during the time of the field investigation, targeted surveys were considered to be inconclusive.

The Eastern Freetail Bat, which is listed as vulnerable under the schedules of the TSC Act, was tentatively identified from Anabat recordings within the billabong area.

4 *IMPACT ASSESSMENT*

An assessment of the potential impacts on native flora and fauna within the proposed southern extension area and services corridor at Carrington was made on the assumption that those areas to be impacted and areas outside of the extension area are those shown in *Figure 1.1*.

4.1 DIRECT IMPACTS

4.1.1 Vegetation Clearance And Habitat Loss

The proposed Carrington extension will involve the clearing of exotic pasture with the exception of a small stand of native trees in the services corridor. Approximately 20 trees may require removal from this area. During the investigation it was estimated that approximately six trees in this area contained small hollows. The possible identification of the Eastern Freetail Bat within the billabong area increases the chance that this species utilises the trees within the services corridor, and may be impacted by the proposed extension. An assessment of the impacts of removal of this potential habitat on the Eastern Freetail Bat is provided in an Eight-part Test, Appendix C.

Potential habitat for the Green and Golden Bell Frog will not be directly impacted by the proposal and any potential indirect impacts from the proposed extension area will be mitigated where possible. Mitigation measures to protect the billabong area against indirect impacts are provided in section 4.5.

4.1.2 Habitat Fragmentation And Connectivity

Given that most of the study area has been cleared of native vegetation and is comprised of exotic pasture, fragmentation and connectivity of vegetation within the immediate area and locality are not expected to change as a result of the proposal. The only area of native vegetation to be removed is a small stand of approximately 20 scattered trees that is already isolated from native vegetation by large areas of pasture. Furthermore, the study area is bound by mining to the north and east and the Hunter River to the south. The riparian corridor along the Hunter River will not be impacted by the proposal and no changes in connectivity of the riparian corridor to areas outside of the study area are expected.

4.2 INDIRECT IMPACTS

4.2.1 *Dewatering*

Operations at the Carrington pit began in 2001. Consequently, there was a decrease in the saturated thickness of the watertable in the area of the billabong of approximately 2 – 3 m (MER 2005). In 2009 a groundwater barrier will be constructed within the Carrington pit that will halt any further groundwater movements from the Hunter River and the billabong area. It is then expected that groundwater levels will gradually return to pre-extension levels. However, this process may take some years.

The extension to the Carrington pit is not expected to further impact on the saturated thickness of the watertable within the billabong area. As such, dewatering as a consequence of the Carrington extension is not expected to directly impact on the billabong area at Carrington, or indirectly impact the River Red Gums in this area.

River Red Gums are known to utilise three sources of water – groundwater, surface flows (rainfall) and river sources (CSIRO 2004). At Carrington the distance of the stand of trees from the Hunter River (approximately 40 – 50 m) would indicate the trees are not utilising this water source (Mensforth *et. al* 1994). Therefore it is likely the trees are dependent on both groundwater and surface flows at the study area. It is possible that dewatering at Carrington has already impacted the River Red Gums by reducing the amount of water available to the trees and impacting the potential for the billabong area to flood.

Other potential indirect impacts to habitats surrounding the proposed extension area include:

- areas downstream of constructed levee banks, in particular the billabong area and associated drainage line, being affected by sedimentation;
- potential for mechanical damage to the River Red Gums from machinery and personnel;
- changes to surface flows within the study area due to construction of levee banks leading to a reduction of inundation at the billabong which may impact the River Red Gums;
- reduction in availability of fauna habitat such as hollow-bearing trees as a result of adverse impacts on the stand of River Red Gums;
- potential spread of weed species from movement of soil into the billabong area; and
- changes to water quality in the billabong and drainage lines downstream of extension areas.

4.3 *ASSESSMENT UNDER SECTION 5A OF THE EP&A ACT*

Pursuant to the EP&A Act, an assessment of the impacts of the proposed works on land that is critical habitat or impacts that are likely to significantly affect threatened species, populations or ecological communities, or their habitats, must be undertaken. If Eight-part Tests conclude that a significant impact is likely on threatened species or ecological communities then a Development Application must be accompanied by a Species Impact Statement (SIS).

An Eight-part Test was conducted for one threatened species, the Eastern Freetail Bat, which was tentatively identified within the billabong area and one endangered population, '*E. camaldulensis* in the Hunter Catchment'. The results of these assessments concluded that given the recommended mitigation and management measures to be undertaken as part of this proposal, impacts from the proposal were unlikely to be significant and an SIS is not required.

Given that the extension area is highly modified and is unlikely to provide potential habitat for any of the other threatened species previously recorded within the locality (*Table 3.4*), no significant impacts from the proposed extension are anticipated and Eight-part Tests are not required for these species.

4.4 *ASSESSMENT UNDER THE EPBC ACT*

The Australian Kestrel is listed as a migratory species under the EPBC Act and was recorded during the field investigation. Although listed as migratory, the species does not migrate and is not migratory as defined in the Bonn Convention, on which the EPBC Act is based. In addition, it is unlikely that the removal of exotic pasture and the small stand of trees in the proposed services corridor will have a significant impact on this species. Furthermore, pasture areas will remain to the south and west of the proposed extension area and woodland will be conserved in the southeast of the study area. It is therefore not considered necessary to prepare a referral to the Department of Environment and Heritage for this species.

4.5 *RECOMMENDED MITIGATION MEASURES*

Given that the proposed mine extension is located adjacent to drainage lines and a remnant stand of River Red Gums that have been listed as an endangered population and, further, provide habitat for a threatened bat species, a number of management measures have been recommended to mitigate potential impacts of the proposal:

- grazing of cattle should be removed from the billabong area to enable recruitment of the River Red Gums and to reduce stresses on this area;
- no River Red Gums should be removed from the billabong area;
- buffer areas (areas in which no construction, vehicle or personnel movements or mining activities are undertaken) should be defined around the stand of River Red Gums surrounding the billabong to prevent compaction of soil and edge effects. It is recommended the buffer be at least 20 m in width;
- fencing should be constructed on the development side of the buffer around the River Red Gums to prevent access by construction personnel and vehicles;
- construction of levees should take into consideration the indirect impacts on surface water flows, particularly close to the billabong area;
- appropriate erosion and sediment controls should be implemented across the study area prior to commencement of any construction activities to prevent potential impacts on the Hunter River, the billabong and drainage lines within the study area;
- pre-clearance surveys in accordance with CNA procedures should be undertaken for all trees to be removed from the services corridor; and
- any soil removed for the proposed mine construction or associated activities should not be dumped on, or directly adjacent to, conserved areas, buffer areas or any watercourses or waterbodies where there is potential for weed seeds to be spread during rainfall events.

Additional Recommendations

Given the status of River Red Gums in the Hunter Valley and the number of trees that occur adjacent to the proposed extension area, the following additional measures are recommended and may be adopted by CNA as a part of this proposal:

- a management plan for the stand of River Red Gums and billabong area could be implemented prior to any works beginning on the Carrington extension. The management plan could include specific protection measures, recommended flooding regimes and potential surface water management to compensate for the lowering of the saturated thickness of the watertable that has occurred in the billabong area previously; and
- a monitoring program could be developed that would enable CNA to detect any changes in the health of the stand of the River Red Gums, with the aim of sustaining this population at the study area. Monitoring would most likely be achievable on a six-monthly basis. However, this would be investigated further should CNA choose to adopt a monitoring program.

5 CONCLUSION

It is considered that with the specific mitigation and management measures to be implemented at the study area, significant impacts to the endangered population of River Red Gums will be avoided. Protecting this area of vegetation will also protect habitat for native fauna, including the threatened Eastern Freetail Bat. The extension of the Carrington pit into other areas is not considered to be of significance to the native flora and fauna of the study area.

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Appendix A

Photographs

Photograph A.1 View of the proposed extension area - eastwards

Photograph A.2 Vineyard area and stand of Ironbark / Grey Box woodland

Photograph A.3   Billabong area

Photograph A.4   Drainage lines in the south of the study area

Photograph A.5 Hunter River Vegetation

Appendix B

Hollow- Bearing Tree Survey

Table B.1 River Red Gum Woodland Hollow- bearing Tree Survey

	Tree	# Hollows	Stag	Size of hollows
	1	1		
	2	0		
	3	3		
	4	5		
	5	5		
	6	0		
	7	1		
	8	4	X	
	9	2	X	
	10	1	X	
	11	3	X	
	12	2	X	
	13	0		
	14	2		
	15	2	X	
	16	2		
	17	0		
	18	1		
	19	5		
	20	3	X	
	21	0		
	22	4		small
	23	2		
	24	2		
	25	1		
	26	7		large
	27	1		
	28	0		small
	29	1		small
	30	4		
	31	2		
	32	1		
	33	4		
	34	4		
	35	4	X	
	36	0		
	37	1		
	38	0		
	39	1		
	40	3		large
	41	2	X	
Total	**33**	**86**	**9**	

Appendix C

Eight-Part Tests

C.1 *EIGHT-PART TESTS*

C.1.1 *Mormopterus norfolkensis* (Eastern Freetail Bat)

The Eastern Freetail Bat is listed as vulnerable under the schedules of the TSC Act. Little is known regarding the breeding or foraging habitats of this bat. However, it has been most frequently recorded sheltering in tree hollows of dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998).

The Eastern Freetail Bat was tentatively identified from Anabat tape recordings within the billabong of the study area. If this species does occur within the study area, the scattered Narrow-leaved Ironbark/ Grey Box trees within the proposed services corridor may also provide potential habitat for this species. Anabats were not used within the proposed services corridor during the investigation due to its isolated and degraded nature and it is therefore unknown whether the species is utilising this area. This Eight-part Test will assess potential impacts to the Eastern Freetail Bat as a result of the removal of this potential habitat.

a) *In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,*

The Eastern Freetail Bat was tentatively recorded within the billabong area at Carrington. This area will not be removed under the proposed extension. The billabong area was utilised by an abundance of hollow-dependent birds and during times of inundation it is likely to provide habitat for a variety frogs and other bird species. In contrast, the vegetation within the proposed services corridor provides habitat of lower quality that is isolated from other areas of fauna habitat by pasture and the Carrington pit. Species recorded in this area were common birds such as Kookaburras and Magpies. The removal of approximately six hollow-bearing trees from the proposed services corridor may impact on sheltering habitat for the Eastern Freetail Bat. However, the abundance of tree hollows within the billabong area and the ability of the species to move from the services corridor to the billabong means that the removal of six trees should not significantly impact on this species. In addition, pre-clearance surveys of all hollow-bearing trees requiring removal under the proposal will ensure no fauna are injured and all are translocated prior to the trees removal.

Given that known habitat for the Eastern Freetail Bat will be conserved within the billabong area and the species is highly mobile, it is considered that the removal of the six trees from the proposed services corridor is unlikely to place a viable local population of the Eastern Freetail Bat at risk of extinction.

b) *In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,*

No endangered populations of this species are currently listed on Schedule 1 of the TSC Act.

c) *In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,*

The Eastern Freetail Bat is distributed along the east coast of New South Wales from south of Sydney extending into south eastern Queensland near Brisbane. It has been most commonly recorded within dry eucalypt forest and woodland and is known to roost in tree hollows. This species has also been recorded under the bark of trees, in the roof of a hut and under the metal cap of a telegraph pole (Churchill 1998). Given that this species inhabits common vegetation types and can roost in habitat other than tree hollows, the removal of six isolated hollow-bearing trees from the proposed services corridor is unlikely to represent removal of a significant area of habitat in relation to the regional distribution of habitat for this species.

d) *Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological* community,

Known habitat for the Eastern Freetail Bat occurs around the billabong of the study area and River Red Gum Woodland in this area will remain connected to vegetation along the Hunter River and will be conserved and protected under the proposal.

Potential habitat for the Eastern Freetail Bat will be removed under the proposal. However, the area of trees to be removed under the proposal is already isolated from other areas of vegetation by pasture and the Carrington pit. Therefore known habitat will not be isolated as a result of the proposal.

e) *Whether critical habitat will be affected,*

No critical habitat for this species has currently been identified by the Director-General of the DEC.

f) *Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,*

Other areas of habitat for the Eastern Freetail Bat will be conserved within the study area and also occur within numerous National Parks and other conservation reserves within the region. Therefore this species and its habitats are likely to be adequately represented within the conservation reserves in the region.

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,*

Clearing of native vegetation has been listed as a key threatening process under the NSW TSC Act. The proposal will clear approximately 20 native trees, six of which may provide potential habitat for the Eastern Freetail Bat.

h) *Whether any threatened species, population or ecological community is at the limit of its known distribution,*

The Eastern Freetail-Bat is found in eastern Australia from southern Queensland to south of Sydney (Churchill 1998). Therefore this species is not at the limit of its known distribution at Carrington.

Conclusion
The proposal has the potential to impact on a small area of potential habitat for the Eastern Freetail Bat. However, a better quality, larger area of known habitat occurs within the study area and will be conserved under the proposal. Given the small and isolated nature of habitat to be affected under the proposal, and mitigation measures to be put in place prior to development, it is considered that an SIS is not required for this species.

C.1.2 *Eucalyptus camaldulensis* in the Hunter Catchment

Eucalyptus camaldulensis (River Red Gum) in the Hunter Catchment is listed as an endangered population in Part 2 of Schedule 1 of the TSC Act.

E. camaldulensis is the most widespread eucalypt in Australia, occurring in all mainland states and territories (Brooker & Kleinig 1999). In NSW the species occurs along western flowing rivers but is known from only one coastal catchment, the Hunter.

Prior to European settlement it is likely that River Red Gums formed extensive stands of woodland on the floodplains of both the Hunter and Goulburn Rivers, especially where water impoundment occurs after floods. Flood mitigation and clearing of native vegetation have greatly reduced the extent of habitat favourable to River Red Gums in the Hunter Catchment. Within the Hunter catchment many River Red Gums are several hundreds of years old (Peake unpubl. data 2005), and there are only 19 known stands of the species in the Hunter (DEC 2005).

Pollination of River Red Gums occurs predominantly by insects but also small mammals and birds, with fruit maturation time sometimes being as short as four months. Flood timing has been known to affect germination success. However, seedling establishment rather than germination is the critical stage in River Red Gum stand regeneration. Dense stands of seedlings appear (sometimes over extensive areas) following floods, gradually thinning out as they grow. Competition for moisture by ground vegetation or over storey trees can influence seedling survival, depending on seasonal variation and flooding. Seedlings are vulnerable to heat stress and immersion during the establishment phase, so spring-summer floods followed by recession are optimal for regeneration (CSIRO 2004).

At the study area, River Red Gums were recorded around a billabong area that was dry during the time of the field investigation. The drying out of this area may have several contributing factors, including the impacts of dewatering of the Carrington pit since mining began in 2001, and the current drought. The billabong is located approximately 50 m north of the Hunter River and a drainage line leads from the billabong to the Hunter River. The River Red Gums are suffering from various stages of dieback.

a) *In the case of a threatened species, whether the lifecycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,*

N/A

b) *In the case of an endangered population, whether the lifecycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,*

River Red Gums are known to use three sources of water – groundwater, rainfall (surface) and river flooding (CSIRO 2004). Dewatering of the Carrington pit has lowered the groundwater table in the billabong area by 2 – 3 m. However, the extension of the Carrington pit is not expected to further impact on groundwater at the study area (Mackie 2005).

The proposal is not expected to impact on the pollinators of River Red Gums, or on natural flooding regimes at the study area. Other disturbances, such as grazing, will be removed from the billabong area as additional mitigative measures. In addition, management measures such as the dedication of a buffer zone around the River Red Gums and a protective fence on the development side of the buffer to prevent any damage by personnel or machinery will prevent other direct impacts on the stand.

Considering the mitigative and management measures to be put in place at the study area, it is considered that the life cycle of the River Red Gums at the study area will not be disrupted such that the viability of the population is likely to be significantly compromised.

c) *In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,*

Only 19 known stands of River Red Gums remain in the Hunter catchment, with an estimate of 600 – 1000 mature or semi mature trees (approximately 15 – 20 ha), and it is likely that any areas where stands occur in the Hunter are considered a significant area of habitat. The stand of River Red Gums at the study area measures 0.4 ha, existing around a billabong and associated drainage line, located 50 m north of the Hunter River. This area will be managed and protected under the proposed extension for retention of the River Red Gums. Adjacent cleared paddocks and mined areas do not provide potential habitat for the species. Therefore a significant area of known or potential habitat will not be removed or modified under the proposal.

d) *Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,*

The River Red Gums at the study area are isolated from other native vegetation remnants and only remain connected to riparian vegetation along the Hunter River. Extension of the Carrington pit will occur to the north of the existing trees. Therefore no known habitat for River Red Gums will become isolated from currently interconnecting areas as a result of the proposal.

e) *Whether critical habitat will be affected,*

No critical habitat for this population has currently been identified by the Director-General of the DEC.

f) *Whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,*

There are no known occurrences of River Red Gum populations in conservation reserves (DEC 2005) and therefore the population is not adequately represented in conservation reserves or other protected areas in the region.

g) *Whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process,*

A small number of trees will be removed under the proposal (approximately 20) and the proposal may impact on the surface water flows of the study area at the leading edge of the pit. However, the extension to existing mining activities is unlikely to be recognised as a key threatening process at the study area.

h) *Whether any threatened species, population or ecological community is at the limit of its known distribution,*

The River Red Gums at the study area are not at the limits of known distribution within the Hunter catchment. The western-most individuals in the Hunter are found at Bylong, south of Merriwa, and the eastern most at Hinton in the Port Stephens LGA.

Conclusion

Potential impacts to the River Red Gums at the study area are not considered to be significant because:

- the individuals at the study area are not at the limit of the population's distribution;
- the proposal will not significantly modify, remove or isolate known habitat for the species; and
- the proposal includes management and mitigation measures to reduce and manage any potential impacts to the River Red Gums at the study area.

In addition, CNA may adopt a management plan and / or monitoring program for the stand to ensure their viability at the study area.

Annex I

Soil Assessment

EXTENSION OF CARRINGTON PIT (HUNTER VALLEY OPERATIONS)

SOIL AND LAND CAPABILITY SURVEY REPORT

Prepared for:

Coal & Allied

Prepared by:

____
R. Masters
Principal
GSS Environmental

Global Soil Systems Project No: CNA 1-5
Issue No. 2
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DOCUMENT CONTROL SHEET

Project No: CNA 1-5

Title: Extension of Carrington Pit (Hunter Valley Operations)
Soil and Land Capability Survey Report

Project Manager: Rod Masters

Author: Rod Masters

Client: Coal & Allied

Client Contact: Dan Eason

ISSUE AND AMENDMENT CONTROL HISTORY

Issue	Date	Description	By	Checked
# 1 (Draft)	30 June 2004	Issued to CNA	GSSE	RM
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Description Master: GSS Environmental
Copy 1: Dan Eason (CNA)

CONTENTS

1.0 INTRODUCTION

1.1 Objectives

GSS Environmental (GSSE) was commissioned by Coal and Allied (CNA) to undertake soil and land capability surveys of the proposed Carrington Pit extension area. Surveys were conducted by GSSE in May 2004. The survey was undertaken in accordance with the requirements of the Department of Mineral Resources (DMR) Mining Operations Plan (MOP) specifications.

The major objectives of these surveys were to:

(1) describe, classify and map soils / land capability within the study area; and

(2) analyse the various soil units to identify their suitability for topdressing of disturbed areas within the study area.

The following report describes the results of the soil and land capability surveys undertaken by GSSE.

1.2 Location

The Carrington Pit is located within the Hunter Valley of New South Wales between Singleton and Muswellbrook. The site is located on the western side of Hunter Valley Operations (HVO) and is adjacent to Lemington Road.

1.3 Regional Setting

The region is underlain by rich coal resources and several coal mines operate nearby, supplying both domestic and export markets. Carrington is part of CNA's HVO which also contains Hunter Valley North, West Pit, Cheshunt and Riverview pits. The area lies north of the Hunter River (refer *Figure 1*).

2.0 PROPOSAL SUMMARY

CNA propose to extend their existing mining operations in Carrington Pit at HVO north of the Hunter River. The proposal includes a southern and eastern extension area totaling 140 hectares. The southern area will be located on agricultural land located between the existing Carrington Pit and the Hunter River, while the eastern area will be located on an existing overburden dump. The extension has been identified as a Section 96(2) modification under the *Environmental Protection & Assessment Act 1979*.

The extension covers an area within ML 1474, CL 360, CCL 755, EL 5418 and EL 5606. The study area consists of approximately 115 ha outside of existing approval limits. The vegetation in this area consists of improved pasture species. No cropping is currently undertaken within the study area. The land to be affected by mining is owned by CNA.

Under the proposal Carrington will continue to operate as an open cut, multi-seam truck and shovel operation.

3.0 METHODOLOGY

3.1 Soil Survey

3.1.1 Introduction

The soil survey was undertaken to fulfill the requirements of the Department of Infrastructure, Planning & Natural Resources (DIPNR) and the Department of Mineral Resources (DMR). Specifically, the soil survey was conducted in a manner which complies with DIPNR's *"Specifications for Soil Surveys to Determine the Stripping Depths of Soil Material to be Removed and Used in Association with the Rehabilitation of Land Disturbed during the Period of the Open Cut Approval".*

The broad objective of the survey is to qualify the reserves of suitable topdressing material to assist planning of future rehabilitation operations.

3.1.2 Mapping

An initial soil map was developed using the following resources and techniques:

(i) **Aerial photographs and topographic maps**

Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape and mapping of features related to the distribution of soils in the area.

(ii) **Previous soil surveys**

Surveys of the existing Carrington lease were undertaken by the Department of Conservation & Land Management (1994), Veness & Associates (1995) and ERM Mitchell McCotter (1999). The surveys encompassed the area to the north of the study area.

During 1991, Kovac and Lawrie completed a soil survey of all areas contained in the Singleton 1 : 250,000 Sheet. The Carrington lease area was included in the soil survey.

(iii) **Stratified observations**

Upon drafting of mapping units, soil profile exposures were visually assessed to ascertain potential mapping units.

3.1.3 Profiling

During the 2004 GSSE survey a total of 23 soil profile exposures were assessed at selected sites to enable soil profile descriptions to be made. The exposure locations were chosen to provide representative profiles of the soil types encountered over the study area. The soil profile sites are shown in *Figure 1*.

The soil layers were generally distinguished on the basis of changes in texture and/or colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994).

Soil observations were also conducted in eroded areas, small access track cuttings, etc by GSSE to confirm soil units and boundaries between different soils.

3.1.4 Field Assessment

Soil layers at each profile site were assessed according to a procedure devised by Elliot & Veness (1981) for the recognition of suitable topdressing materials. The system remains the benchmark for the coal mining industry.

The system is described in ***Appendix 1***.

3.1.5 Laboratory Testing

Soil samples were taken from exposed soil profiles during the soil survey. The samples were subsequently analysed for the following parameters:

- Particle Size Analysis
- Emerson Aggregate Test
- pH
- Electrical Conductivity

A description of the significance of each test and typical values for each soil characteristic are included in ***Appendix 2***.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for stripping and re-use for the rehabilitation of disturbed areas. The soil test results for the soil survey are provided in ***Appendix 3***.

3.2 Land Capability Survey

The land capability survey was conducted according to the DIPNR rural land capability assessment system. The system consists of eight classes which classifies land on the basis of an increasing soil erosion hazard and decreasing versatility of use. It recognizes the following three types of land uses:

- land suitable for cultivation;
- land suitable for grazing; and
- land not suitable for rural production

These capability classifications identify the limitations to the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognized by these capability classifications is the stability of the soil mantle (Soil Conservation Service, 1986).

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land use, rather it indicates the potential of the land for such uses as crop production, pasture improvement and grazing.

4.0 RESULTS

4.1 <u>Soils</u>

4.1.1 <u>General</u>

The majority of the survey area is encompassed by the “Liddell” and “Hunter” Soil Landscapes (Kovac and Lawrie, 1991).

Soil unit classifications for the GSSE survey were based on the Stace *et al* (1968) Great Soil Group classification system.

The following soil units were identified within the proposed study area:

- Red Brown Earth
- Brown Clay
- Black Earth

The distribution of these soils is illustrated in *Figure 2*.

The Red Brown Earth occurs on the western ridge and upper to midslope areas. It covers approximately 28% of the total study area. The soil is characterised by a dark brown hardsetting sandy loam surface horizon eventually grading to a reddish brown massive medium clay subsoil.

The Brown Clay occurs within the central drainage depression and footslope area. The soil unit encompasses approximately 29% of the study area. A yellowish brown medium clay surface horizon grades to a brown sticky silty clay and eventually to a yellowish brown plastic heavy clay.

The Black Earth is located on the alluvial flats adjoining the Hunter River and encompasses some 43% of the study area. The soil is characterised by a self mulching, dark brown silty clay loam surface horizon grading to a strong structured brown black silty clay loam and eventually to a deep brown sticky silty clay.

4.1.2 <u>Profile Descriptions</u>

The following profile descriptions are characteristic of their respective soil unit.

SOIL UNIT: RED BROWN EARTH		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.10	Hardsetting dark brown sandy loam horizon. It is weakly to moderately consistent and coherent; moderately pedal with rough-faced porous sub-angular blocky peds 20-100 mm breaking to sub-angular blocky, round, granular and crumb peds <2-10 mm diameter. It has 10% rounded fine gravel and ironstone fragments and many roots are present. The lower boundary is sharp and wavy to layer 2.
2	0.10 – 0.30	Dark brown light sandy clay loam. The structure is weakly pedal and the consistence moderately weak or crumbly, containing rounded ironstones. The boundary is clear to diffuse and even to wavy to layer 3.
3	0.30 – 0.70	Brown light clay with strong pedality and consistence. The layer contains gravel sized ironstone. Calcium carbonate nodules are present. A gradual, wavy boundary to layer 4.
4	0.70 – 1.50+	Reddish brown massive medium clay with abundant orange and grey mottles. Ironstone and calcium carbonate are present.

SOIL UNIT: BROWN CLAY		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.50	Dull yellowish brown medium clay. It has strong pedality and consistence is moderately firm. Orange mottles follow root traces. The lower boundary is gradual and wavy to layer 2.
2	0.50 – 0.95	Brown to yellowish brown slightly to moderately sticky silty clay. It is moderately consistent and weakly coherent dry, not coherent wet: Weakly pedal with sub-angular blocky peds. The lower boundary is sharp and even to layer 3. A gradual change to layer 3.
3	0.95 – 1.50+	Yellowish brown plastic heavy clay. Calcium carbonate nodules occur at depth. The layer is massive.

SOIL UNIT: BLACK EARTH		
LAYER	**DEPTH (m)**	**DESCRIPTION**
1	0 – 0.10	Dark brown self mulching silty clay loam. The soil consistence is very firm and crumbly when dry. The layer exhibits strong pedality with rough-faced, polyhedral peds 50-100 mm in diameter. Many to abundant roots occur; the soil is moderately bioturbated. The lower boundary is gradual and wavy to layer 2.
2	0.10 – 0.80	Brownish black silty clay loam. It is moderately consistent and has strong polyhedral and prismatic peds. Some calcium carbonate nodules are evident. There are many roots. The lower boundary is sharp and wavy to layer 3.
3	0.80 – 1.40+	Brown sticky silty clay. It is moderately to strongly consistent and moderately coherent; moderately pedal with smooth and rough-faced peds 50-200 mm. Some calcium carbonate nodules are evident.

4.1.3 Laboratory Testing

All soil samples taken during the GSSE survey were analysed by the Department of Land's Soil and Water Testing Laboratory at Scone, NSW. All soil analytical results are provided in ***Appendix 3***.

The Red Brown Earth is a duplex soil that generally grades from a sandy loam texture to a contrasting medium clay subsoil. The subsurface soil is structurally weak. An alkaline trend occurs down the profile with pH recordings of 6.5 to 9.2. Subsurface soil pH often exceeds 9.0 and is structurally unstable (Emerson ratings of 2). The soil unit is non-saline.

The Brown Clay is a uniform soil with a very fine texture (high clay content). An alkaline trend occurs down the profile and the soil is non-saline, however, the soil unit is unstable (Emerson rating of 2).

The Black Earth has a uniform profile grading from a silty clay loam to silty clay. The soil is structurally stable (Emerson rating of 5 to 3). An alkaline trend occurs down the profile with surface soil pH being slightly acidic (pH 7.1 to 7.6). The soil unit is non-saline.

4.2 Land Capability

The survey area contains four classes of land capability; Classes II, IV, VIII and M. Class IV land dominates the proposed extension area comprising some 60% of the study area. Class IV land comprises the better classes of grazing land and whilst it is capable to cultivate for an occasional crop, it is not suitable for cultivation on a regular basis owing to limitations of slope and erosion potential.

A large component of the alluvial land adjoining the Hunter River is Class II land, comprising approximately 37% of the study area. It is gently sloping land suitable for a wide variety of agricultural uses. It has a high potential for production of crops on fertile soils and includes "prime agricultural land".

Small portions of Class VIII and M land are represented by a swampy area in the south east and a small overburden stockpile in the north east corner, respectively. Both land classes are unsuitable for agriculture.

Figure 3 shows the pre-mining land capability classification of the study area.

5.0 TOPDRESSING SUITABILITY

Details of the soil test results (refer ***Appendix 3***) were used in conjunction with the field assessment (refer ***Appendix 1***) to determine the depth or thickness of soil materials that are suitable for stripping and re-use in the rehabilitation of disturbed areas.

Structural and textural properties of soils within the study area are the most significant limiting factors for determination of topdressing suitability. The sub-surface horizons of the duplex soil (Red Brown Earth) are structurally weak and are considered not suitable for stripping, stockpiling and re-spreading as a topdressing material for reshaped overburden. Limited stripping potential (0.1m) is available on the majority of ridge and upper-slope areas on the western side of the study area. The combination of fine texture, structural weakness (high ped disruption rating) and high pH of sub-surface horizons translates to these materials being unsuitable as topdressing media.

The Brown Clay soil unit is generally not suitable for stripping and re-use during rehabilitation operations because of very high clay content throughout the profile. Each soil layer is very dispersive and therefore would be prone to surface sealing during rehabilitation once disturbed.

The topsoil layers of the Black Earth unit can be stripped to an average depth of 0.8m for re-use as topdressing material. The soil unit is texturally and structurally sound, is non-saline and generally has a near neutral to slightly alkaline pH range.

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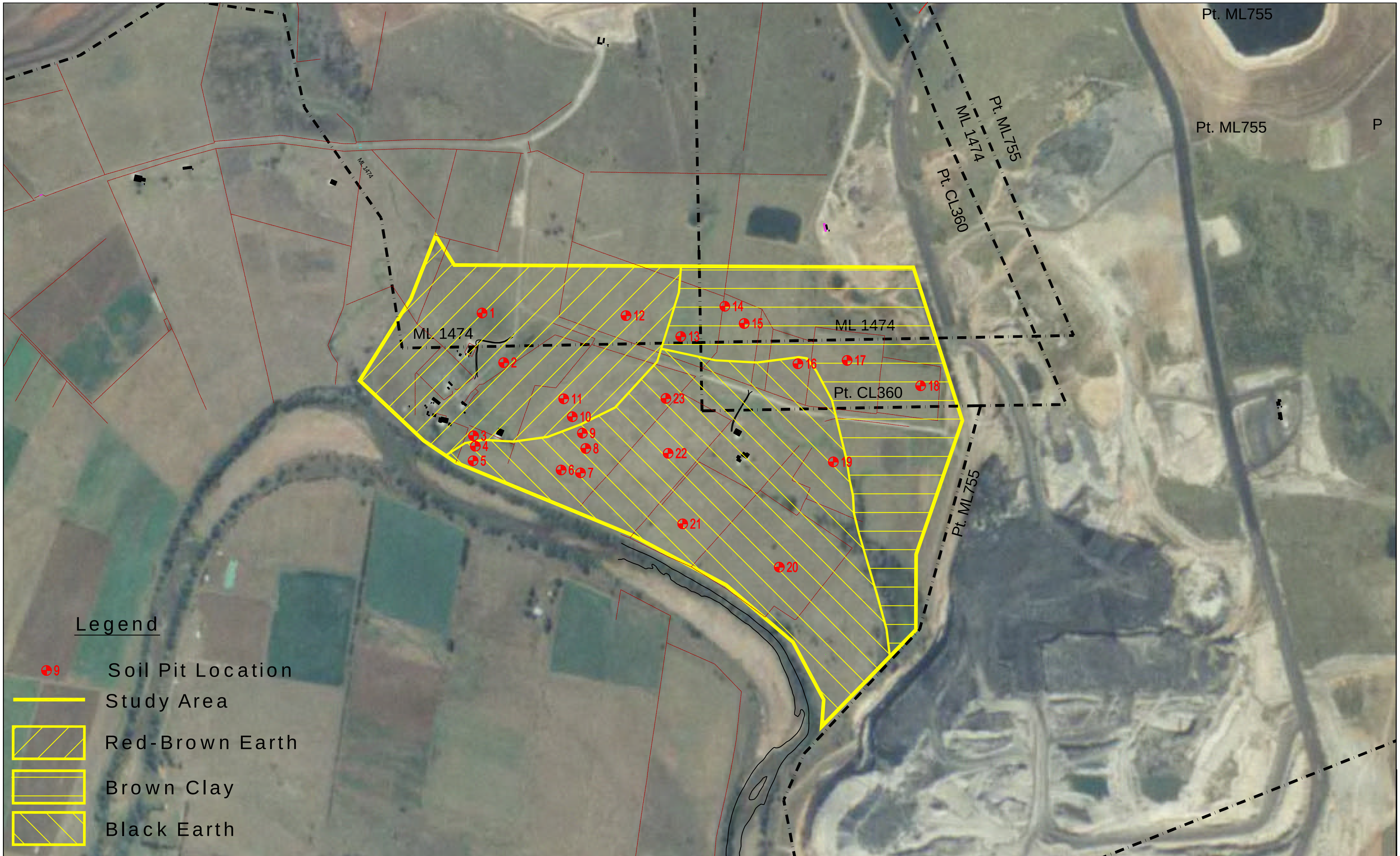
rawing No. CNA 1-5-1

Carrington Extension
Soil & Land Capability Survey
Study Area & Soil Pit Location Plan

FIGURE 1



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Carrington Extension
Soil & Land Capability Survey
Soil Units

FIGURE 2

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Carrington Extension
Soil & Land Capability Survey
Existing Rural Land Capability Clasification

FIGURE 3

APPENDIX 1

FIELD ASSESSMENT PROCEDURE

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as the Hunter Valley.

Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.

APPENDIX 2

SOIL INFORMATION

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1	-	very dispersible soils with a high tunnel erosion susceptibility.
Class 2	-	moderately dispersible soils with some degree of tunnel erosion susceptibility.
Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected
(4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (*d*S/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

APPENDIX 3

SOIL TEST RESULTS

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO04/129R1

Client Reference: Rod Masters
GSS Environmental
PO Box 3214
Wamberal 2260

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH
1	Carrington Extension SS 1/1	9	5	38	47	1	8/5	0.33	6.5
2	Carrington Extension SS 1/2	39	9	22	30	<1	3(2)	0.14	7.3
3	Carrington Extension SS 1/3	47	9	18	26	0	2(1)	1.10	9.2
4	Carrington Extension SS 11/1	13	15	26	46	<1	3(1)	0.09	7.1
5	Carrington Extension SS 11/2	10	7	26	56	1	3(1)	0.05	8.1
6	Carrington Extension SS 11/3	25	7	24	44	<1	3(1)	0.12	8.4
7	Carrington Extension SS 13/1	41	24	22	13	0	2(2)	0.61	6.7
8	Carrington Extension SS 13/2	33	29	20	18	0	2(1)	0.53	7.3
9	Carrington Extension SS 13/3	38	8	21	33	0	2(3)	0.55	8.4

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Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH
10	Carrington Extension SS 17/1	46	26	24	4	<1	3(2)	0.11	7.0
11	Carrington Extension SS 17/2	71	11	14	4	<1	2(2)	0.20	8.5
12	Carrington Extension SS 17/3	70	16	9	5	<1	2(3)	1.00	9.0
13	Carrington Extension SS 19/1	34	41	24	1	<1	3(1)	0.14	7.6
14	Carrington Extension SS 19/2	30	42	22	3	3	3(2)	0.08	8.1
15	Carrington Extension SS 19/3	61	28	10	1	<1	2(1)	0.32	9.0
16	Carrington Extension SS 22/1	28	28	44	0	0	5	0.24	7.1
17	Carrington Extension SS 22/2	32	34	34	0	0	3(2)	0.11	8.4
18	Carrington Extension SS 22/3	54	27	18	1	0	3(1)	0.13	8.6

END OF TEST REPORT

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